

JISC DEVELOPMENT PROGRAMMES

Project Document Cover Sheet

DIDET Project Final Report

Project

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The project was a collaboration between the University of Strathclyde (Glasgow, UK), Stanford University (California, USA), and latterly Olin College of Engineering (Massachusetts, USA).

At the University of Strathclyde, the Department of DMEM (Design, Manufacturing and Engineering Management) led the project, working collaboratively with Learning Services, CAPLE (Centre for Academic Practice and Learning Enhancement) and CDLR (Centre for Digital Library Research).

At the University of Strathclyde, project direction was given by William Ion (formerly Neal Juster) and the project was managed by Caroline Breslin (formerly LouMcGill) who also provided information specialist support. The Academic Leader was William Ion, and the class lecturers were Andrew Wodehouse and Hilary Grierson. The LauLima system was developed by Andrew Lynn and Anu Joseph and evaluation work was also done by Hilary Grierson. Work on developing a specification for the digital library was carried out by Dennis Nicholson.

The following staff also provided input as members of the DIDET Project Team at Strathclyde.

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- Alex Duffy – DMEM
- Allison Littlejohn – CAPLE
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- David Nicol – CAPLE
- Niall Sclater – Learning Services
- Ali Shiri – CDLR
- Kevin Steel – DMEM
- Angela Stone – DMEM
- Avril Thomson – DMEM

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At Stanford, the senior project personnel were Larry Leifer, Ade Mabogunje and Ozgur Eris (latterly of Olin College). Judith Lee provided administrative support and graduate students Shashikant Khandelwal, Malte Jung and Neeraj Sonalkar were part of the project team.

The following graduate students were also involved in the project via Stanford.

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Other organisational partners are as follows.

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- Profs David Maier, Paul Gorman, and Lois Delcambre, **Oregon Health and Science University**
- Prof Alice Agogino and her team for use of SMETE, **University of California-Berkeley**
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- Helen Josephine, Head Librarian, Engineering Library, Stanford University
- Robert Schwarzwald, Associate University Librarian for the Science and Engineering Libraries, Stanford Universities

Ozgur Eris was responsible for project work at Olin College, formerly being part of the team at Stanford. Contributions to the project work were also made by students Liana Austin and Mel Chua.

Executive Summary

The central goal of the DIDET Project was *to enhance student learning opportunities by enabling them to partake in global, team based design engineering projects, in which they directly experience different cultural contexts and access a variety of digital information sources via a range of appropriate technology.*

To achieve this overall project goal, the project delivered on the following objectives:

1. Teach engineering information retrieval, manipulation, and archiving skills to students studying on engineering degree programs.
2. Measure the use of those skills in design projects in all years of an undergraduate degree program.
3. Measure the learning performance in engineering design courses affected by the provision of access to information that would have been otherwise difficult to access.
4. Measure student learning performance in different cultural contexts that influence the use of alternative sources of information and varying forms of Information and Communications Technology.
5. Develop and provide workshops for staff development.
6. Use the measurement results to annually redesign course content and the digital libraries technology.

The overall DIDET Project approach was to develop, implement, use and evaluate a testbed to improve the teaching and learning of students partaking in global team based design projects. The use of digital libraries and virtual design studios was used to fundamentally change the way design engineering is taught at the collaborating institutions.

This was done by implementing a digital library at the partner institutions to improve learning in the field of Design Engineering and by developing a Global Team Design Project run as part of assessed classes at Strathclyde, Stanford and Olin.

Evaluation was carried out on an ongoing basis and fed back into project development, both on the class teaching model and the LauLima system developed at Strathclyde to support teaching and learning.

Major findings include the requirement to overcome technological, pedagogical and cultural issues for successful elearning implementations. A need for strong leadership has been identified, particularly to exploit the benefits of cross-discipline team working. One major project output still being developed is a DIDET Project Framework for Distributed Innovative Design, Education and Teamwork to encapsulate all project findings and outputs.

The project achieved its goal of embedding major change to the teaching of Design Engineering and Strathclyde's new Global Design class has been both successful and popular with students.

Background

The design and development of new products for the global marketplace requires engineers to perform in internationally situated teams. Modern communication technologies such as virtual environments, digital libraries, shared workspaces, video and audio conferencing and email are increasingly being used to enhance performance by supporting information creation and sharing. Therefore, in higher education, it is necessary for design engineering students to learn to work in distributed teams by utilizing cutting edge information management technologies.

High performance design engineering teams are composed of autonomous learners, who can independently determine and pursue their learning goals and content. The nature of design activity requires them to act that way; designing is context dependent and open-ended, and therefore does not revolve around a specific body of information or knowledge. This poses a problem for design education since teachers cannot predict in advance what students will decide to learn. Coaching, rather than didactic teaching, has proved to be effective in addressing that problem. Expert coaches guide and facilitate rather than try to specify what information should be used

This educational paradigm shift from teaching to coaching requires students to have access to as wide a range of information as possible. In most cases, much of that information lies outside the students' immediate domain. Digital libraries provide an excellent opportunity for extending the range of information available to design students. However digital libraries bring their own problems for all stakeholders including library staff, teachers and learners. Previous experiments conducted by Strathclyde have shown that virtual studio environments, discussion fora and synchronous chat facilities can aid communication between design engineers. However the same study also shows that barriers of culture, discipline, distance, network and technology may prevent successful use of ICT.

In a separate investigation by Stanford, the important role that expert coaches play in facilitating the successful adoption of new technologies by design teams, and three key learning mechanisms within design activity through which knowledge acquisition takes place have been identified. These are displayed in Figure One below – Eris and Leifer's 'Design Knowledge Framework'

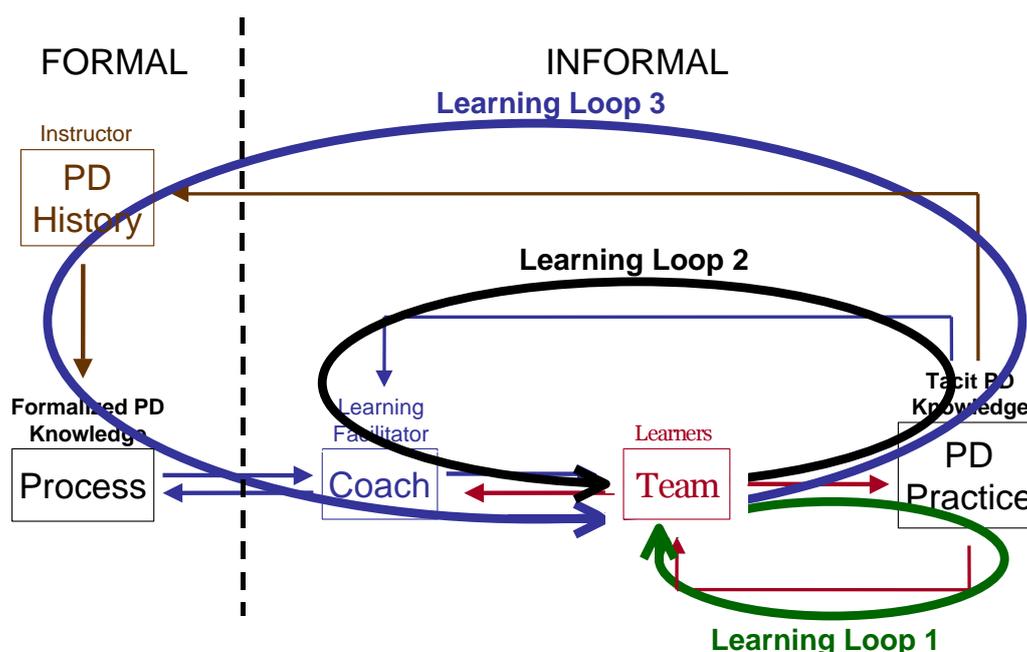


Figure One: Eris and Leifer's Design Knowledge Framework

This product development knowledge acquisition model makes a distinction between formal and informal aspects of practice and knowledge. Organization, Product Development History, and Product Development Process are considered to be predominantly formal elements. (In an education context,

Organization is represented by Instructor.) Expert Coaches, Teams, and Product Development Practice are considered to be informal elements. The arrows represent the "acquisition" or "co-generation" of product development knowledge.

The formalized tasks and procedures embodied in a product development process need to be interpreted and contextualized for product development teams. Otherwise, what the process suggests does not appear tangible and valuable to teams, and runs the risk of being perceived as an overhead. What is of value to the teams is to contemplate the intent of the process—the rationale behind the suggested definitions and procedures. The intent of a product development process is not necessarily what can be formally captured and represented in flow charts, resource allocation tables, and task and deliverable definitions. On the contrary, it is mainly a common informal understanding of ways of doing the things that are necessary to develop a product, and relies heavily on the interactions of the involved parties.

Expert Coaches appear at the boundary between formal and informal domains, and play a critical role in transforming the formalized aspects of the process to the informal medium teams prefer to work with. They achieve that role by drawing on their own past as well as ongoing product development practices. In fact, it is critical that coaches engage in—at least as an observer—the ongoing product development practices of the teams; the relevance of their interpretations increases when they are grounded in the situations they are interpreting for. Thus, for coaches, an Observe-Interpret-Contextualize cycle forms the basic mechanism for facilitating the knowledge acquisition of teams.

And finally, it is important to note that there is no specific node or interaction where product development knowledge is "created". The model advocates that product development knowledge cannot be embodied in a specific individual, a specific group of individuals, or a formal process. Those elements can only embody aspects of product development knowledge. Interaction of those elements is what assigns meaning to the aspects of knowledge and allows for their synthesis. Therefore, it can be said that product development knowledge emerges out of the combined interaction of the involved people and resources.

The three learning mechanisms shown in Figure One can be seen in the following way:

- **Learning Loop 1 – Designing:** Teams apply the product development process contextualized for them by coaches in their design practice. They utilize the information embodied in the process, and in doing so, generate new information.
- **Learning Loop 2 – Coaching:** Coaches observe the design practices of teams, and use the understandings they gain in contextualizing the product development process for them. Based on the needs of teams, coaches selectively extract information from the product development process and present it to the teams in a meaningful way.
- **Learning Loop 3 – Capturing, Indexing, and Publishing:** Instructors retain a history of the new knowledge generated during design practice, and extract new elements from it in order to improve the product development process. Instructors manage the capture, indexing, and publishing of the new information that teams generate in loop 2 in the form of a product development process.

The DIDET Project aimed to embed teaching methods and technology within Design Engineering at Strathclyde and Stanford to prepare students for the global marketplace; enabling them to become effective designers, able to work in global teams using innovative technology.

Aims and Objectives

The central goal of the DIDET Project was *to enhance student learning opportunities by enabling them to partake in global, team based design engineering projects, in which they directly experience different cultural contexts and access a variety of digital information sources via a range of appropriate technology.*

To achieve this overall project goal, the project delivered on the following objectives:

1. Teach engineering information retrieval, manipulation, and archiving skills to students studying on engineering degree programs.
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5. Develop and provide workshops for staff development.
6. Use the measurement results to annually redesign course content and the digital libraries technology.

The project aimed to develop methods and use technology that would be embedded into the teaching of engineers in the two institutions, who between them graduate nearly 900 engineers each year.

Methodology

The overall DIDET Project approach was to develop, implement, use and evaluate a testbed to improve the teaching and learning of students partaking in global team based design projects. The use of digital libraries and virtual design studios would be used to fundamentally change the way design engineering is taught at the collaborating institutions.

In order to achieve its aims, DIDET methodology was two-fold. Firstly, the project planned to implement a digital library at the partner institutions to improve learning in the field of Design Engineering. The use of this digital library was to be embedded in classes at Strathclyde and Stanford to support learning by providing a repository for students to create, store share, use and reuse information resources for Design Engineering team work. Secondly, the project planned to develop a new Global Team Design Course that fitted the curriculum of both the University of Strathclyde and Stanford University, allowing the students at both institutions to collaborate; working together across geographical and cultural boundaries in global design teams, despite not being able to meet in person. The digital library (and other technology) would be used to support global team work. After the first two years of the project, it became apparent that it would not be possible to develop a single course that could possibly be tailored to be suitable at both institutions. This was due to the different course structures, timetables and credit for assessment at each institution. Rather than abandon this part of the methodology, or attempt to achieve it and fail, the project agreed with approval from the programme manager and evaluators in September 2005, that it would prove much more effective to run joint a joint *element* of classes at Strathclyde, Stanford and Olin (now part of the project) rather than developing a complete new module shared between the institutions. In practice, this meant developing a new global project for UK-USA student teams that would be an assessed element of new classes at Strathclyde and Olin, and part of an existing class at Stanford.

Implementation

The key stages of implementation of the DIDET Project were as follows.

- Library Specification
- Library Development and Implementation
- Student Use of Library
- Global Team Design Project
- Evaluation

Each of these key stages is discussed in more detail below.

Library Specification

One of the first stages in specifying the project digital library was a review of existing products and technologies. Evaluation of existing groupware and digital library products was carried out, including

technologies such as BSCW, Intrallect, Groove and TikiWiki. A pilot exercise in information seeking was carried out at Stanford to further investigate requirements for a project digital library and several other digital library projects were investigated with visits to Carnegie Mellon University, Pittsburgh, the University of California at Berkeley and Oregon graduate Institute. The following key findings related to the DIDET digital library emerged during specification.

- The need for two related repositories; a learning environment which is a student-shared workspace where academic staff and students working on projects can upload content to share with group members and other teams. This is the area where student content, resource management and use can be evaluated, including the impact on their learning experience. Not all of this content is appropriate for reuse by staff and students, necessitating the need for a second repository which is a formal digital library; a managed repository containing resources which have been evaluated and validated.
- An investigation into UK Intellectual Property Rights (IPR) and Digital Rights Management (DRM) led to a redefinition of the student agreement and strict guidelines for content uploading. DIDET was included as a use case in a UK DRM report for JISC and participated in one of the related workshops held by Intrallect. IPR/DRM issues had to be investigated in the context of USA law and similar student agreements had to be created for all students regardless of their location.
- A workflow was required for uploading content to the library system and applying metadata. When students and academic staff upload content into the learning environment some of the metadata is applied automatically by the system (file type, date added, depositor name and team). At this stage additional metadata can be applied by the depositor (title, format, source, citation, keywords). The second stage of the process involves academic staff evaluating content and checking student metadata. If the content is applicable for uploading to the digital library it can be flagged and metadata added (additional keywords, educational context information). Any information identifying students by name can be removed at this stage (data protection). The third stage involves a Librarian/Information specialist checking content for legality, etc. and applying final stage metadata (rights information, additional keywords). At this stage content is officially uploaded into the digital library and will be available for other students and staff to use.
- Dublin core metadata standards were identified as the best choice for both repositories with additional fields as required by the project. Recording educational contexts and of use of content has emerged as an important need. This takes the form of an Amazon type feature where academic staff can record how they used a resource. This allows multiple types of use to be recorded and accessed by other staff.
- The 'INSPEC' Thesaurus was identified to provide a controlled vocabulary for keywords. Selected terms are available to students and staff as a drop down list. The full thesaurus is available to academic staff and the Librarian/Information Specialist in the second and third stages of the workflow process.

The SMETE and Informedia based digital library usage scenarios were refined based on initial experimental findings at Stanford. Students at Stanford are now required to document critical aspects of their designs by producing short video clips and submitting them to the class Informedia archive. A new visual summarization method was developed by Stanford to make navigating the video library easier.

Library Development and Implementation

Following review of existing products and technologies, and development of a formal specification, a decision was made that the existing 'TikiWiki' open source groupware product was best suited to the project's requirements, but that it would need to be extensively customised for use in teaching and learning. At this stage in the project, a courseware developer was recruited to take on this work. The new system developed from TikiWiki was eventually named 'LauLima' which is Polynesian for 'Group of people working together.' This new name distinguished LauLima from TikiWiki and acknowledged the range of new features including those added by the DIDET Courseware Developer. In summary these features initially included

- An extensive permissions system to facilitate the sharing of folders and files with individuals and/or groups.
- Integration with the central university login system to negate the need for an additional user name and password.
- Hierarchical file structures for file storage to enable students to organise and manage their information as they upload it to the repository.

As per the specification, two related repositories were implemented. The **LauLima Learning Environment (LLE)** comprising the student-shared workspace where academic staff and students working on projects upload content to share with group members and other teams. This is the area where student content, resource management and use is being evaluated, including the impact on the student's learning experience. Only a small proportion of the student-created LLE content is appropriate for reuse by staff and students, necessitating the need for a second repository – the **LauLima Digital Library (LDL)**. This is a managed repository containing resources which have been evaluated and validated, with a focus on student-created resources. See Figure Two: LauLima System Architecture for a representation of the two related repositories that make up the LauLima System.ⁱⁱ

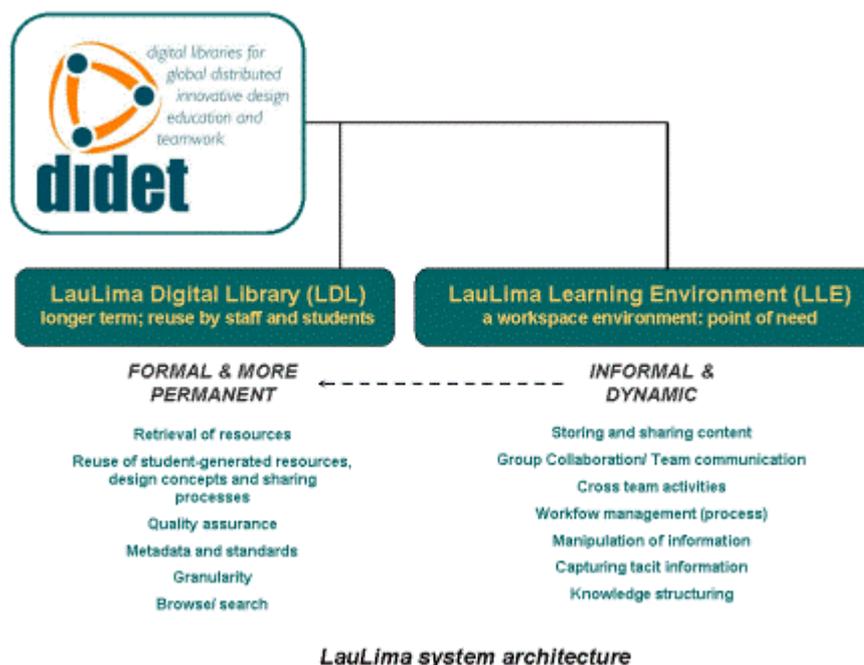


Figure Two: LauLima System Architecture

One key implementation was not simply the system itself, but a corresponding workflow for uploading content to the system and applying appropriate metadata. When students and academic staff upload content into the LLE some of the metadata is applied automatically by the system (file type, date added, depositor name and team). At this stage additional metadata is then applied by the depositor (title, format, source, citation, keywords). The second stage of the process involves academic staff evaluating content and checking student metadata. If the content is applicable for uploading to the LDL it is flagged and metadata added (additional keywords, educational context information). Any information identifying students by name is removed at this stage (data protection). The third stage involves an Information specialist checking content for appropriateness, quality and legality, and applying final stage metadata (rights information, additional keywords). At this stage content is officially uploaded into the LDL and is made available for other students and staff to use.

Referring back to the project background and Eris and Leifer's 'Design Knowledge Framework', this was evolved to reflect how the LauLima system interacts with the 3 learning loops as shown in Figure Three.ⁱⁱⁱ

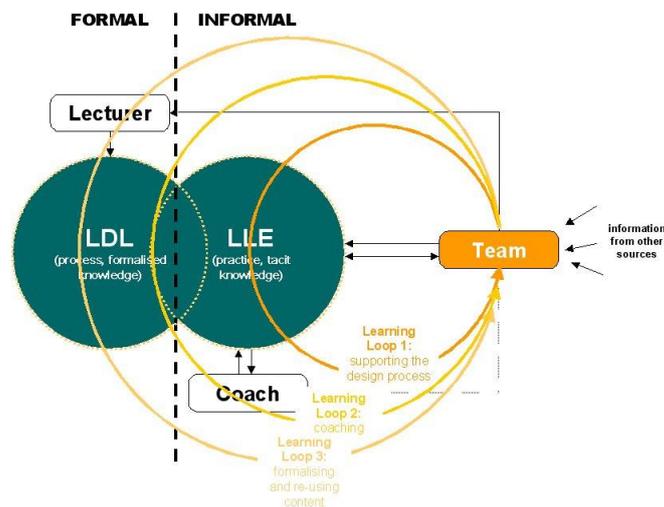


Figure Three: Adapted Design Knowledge Framework

The LauLima Learning environment (LLE) is a dynamic shared workspace designed to support collaborative learning during product design as shown in Learning Loop 1 in Figure Three. The LLE is focused on DMEM students working in teams on design projects and creating, storing, accessing, managing and sharing digital content rather than accessing content supplied by teaching staff. The LLE has a file storage area and allows the creation of dynamic wiki pages with which student teams can map their design process from beginning to end. The LLE offers great flexibility during group working as students can access and manage resources online at any time from any location and can collaboratively manage their learning and workflow.

Learning Loop 2 illustrates how student teams are supported by a 'coach' who guides and facilitates their design processes. The coaching process involves interactions with both the LLE and LauLima Digital Library (LDL) components of the system.

The LDL, in contrast to the LLE, is a formal and more permanent repository where resources relating to Design Engineering education are built up over time to be reused as depicted by Learning Loop 3. Externally created resources or references to them can be stored in the LDL, however an important focus of the DIDET project is that *student-created* resources are stored for reuse by future students and staff in the department. Staff and students in the department can browse or search the LDL, making use of the rich metadata to retrieve quality resources relating to Design Engineering in general or relating to a specific class or project.

Although the LLE and the LDL components can be considered discrete elements of LauLima, they are designed to be interdependent and the workflow procedure inter-links them. Staff in the academic department harvest the most useful resources from students' LLE workspaces and submit these for inclusion in the LDL: 'usefulness' in this context refers to 'potential for reuse'. This selection is subject to a final approval stage where an information specialist checks the resources for quality and legality and adds additional metadata. In turn, resources also move from the LDL to the LLE when students retrieve them to inform their design projects. This creates a workflow 'loop' of creation, use, storage and reuse.

The LLE provides an additional layer of support as a communication tool and can be used by the coaches of student teams to monitor work on an ongoing basis; providing support and advice throughout the lifecycle of the project and not only at the final assessment stage. The LLE is also used by staff to distribute class materials and information.

It should be noted that in light of DMEM's commitment to using LauLima for teaching and learning on an ongoing basis, features are continually added and improvements made based on ongoing user feedback and requests. To date, these include the following.

- Drag and drop facility for uploading files.
- Drag and drop facility for embedding images in wiki web pages.
- Functionality to upload files directly into wiki pages being edited rather than uploading separately and having to reference files in the page.

Student use of Library

Initial stages of student use involved several small studio-based experiments being carried out by students in order to examine how they stored, shared and used information in team design projects. One such exercise involved students designing a gear mechanism using the digital library to store and share resources. The project has published outputs from these experiments, ^{iv} such as the 'paper bike' exercise where teams at Strathclyde and Stanford designed and made bicycles made from paper products. Evaluation involved testing and racing the design outputs at each site. Initial use in the classroom involved 15 four-person student teams being observed conducting the design and prototyping of a "Can Crusher" exercise in the 3rd year BEng/MEng module *56314 Integrated Design Project* during Semester 1 (2003/04). The TikiWiki system being used was modified and a new site created to enable individual and team access to the "Bread Maker" exercise on the 3rd year BEng/MEng module *56314 Integrated Design Project* during Semester 2 (2003/04).

A further TikiWiki site was created for the team based design projects conducted in the 4th and 5th year of the Strathclyde undergraduate courses (*56409 Product Development Project 1*, *56502 Product Development Project 2*, *81507 Design Practice*, *81423 Product Design 3*). This site was not used as extensively as the site developed for the Can Crusher and Bread Maker exercises.

Stanford's approach complemented this through the exploration of two digital library technologies; the **Informedia** video processing software and the **SMETE** library. Informedia was used to index and retrieve design team interactions that have been captured in video since video is an effective medium for the capture of tacit knowledge such as design rationale. Audiovisual data is inherently "richer" than traditional text data. In conjunction, SMETE was used to index and retrieve design documents since text-based design documents are effective in capturing formal design knowledge such as product representations and specifications.

Strathclyde continued investigating student use in 2004/2005 with 20 four-person student teams being observed conducting the design and prototype of an "Ice Crusher" exercise in the 3rd year BEng/MEng module *56314 Integrated Design Project* during Semester 1 (2004/05). This followed from the lessons learnt in the "Can Crusher" exercise conducted in the same module in 2003/04.

LauLima was again used for the team based design projects conducted in the 4th and 5th year of the Strathclyde undergraduate courses (*56409 Project Development Project 1*, *56502 Product Development Project 2*, *81507 Design Practice*, *81423 Product Design 3*).

The LauLima system was used in different ways for different classes; for example, it was used as a tool for the management of resources in the IDP class and more as a project management tool for PDP.

By the end of 2005, teaching staff began to demonstrate the browse and search facilities to students in relevant classes and the number of resources in the LDL was greater than 500. Staff were cautious not to promote the use of the LDL to students until there was a sufficient number of useful resources to be retrieved. In addition, a set of guidelines to aid staff selecting and uploading resources to the LDL as it was concluded that having items rejected could be a disincentive to use.

One major issue in using LauLima was the conflict between student creativity and compliance with copyright law, and the system was actually seen as stifling the design process in the early stages of use. One common process when tasked with a design brief is to review existing products. Students

traditionally often made up 'story boards' by cutting out images from paper media. Replicating this process on LauLima meant that students would be breaching Copyright by taking electronic copies from external websites. In consultation with the JISC Legal service,¹ the team investigated Copyright exemptions for educational assessment. This was not seen as a 'quick fix' however, and Information Literacy is still embedded in the curriculum to teach students about Copyright and adequate referencing.

It should be noted that the first three stages of this implementation, i.e. Library Specification, Library Development and Implementation and Student Use of Library, were iterative, with several versions of the 'DIDET Library' being specified, developed, implemented, used, evaluated then being re-specified and redeveloped based on evaluation results and feedback. As this iterative process continued, changes were more in the form of extra and refined features rather than fundamental shifts in approach. Software enhancements were frozen for the duration of a class or experiment and then modifications made in the light of new knowledge gained in the class or experiment.

When the software had reached this more mature stage, it was rolled out to several different users for a variety of applications. Some of these use cases were very informal, such as a group of students wishing to use the system for collaborative work in their own areas of interest, and others were more formal, such as the system being used for other applications. Five case studies were developed to demonstrate the range of uses of the LauLima system, or selected elements of it, and cover the use of LauLima for teaching and learning, to support research and for other information systems.^v LauLima was then made available for download from the DIDET Project website as an open source product with associated help and user forums.

Global Team Design Project

Several experiments were carried out before planning and implementing the Global Team Design Project. This was done to streamline the pedagogical approach, but also as a test run to uncover any technical issues that would have to be overcome. The initial stages of experimentation involved developing scenarios for using the DIDET library in classes. These were based on a project at Stanford, 'The Paper Bike Design Challenge' whereby teams of students have to specify, design, build and race a bicycle made solely from paper products.

By the end of May 2005 Stanford and Strathclyde had developed and conducted a short collaborative global design experiment. The experiment was designed to examine the technical set-up and observe subject behaviour during the collaborative design of a paper can crusher from distributed locations (Stanford and Strathclyde). Subjects had access to the LauLima Learning Environment (LLE) and LauLima Digital Library (LDL) containing some of Strathclyde's previous can crusher and ice crusher material, and the SMETE Digital Library containing some video clips of Stanford's paper bike exercise. It was intended to be a connectivity test not a test on the content of the digital libraries. It was a multi-day exercise (2 days plus presentation) involving two students on each side who played the role of test pilots and was run to completion. Evaluation included subject observation and a debriefing session involving students, staff and researchers. Figure Four shows how the institutions worked towards the collaborative Global Team Design Project together, leading complementary activities to work towards the common project goal.

¹ www.jisclegal.ac.uk

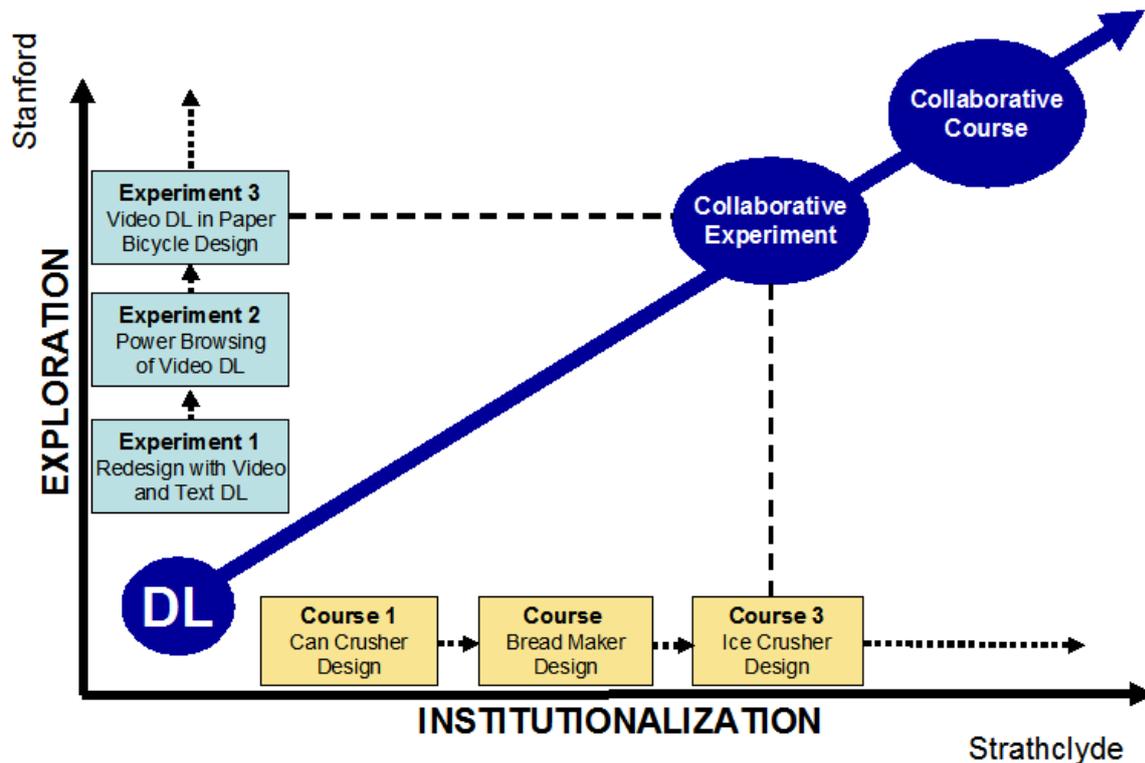


Figure Four: Working Towards the Collaborative Global Team Design Project

Development of this Global Team Design Project was greatly helped by a face-to-face meeting of the project partners in February 2006 at Olin College. Further progress was made by working together online and by videoconference. The project was developed as part of new classes at Strathclyde and Olin and an existing class at Stanford. Class descriptions were developed for all 3 institutions to confirm compatibility.

The project was an integral part of Strathclyde’s new ‘Global Design’ class which was launched at the start of academic year 2006/2007. The class educational aims, learning outcomes, syllabus and assessment methods and criteria had to be approved by committee at Strathclyde. The Global Design Team Project was part of the following classes.

- University of Strathclyde – *56521 Global Design* – a new optional class for 5th year undergraduate students
- Stanford University – *ME397 Design Theory and Methodology - Distributed Design with Digital Libraries* – an existing class for students at Stanford’s Center for Design Research
- Olin College – *2260 Distributed Engineering Design* – a new optional class for undergraduate students

Following discussion and development work between all three sites, a design brief for the student project was developed. Student teams were tasked with designing a coffee cup holder. Strathclyde set a timetable for the class and drafted a week by week class plan. This weekly class plan included details of the weekly lecture topic, suitable case studies and resources to relate to it, a tutorial exercise for students and any deliverables that the students must develop.

The New DMEM Digital Design Laboratory was used for the Global Design class at Strathclyde. The LDL was configured to allow both Stanford and Strathclyde their own digital libraries in LauLima, but to allow each of the three sites access to the resources within both. As reported during the project, this was devised in order to overcome the fact that information law is very different for the USA and the UK so rather than compromise procedures for all sites, we are able to work within our own respective legal frameworks.

Teaching and Learning

The focus of the new Global Design class at Strathclyde is the nature and management of distributed design, and the technology used to support global design activity. Students put the theory learned into practice by working in globally distributed design teams as part of the class. The Global Design class was run in 2006/2007 for the first time over the first 8 weeks of the first semester. The collaborative Global Team Design Project was a three-week element in the middle of this class run in conjunction with Stanford and Olin, whereby teams made up of both USA and UK students worked together on a design project. Each student team was given the same design brief to design a coffee cup holder. The teams were expected to explore the issues related to this task that would apply in both the USA and the UK to develop a design solution to carry multiple coffee cups effectively and safely.

We used a framework suggested by Ozgur Eris at Olin to explore the theory of the class. Students and staff placed key points from literature into the framework matrix, classing them as relating to Social, Emotional, Cognitive or Technical and as relating to Co-located or Distributed teamwork.

Format

Global Design classes at Strathclyde were held in DMEM's new Digital Design Laboratory. The class format was a short lecture followed by case studies (some by visiting lecturers) and then tutorial tasks – all relating to the weekly topic. A further tutorial was held later in the week. The class timetable for the three collaborating classes at Strathclyde, Stanford and Olin is shown below in Figure Five.

Time at Stanford	Time at Olin	Time at Strathclyde	Monday	Wednesday
.
0600-0900	0900-1200	1400-1700	Strathclyde Class	-
.
0930-1130	1230-1430	1730-1930	Olin Class	-
.
0200-0300	0500-0600	1000-1100	-	Strathclyde Class
.
1515-1705	2015-2205	2315-0105	-	Stanford Class

Figure Five: Class Timetables

DMEM's Digital Design lab is a flexible working space which has a large screen and projector in a presentation area, also equipped with a PolyCom videoconference unit. There are individual PCs with digital camera software for desktop videoconferencing and tables and chairs which can be configured as required in 'break out' areas.

There were 16 students participating in the class at Strathclyde, 7 at Olin (due to one student dropping the class) and 7 at Stanford. This made 6 teams, each team was assigned a UK and USA coach, both of whom could be contacted by any member of the team, regardless of location.

It had been agreed that teams would be formed at the very beginning of the semester even though the Global Team Design Project did not start for a number of weeks. This was to give the students time to get to know one another and for co-located team members at Strathclyde to work together on tutorial tasks. Stanford's culture, however, means that students have much longer than those at Strathclyde and Olin to make a final decision on which classes they are taking and it is common for students to 'shop around' until the deadline in October. It therefore took a couple of weeks to finalise team formations. Stanford were pro-active in encouraging their students to make a final decision on this particular class before their deadline. Stanford formed the teams using placement questionnaires to achieve maximum diversity which has been shown to give better team performance. The Strathclyde students were receptive to this method.

Collaboration

Strathclyde, Stanford and Olin used the development space on LauLima to share plans for their individual classes and the collaborative Global Team Design Project. Coaches also used LauLima to collate feedback before sending to student teams after each milestone deliverable was submitted. All institutions shared teaching and class plans before and during the first semester. Although there were some issues with collaborating institutions due to differing cultures and methods of teaching and learning, the Global Team Design Project was successful, particularly for the first year of implementation.

Technology, including LauLima

The global design teams were expected to use a range of technologies to support their collaborative work. Although we provided certain tools such as LauLima, they were free to explore new tools or use others that they were already familiar with. As outlined earlier, the LDL was configured to allow both Stanford and Strathclyde their own digital libraries in LauLima, but to allow each of the three sites access to the resources within both.

All students participating in the class signed up to LauLima and teams were encouraged to create a homepage using the wiki technology.

Students teams at Strathclyde were able to sign out a web camera to allow them to desktop videoconference; Strathclyde staff had sought permission from the Open University to use the online FlashMeeting² service for the duration of the project. Strathclyde students could also book the PolyCom Videoconference equipment which we temporarily based in a spare office for their use. We provided out of access permission cards for students so that they could work in the university outwith normal office hours.

We were not able to use Informedia as remote web access was too problematic. Our USA partners found it difficult to access video resources on LauLima due to the speed when downloading large files, therefore we used YouTube in conjunction with LauLima whereby videos could be embedded within LauLima pages.

We compiled a list of tools useful for the class and students working in teams used a range of additional tools and services to carry out their collaborative work. The tools used as part of the Global Design class included the following.

- LauLima: Learning Environment and Digital Library
- External file sharing tools such as YouTube.³
- Messaging tools such as MSN Messenger⁴ and Campfire⁵ real time group chat tool
- Google Documents
- Thinkature real time collaboration tool⁶
- Other wiki systems
- FlashMeeting online desktop videoconferencing service

After the success of the new Global Design class at Strathclyde, DMEM was committed to offering the class on an annual basis. The DIDET Project partners reviewed the previous year's reflection (by both staff and students) and concluded that in many ways the Olin class was more aligned with Strathclyde's than Stanford's was.

There were many cultural issues experienced during the Global Team Design Project – by the students participating and by the staff running it. Students found difficulties where they were being assessed differently at different sites, therefore had different priorities when conducting the project work. This was an issue as Stanford's students were postgraduates and Strathclyde and Olin

² www.flashmeeting.com

³ www.youtube.com

⁴ www.msn.co.uk

⁵ <http://www.campfirenow.com/>

⁶ <http://thinkature.com/>

students were undergraduates. The DIDET Project team worked on resolving some of these issues, however with the understanding that these national, ethnic, generational, methodological and philosophical differences, although often requiring additional management, are also benefits of global working. The whole purpose of the DIDET project was that students are able to directly experience global working and learn about tools, technology and methods to effectively manage global design to realise the benefits.

Some of the more operational issues did have to be addressed, for example managing the project work differently in the second year so that teams did not have to be in place for more than a week at a time – this allowed us to continue to work with Stanford who have a ‘seminar’ based class where students may choose not to continue even after a few weeks therefore team continuity cannot be guaranteed for longer periods. The teaching team were also more conscious of the time difference and working patterns when setting submission dates and times. Strathclyde students are also very wary of being used as ‘research subjects’ while attending classes and we have been careful to brief students on any outputs that we may examine for research purposes.

In practice, unfortunately Olin was unable to collaborate again in 2007/2008 due to staff illness. Strathclyde investigated the possibility of a new Postgraduate class with which to collaborate with Stanford on a new project, however this was not deemed a suitable option. The undergraduate class was still in its infancy and required effort to make it successful again in 2007/2008.

Following more development work on the Global Design class, Strathclyde proceeded in 2007/2008 with Stanford as a partner, but using a ‘task-based’ approach whereby students undertook weekly global design tasks with different global partners over 3 separate weeks, rather than one 3-week long project. Stanford were one of three partners for the Global Design class in its second year, the University of Malta and Swinburne University in Australia were the other two.

The format of the Global Design class in 2007/2008 was as follows.

- Week 2 Introductory Lecture
- Week 3 Management Lecture
- Week 4 Asynchronous Exercise with Swinburne University, Australia
- Week 5 Asynchronous Reflection on Exercise with Swinburne University, Australia
- Week 6 and Week 7 Global Digital Libraries Exercise and Reflection with Stanford University, California
- Week 7 Stanford Reflection/ Assessment Lecture
- Week 8 Technology Lecture
- Week 8 and 9 Introduction to the University of Malta and Synchronous Exercise with the University of Malta
- Week 9 and 10 Synchronous Reflection on Exercise with University of Malta

This task-based approach was much more successful for Strathclyde, it mitigated the risk of not finding a suitable global partner for a 3 week project and also made the student activities more tightly focused. Students were encouraged to reflect on various aspects of the different design tasks, comparing and contrasting different cultures, technologies and methods of communication. They were able to directly experience and compare synchronous and asynchronous working and relate the theory of the lectures to the case studies given in class, furthermore comparing the theory to their own practice in real global design teams. This task-based approach will be employed again by Strathclyde for 2008/2009 and beyond.

Evaluation

Evaluation, as planned, was both formative, to improve the project and inform the development of the infrastructure as it is progressing, and summative to determine the overall success of the project on a year-on-year basis. The project has regularly published and presented evaluation findings^{vi} and has continually used them to improve development and teaching practice.

A range of qualitative and quantitative evaluation methodologies were used at Strathclyde, for example observation, questionnaires, reflective blogs, examination of student material, student and

staff de-briefing sessions and student team interviews. Evaluation was carried out during experimental activities and during 3rd, 4th and 5th year classes, including the new Global Design class at Strathclyde where student and staff feedback from all global team members was sought.

Key to the research philosophy of DIDET is the interpretivist paradigm to provide insight and a deeper understanding of design information processes and experiences.^{vii} The majority of the studies were of an empirical nature, i.e. based on observation and experiment, within the classroom setting. Studies of this kind have gained more importance and are becoming more commonly used in engineering design research since engineering design research has widened its view from prescribing to describing design activities.^{viii}

Both quantitative and qualitative methods were used to evaluate studies in the different classes and the global design projects on the DIDET project. For example in the Integrating Design Project Class (where the focus was on information use and interaction; storing and sharing; and the use of digital libraries), and in the Product Development Partnership Class (where the focus was on project and team management through the use of technologies), quantitative methods such as surveying class opinion via questionnaires and polls; and weekly analysis of file galleries, wiki pages, internal email, blogs, templates, discussion forums in student shared workspaces, were undertaken. The need for a rich and detailed understanding of how and why various phenomenon occurred, and how processes might be improved through change, also necessitated a greater use of qualitative methods, for example, observation; reaction cards, interviews, reflective sessions, focus groups and examination of student reflective reports.

Prior to Global Design Classes a number of short global experiments were carried out using volunteers, e.g. paper bike experiment, to establish the logistics of running such classes and gain feedback on the use of digital libraries. These were assessed via a participant questionnaire and a reflective focus group. The Global Design Project, designed and offered at the University of Strathclyde, University of Stanford, CA. and Olin College, MA. in 2006 and the more recent global design tasks between the University of Strathclyde and the University of Stanford, CA., University of Swinburne and the University of Malta; were evaluated through shared student and staff reflective sessions at the end of the class and analysis of shared workspace and data logs.

Evaluation Class Studies

One of the primary goals of the DIDET Project was to integrate digital repositories into the classroom by integrating resource creation and reuse into class activities, thereby providing opportunities for students to improve information literacy skills and develop team-based design process skills.

Evaluation has taken place in 3 classes in DMEM and each class has had a particular evaluation focus at different stages in the project. The Integrating Design project evaluation focused on the use of information storing and sharing and latterly on the use of digital libraries within this class; the Product Development Project Class focused on gathering students' feedback on the use of LauLima to support project management and reflection in industry related team projects; and, the Global Design evaluation focuses on the logistics of running a distributed class - the teaching and learning; collaboration; technologies; all in the context of global product development. Evaluation also includes an in-depth study into the use of digital libraries by Stanford University.

Full details of evaluation and key findings for each class is linked from the project website.^{ix}

Outputs and Results

The global DIDET Project agreed the main outputs from the 5-year project as follows. All of these are linked on the DIDET Project website at www.didet.ac.uk

- 7 Journal articles
- Over 30 Conference presentations (and papers)
- 2 magazine articles
- A large number of other presentations
- 5 case studies showing a range of uses of the LauLima system

- The LauLima system as described in the 'Implementation' Section
- Supporting documentation for LauLima
- LauLima workflow model
- Coaching/Teaching and Learning Model; the Design Knowledge Framework and the evolved 'DIDET version' of this
- The DIDET Project framework
- Guidelines for global design (being developed)
- Programme DVD
- Digital Libraries in Design Engineering video (to be developed at Stanford)
- Website
- Extensive evaluation outputs
- Use case (in conjunction with the CD-LOR project)
- Workshops, those delivered and possible future workshops
- People! Stakeholders have benefited, for example by developing enhanced skills

Outcomes

The team reviewed all of the original project objectives and reflected on how these have been achieved and how the project outcomes related to these. The terminology used relates to NSF reporting, which requires a description of the major research and educational activities of the project, i.e. the 'Activities' undertaken to achieve the project goals and objectives – the 'Aims'. 'Project Findings' then explain what has been concluded, 'Publications and Products' resulting must be listed, as well as 'Contributions', and any 'Special Requirements'.

At the DIDET global team meeting in January 2008, the agreed project outcomes were framed in terms of the 6 original project 'Aims', each with each with corresponding 'Activities', 'Findings' and 'Contributions'. A 7th and final 'Aim' was added to reflect on any new aims and unexpected findings.

AIM 1: Teach information retrieval, manipulation and archiving skills to engineering students

ACTIVITIES:

- 1 IDP class teaching model at Strathclyde and embedded information literacy education
- 2 New global design class at Strathclyde with Strathclyde, Stanford and Olin projects
- 3 PDP class – information management training/practice introduced as part of class at Strathclyde
- 4 Development of LauLima system
- 5 Repository of learning resources

FINDINGS/REFLECTION:

- 1 Students do not learn information literacy skills without coaching
- 2 Staff have to learn these in order to teach them! (information specialist hands over to engineering staff when skills acquired)
- 3 Teach use of 'information repositories' rather than 'digital libraries', also teach development and use. They require contributions – learn how to contribute, essential for knowledge management.
- 4 Teach these skills in context of design rather than individually
- 5 Students learn from building their own repositories
- 6 Finding information is part of design throughout process

CONTRIBUTIONS:

- 1 Knowledge – coaching model (mediation framework)
- 2 Embedding as part of class
- 3 Transfer/adoption by other classes - influence on department, university, wider community
- 4 Distributed collaboration class for conceptual design
- 5 Reflective (task-based approach) to learning in design project classes
- 6 LauLima system – see case studies to illustrate different uses

AIM 2: Measure the use of those skills in design projects in all years of UG degree programs

ACTIVITIES:

1 Year on year evaluation of IDP, PDP, Global Design classes (not all years) at Strathclyde

FINDINGS/REFLECTION:

1 Skills should be measured as part of class assessment

2 Creating project repositories helps students develop an understanding/overview of design problem

CONTRIBUTIONS:

1 Preparation for industry

2 Wikis providing integrated project and information management

AIM 3: Measure learning performance in engineering design courses affected by the provision of new types of information

ACTIVITIES:

1 Experimental observations: year on year evaluation of IDP, PDP, Global Design classes (not all years)

2 reflective activities

FINDINGS/REFLECTION:

1 Different types of media (text, video, images, etc.) have different affordances for student learning. (experiments in design lab)

2 Different media types affect idea transfer and idea generation/propagation

3 Information management and project management closely related for team situation

4 Reuse of student generated content is sustainable and adds value

CONTRIBUTIONS:

1 Framework for use of DLs in classroom (triple loop)

2 Framework for developing scenarios of use for DLs in classroom

3 Design information retrieval measurement system

AIM 4: Measure student learning performance in different cultural contexts that influence the use of alternative sources and forms of information and communications technologies

ACTIVITIES:

1 Global Design class at Strathclyde (and projects at Stanford and Olin) and evaluation work on this

FINDINGS/REFLECTION:

1 Dimensions of uncertainty and ambiguity can be used to characterise cultural differences

2 Discipline is as big a barrier as location and must be considered in repository structure/design (repository – adaptive service - user)

3 Differences in teaching practices is good

CONTRIBUTIONS:

1 Framework (should address cultural context)

AIM 5: Develop and provide workshops for staff development

ACTIVITIES:

1 Online content – tutorials, videos, forums

2 DMEM adoption of LauLima DL

3 DMEM adoption of LauLima for departmental Academic information system

4 Higher Education Academy workshops on global design (UK based)

FINDINGS/REFLECTION:

1 Classroom was used to develop methods for distributed VC

CONTRIBUTIONS:

1 Coaching workshop for ME310 class done on annual basis – cultural coaching to help

understanding between different cultures.

2 Best practice model for distributed teamwork (Peter Ball MOM journal paper)

AIM 6: Use the measurement results to annually redesign course content and the digital libraries technology

ACTIVITIES:

1 Ongoing development of LauLima and classroom model on an annual basis based on reflection and evaluation

2 Ongoing new module development (i.e. classes used as experiments are spawning new classes, courses and activities)

FINDINGS/REFLECTION:

1 Assess impact of technology on course content

CONTRIBUTIONS:

1 evaluation and record of use in classes -->reflect --> 'redesign' class

AIM 7: Any new or unexpected aims not specified at the beginning of the project

ACTIVITIES:

1 Exploratory study of ways in which design learning from video resources is affected by playback speed of the video

2 Exploratory study of the effects of sharing unedited short video clips of design ideas between members of a geographically distributed team

FINDINGS/REFLECTION

1 Speed is good

2 Immediate adoption of service

3 Effect in speed of understanding of previous design

CONTRIBUTIONS

1 Power browser

2 Video information block (for sharing information quickly – in quick bursts)

3 Video metadata

During the last year, the project team has been working on developing the 'DIDET Project Framework' to encapsulate all of our findings relating to the use of digital libraries in collaborative design education. The project began using Eris and Leifer's 2003 'Design Knowledge Framework' ^x which was developed throughout the project and evolved to an adapted version representing how the three 'learning loops' relate to the supporting technology. ^{xi} The team collated all work on this framework at the final global project meeting and agreed a draft which is shown in Figure Six. The team intends to further develop this framework and use it for future dissemination and development of guidelines for other teaching and learning ventures relating to global design.

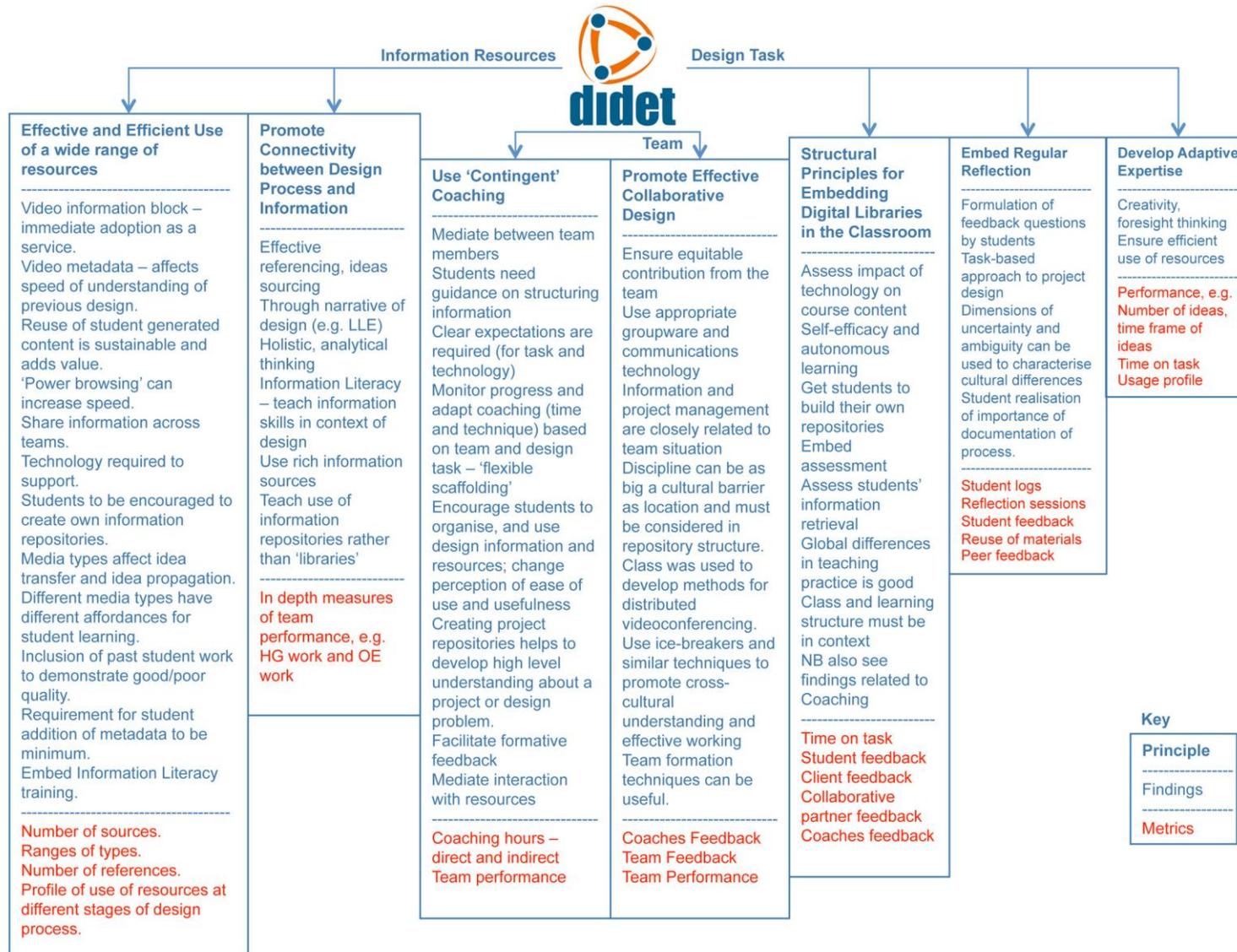


Figure Six: DIDET Project Framework

Conclusions

This section outlines the project conclusions in terms of technology, pedagogy and culture and has been adapted from a DIDET journal paper on embedding elearning.^{xii}

Technology

- Technology introduced requires adequate technical support and staff training on an appropriate scale; departmental, faculty, institution, etc.
- Integration with existing and new systems may be required, interoperability may also be an issue – can system reuse existing resources from other systems? Is an archiving system in place for content?
- There must be sufficient availability of hardware and peripheral resources and services for the benefits of a system to be maximised, in the case of DIDET this meant scanners, digital cameras, etc. to capture design material.

Pedagogy

- Despite potential benefits of introducing new technology, it has been shown that such innovation must be led by the pedagogy.^{xiii xiv} In the case of DIDET, the discipline itself was a factor; the unique requirements of Design Engineering led to the development of the digital library system which allows even tacit design knowledge to be created, captured, stored, shared and reused. The use of LauLima was embedded into the curriculum of classes in which it was used.
- The requirement for Information Literacy education in conjunction with elearning projects such as DIDET is very apparent. This was developed initially by an Information Specialist and is being handed over to DMEM staff who now have sufficient experience. There is a strong argument that all staff should now have these skills.
- Evaluation is required on an ongoing basis to inform ongoing project activity and development. This allows regular improvements in teaching and learning and associated systems to be made.
- Quantity and quality of resources. Having a sufficient number of high quality resources is critical to the uptake of use of a digital library. Student questionnaires were issued regularly to examine use of LauLima along with system use logs. The LauLima workflow introduced by the then Project Manager has ensured a high standard of quality of resources and their metadata. Refer back to Information Literacy training which should encourage both staff and students to maintain high quality standards when uploading resources and adding their own metadata.
- Time and resource is a major issue for ongoing population of any digital library. DMEM is currently examining the workflow to investigate if it can be streamlined.

Cultural Issues

- Time to effect change – true embedding of pedagogical change was enabled by the 5-year length of the DIDET Project.
- Senior buy-in is required to implement major changes such as those in DIDET. Not only to help ensure commitment to make change, but to ensure that required support is in place. We would have been able to run global exercises at Strathclyde, but to actually implement major change, i.e. commit to running a new annual Global Design class, those with authority to make those decisions had to be on board. Although many changes can be effected from the 'bottom up', buy in at other levels may still be required to ensure that sufficient support is in place to *embed* and *sustain* transformational change.
- A cross discipline team can provide the range of skills required, however human factors can become an issue and strong leadership is required. "While challenges relating to technologies can often become the focus of attention for elearning projects, it is the attention to human factors that moved the DIDET Project forward"^{xv}
- DIDET adopted a 'course team approach' whereby all of the core project team were involved in team coaching. This gave those not traditionally involved in classroom a greater understanding of how the pedagogy and technology was applied.

- Uptake and acceptance of new methods and technologies can be difficult to encourage, with staff and students. In global projects, each site tends to favour their own chosen or developed technologies, for cultural and practical reasons, e.g. familiarity and availability of support. Stanford's evaluation from the 2007/2008 Global Team Design Project showed that the Strathclyde and Stanford students favoured LauLima and SMETE respectively. Regular use must be encouraged for users to gain familiarity.
- The experience of DIDET has shown that there are many cultural issues, not only with location, but also with academic discipline; the undergraduate and postgraduate students worked in very different ways, as did engineers with different backgrounds, for example those with backgrounds in Mechanical Engineering often approached work differently from those with backgrounds in Design Engineering – this was highlighted by both staff and students during reflection. Different methods can be used to overcome cultural issues for team work, including ice breaker exercises and effective project management.

Implications

Through very wide dissemination, the findings from the DIDET Project have been propagated to professionals in the fields of Pedagogy, Design Engineering, Engineering Education and Educational Technology. Having presented and published findings related to Global Design, the team also intends to develop guidelines for those institutions who may wish to implement similar projects or classes. During the experiments and also when running the new Global Design class at Strathclyde, it became apparent that the logistics of co-ordinating global activities would be much more complicated and time consuming than first expected. As expected, these logistical issues became easier to deal with year-on-year as staff became more experienced and processes became more streamlined. The Global Team Design Project also changed in format based on experience and was run in its second year using a 'task-based approach'.^{xvi}

The team feels that there would be value in further exploring potential enhancement in coaching models and perhaps exploring global coaching models where the staff-student relationship is distributed.

More research and evaluation could be carried out related to system use, for example investigating its use relating to assessment and assessment of global team work. One major finding of the DIDET Project's work on the reuse of student created resources was that students are keen to view previous work in the context of assessment. Already, the project evolved to allow for this, and the 'Educational Context' field of each resource in the LauLima Digital Library gives information on why a particular resource is useful. Regarding assessment, the resource could be an exemplar, or the metadata could explain weaknesses which could be improved. While students would always be encouraged to maximise their learning, not only focussing on assessment, there is potential for students and student teams being able to 'self assess' by using available resources in the digital library with a range of marks, and judging where their own project outputs 'fit in'.

During the 5 years of the DIDET Project technology and its availability has moved on. The wiki technology adopted was emerging at that time and is now fairly well established, even in teaching and learning contexts. There may be potential in exploring new emerging technologies and their potential for use in the classroom.

The Final Say

As with all classes at the University of Strathclyde, each module ends with a feedback form being distributed to students. Staff in DMEM have taken on board many suggestions and other comments from students in order to improve classes. There were suggestions on improving the Global Design class and some comments reflective of resistance to using new tools, however most of the feedback was positive. Final reflection on the DIDET Project are positive comments from the students themselves who participated in Global Design in both 2006/2007 and 2007/2008...

(On the LauLima system) “In design projects things get said or written that are never given to other people and sometimes that’s a **major** part of the project. Things that you do, quick sketches that only you see, can often be lost... Having a place where you can keep all the information – make sure everything gets **shared** – is very important.”

“Fun, small class, use of technology seemed more like **real life scenario** than typical uni.”

“I especially enjoyed getting to **contact other unis.**”

“Using LauLima as our storage/hand-in base really helped **get things done**”

“...**ace for interviews** to say I’ve worked in **distributed teams**”

“**Great class**, a joy to attend, like the focus”

“Really enjoyable. **Best class in years**, maybe ever. Good that it was **process focused**, not project based”

Please also refer to the DIDET Project video for a short overview of the project which features student interviews:

<http://www.jisc.ac.uk/media/avfiles/programmes/dlitc/didet.wmv>

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