Section Two

1. Project Outcomes

The project is progressing as planned. Initial findings will be published widely in the next reporting period (see Section 4).

Four key findings are:

- The application of a shared workspace/digital repository (in this study 'TikiWiki') positively influenced the way students used information to develop engineering design concepts and the quality of those concepts.
- Encouraging students to organise design information and resources using inter-linked Wiki-pages (like web pages) helped support the access and sharing of these resources across design teams.
- More work is needed to help prepare students to use metadata (e.g. keywords and descriptions) for cataloguing and searching resources. Academic staff need to work with librarians to formulate an agreed (and controlled) keyword vocabulary and students need more training in how to select keywords and formulate resource descriptions.
- The resources sourced through nationally available digital repositories such as SMETE, NEEDS and EEVL were not found to be useful by engineering students conducting the can crusher project.

Design and implementation of current and future work-packages will attempt to address these problems.

The key objectives for the next planning period are:

- To develop materials to improve student information literacy skills.
- To update 2-3 classes at Strathclyde for next academic session to allow use of digital libraries and evaluation of their use.
- To begin to develop a joint Stanford/Strathclyde global design course.
- To update Tikiwiki to allow new functionality identified from year 1 as being desirable for good digital library access and design collaboration.
- To update the "digital library" by identifying and enabling access to digital resources, improving searching and browsing functionality and defining a controlled "search vocabulary".
- To develop a controlled experiment to monitor and evaluate student use of information resources when conducting design tasks.

2. Intellectual Property Rights

Currently there are no problems between the partners but a formal collaboration agreement has yet to be signed.

3. Evaluation

Evaluation is an ongoing element of the project (Work Package 12). Current progress is best shown through the paper *Structuring and Sharing Information Resources to support Concept Development and Design Learning* to be presented at the Networked Learning Conference in Lancaster, UK in April. The paper is attached as Appendix A.

4. Dissemination

No direct publicity during reporting period.

A project web-site exists at: http://dmem1.ds.strath.ac.uk/didet/ Lou McGill is currently leading the development of the website to include more publicly accessible information in time for the Times

Higher Article (below). This information will include copies of the final papers referred to in this section.

Strathclyde are currently talking with Times Higher Education Supplement regarding an article due to be published in the next 2 months.

Neal Juster (Strathclyde) will demonstrate the Informedia software and its use in the project at the JISC conference in Birmingham at the end of March.

The following papers have been written and will be presented in April. The first is attached as an Appendix A*:*

- *Structuring and Sharing Information Resources to support Concept Development and Design Learning*. Hilary Grierson, David Nicol, Allison Littlejohn and Andrew Wodehouse. Networked Learning Conference, April 2004.
- *The Impact Of Documentation And Reflection On Student Learning In Engineering Design,* Andrew Wodehouse, Hilary Grierson, Bill Ion, Neal Juster and Angela Stone. Europe-Asia Symposium on Advanced Engineering Design and Manufacture for Globalisation, Xian, China April 2004.
- *Educating The Global Designer*, Bill Ion, Andrew Wodehouse, Neal Juster, Hilary Grierson, and Angela Stone. Europe-Asia Symposium on Advanced Engineering Design and Manufacture for Globalisation, Xian, China April 2004.

The following paper has been submitted and is awaiting review:

- *Using Digital Libraries To Enhance Distributed Design Team Performance*, Neal Juster, Hilary Grierson, David Nicol, Bill Ion, Angela Stone and Andrew Wodehouse. ASME Design Engineering Technical Conferences, Salt Lake City, Utah, USA, September 2004

The following abstracts have been accepted, full papers are in preparation:

- *A Study of Student Learning in Design Projects,* W J Ion, A Stone, A Wodehouse, H Grierson, N Juster. IEPDE'04 Delft, September 2004.
- *TikiWiki: a tool to support engineering design students in concept generation,* Andrew Wodehouse, Hilary Grierson, Bill Ion, Neal Juster, Andrew Lynn, Angela Stone. IEPDE'04 Delft, September 2004
- *Supporting Student Learning through Use of a Digital Repository – the DIDET Project,* Hilary Grierson, Lou McGill, Allison Littlejohn, David Nicol. ALT-C Spring Conference

Plans are to continue publishing in conferences as results become available and to produce at least two good journal papers a year.

APPENDIX A

Structuring and Sharing Information Resources to support Concept Development and Design Learning

Hilary Grierson, David Nicol, Allison Littlejohn, Centre for Academic Practice**, Andrew Wodehouse,** Design Manufacturing & Engineering Management, University of Strathclyde, Glasgow.

1. ABSTRACT

This study investigates how a shared workspace and digital repository might help student teams share information and resources while learning to design. An open-source groupware product called TikiWiki was configured so that teams could structure their design resources using wiki pages (like web pages) and share them using two search strategies – browsing the wiki pages or using keywords. The results showed that the structuring of information supported learning and that teams preferred to search the wiki structures rather than use keywords. The discussion focuses on students' search strategies and ways that metadata that might improve resource sharing across teams.

Keywords

Digital repository, shared workspace, metadata, group learning, design education

2. INTRODUCTION

Research in networked learning has shown that groupware technology can support collaborative learning through the creation of a shared information workspace (Shaikh and Macauley, 2001; Sikkel, Gommer and van der Veen, 2002). When used in the context of team projects in engineering design, a shared workspace serves as a central access point and repository for working documents that can be updated and added to by team members at anytime and from any location. Students have reported that this creation and sharing of task relevant documents supports design and project learning (Nicol and MacLeod, 2004). Other research suggests that constructing resource collections contributes to learning by requiring students to analyse, organise and reflect on their knowledge (Jonassen and Carr, 2000; Denard, 2003). This study goes beyond earlier research by investigating how resources created, organized and stored by one design team in a shared workspace can be used to benefit the learning of other design teams.

There are two unique features in this study. Firstly, it examines how students in design teams interlink resources to create an information structure using wiki pages (similar to web pages). It explores how that structure impacts upon the sharing of information and the generation of design concepts. The way information is structured has been shown to be an important consideration for designers working in large corporations (Davis et al, 2001). Secondly, in order to ascertain whether metadata might be used to help teams access and share each others' resources, students were asked to supply resource descriptors and keywords when uploading information to the shared team workspace. There are few studies on the creation of metadata by students although there is some research on teachers' experiences of creating metadata (Foster-Jones and Beazleigh, 2002).

3. Project Description

This study, entitled 'Distributed Innovative Design, Education and Teamworking' (DIDET), is part of a larger investigation on 'Digital Libraries in the Classroom' funded by JISC/NSF. This paper reports on work with a third year engineering product design class (40 students) in the Department of Design Manufacturing & Engineering Management, Strathclyde University. Students were required to prototype a domestic 'can crushing device' for containers for soft drinks. The task of prototyping the can crusher had three phases: information gathering, storing and structuring;

concept generation; and development and prototyping. Over six weeks the students worked in small teams of 4 and met face-to-face several times per week. Tasks and assessments were designed to encourage students to store and share information online. Resource sharing was supported an open-source groupware product called TikiWiki.

TikiWiki's functionality was tailored to suit student needs based on previous studies of student usage of online shared workspaces (Nicol & MacLeod, 2004). The main features included document management facilities (file, image and web link galleries and wiki pages) and communication tools (a 'shout' facility, email, forums for technical problems). The focus of this study was the use of TikiWiki as a central shared workspace and repository. The communication tools were not of interest because the students could communicate face to face. The key stages and role played by TikiWiki in the storage and sharing of resources are shown in Figure 1.

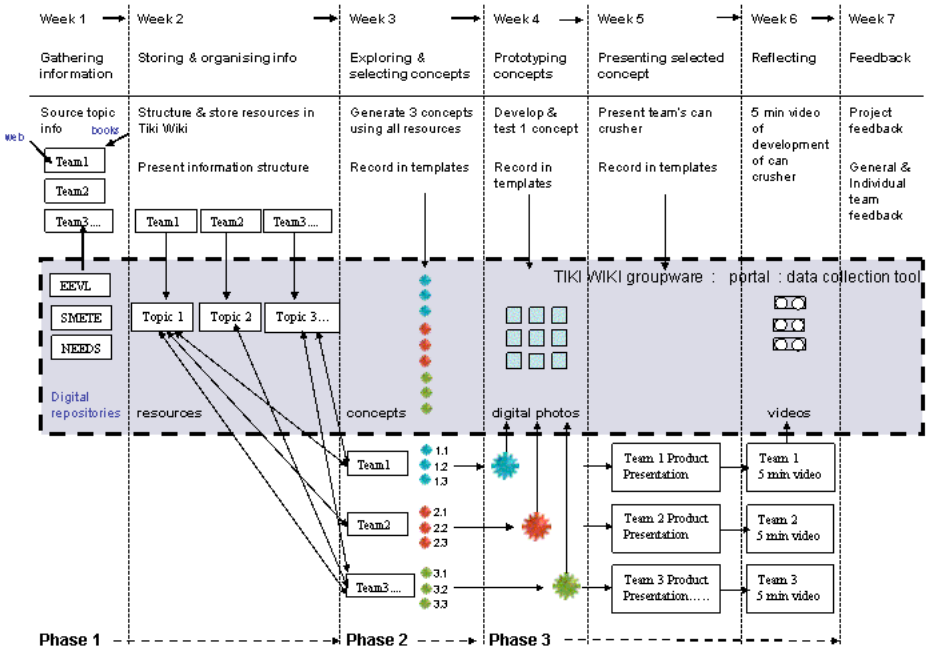

Figure 1: Project sequence and the use of Tikiwiki groupware

Phase 1 – Information gathering, storing and structuring

During the first week each team was required to search for information and create resources on a specific area of research relating to a can crusher (e.g. market, user environment, recycling, mechanisms, aesthetics, ergonomics and safety). This information had to be stored in a shared team workspace within Tiki-Wiki. In order to facilitate the sharing of resources at the later concept generation stage, the teams were required to supply metadata when they uploaded files into their workspace. These comprised a file name, at least three keywords and a description for the resource. Other metadata were applied automatically by TikiWiki (i.e. date and author). These five core elements form the basis for categorization of information within the Edinburgh Engineering Virtual Library (EEVL http://www.eeevl.ac.uk), part of the UK national Resource Discovery Network (RDN). Supplying metadata was considered a good way to get students to interact with information and resources and reflect on them (Jonassen and Carr, 2000). In week 2, each team was required to create an organizational framework for their resources in their team workspace using a set of structured and interlinked wiki pages (similar to web pages).

Phase 2 – Concept generation

In phase 2, access rights within TikiWiki were lifted and the team workspaces were merged into a single, searchable resource repository. Each team was required to develop three different concepts for a can crusher, drawing on the resources they had created as well as those created by others from the earlier team investigations. Students could search through resources in the resource

repository in two ways: using keywords and by navigating through the team-created, structured resources on the interlinked wiki pages. The three concepts developed were stored online using a pre-designed concept template (wiki page). This comprised an image of the concept, a text description, keywords and references to the resources that informed that concept. All students had access to these templates.

Phase 3 – Development & Prototyping

During phase 3, each team developed their chosen concept to proof-of-concept model stage, documenting the process using notes, sketches, digital photography etc. Two short team presentations were made; the proof-of-concept model and a 5 minute presentation outlining the design process and what had been learnt from the experience. The latter was videotaped and archived. The results of phase 3 are not reported in this paper.

4. AIMS and Evaluation Methods

The general aim of this study was to investigate the effects on design learning of students constructing and sharing a central repository of searchable resources. The specific objectives are to:

- Examine how design students store and interlink resources while researching specific aspects of the design problem and how this impacts upon the development of their design concepts.
- Evaluate the extent to which the interlinked pages and the metadata descriptions facilitate the sharing of resources across teams

Evaluation was conducted throughout the project using a variety of methods. It focused primarily on students' and teaching staff's perceptions and experiences. An evaluator (HG) observed and met with teams in *focus groups* for 10 minutes during the 1 hour weekly class studio sessions. At the beginning of each class, *one minute reaction cards* (cards with 4 questions to be answered by students) were handed out. The cards were gathered in at the end of the class. In week 3, during the team presentations (for assessment) *staff observed and discussed* with teams the effectiveness of their information structures (linked Wiki pages). Some of these sessions were recorded by the evaluator. At the end of the project*, a feedback session for each team with 2 members of staff* allowed both staff and students to give feedback on their overall experience and project outcomes. Also, at the end of the project there was a *focus group meeting with all the teaching staff*. Objective data was provided through weekly *analysis of TikiWiki team pages and files*. This provided information about how students had interacted with the resources, what metadata they had created etc.

5. Results

Results from the student perspective are presented in two sections detailing their experiences of (i) creating and organizing resources in the shared workspace and of (ii) using and sharing design resources in the shared repository.

Students' views: creating and organising resources

The design teams created and organised a wide range of resources in their Wiki sites. Resources included files downloaded from the internet (e.g. explanations of can-crushing processes, digital images of prototypes, calculations of forces), student-generated files (e.g. new text, data, images and photographs derived from externally sourced information or created from scratch) and links to external sites. This information was initially stored in file galleries in TikiWiki and subsequently structured into linked wiki pages.

Wiki Pages

Analysis of the pages on the TikiWiki site and the student presentations of these pages in class revealed that all teams had structured their resources using linked pages. The reaction cards indicated that teams had tried to organise and prioritise this information so that other teams could find what they were looking for. Typical comments were: 'we have tried to allow ease of navigation by others'; 'everything is laid out on the main page'; 'we used main headings and sub-headings to ease navigation'. Figure 2 gives an example of one team's wiki index page: this provides a lead in to that team's site and highlights links to their other wiki pages. The TikiWiki site showed that teams

had sub-divided their topics into between 3 and 8 sub-categories and their resources had between 2 and 6 levels of information with more detail located at lower levels.

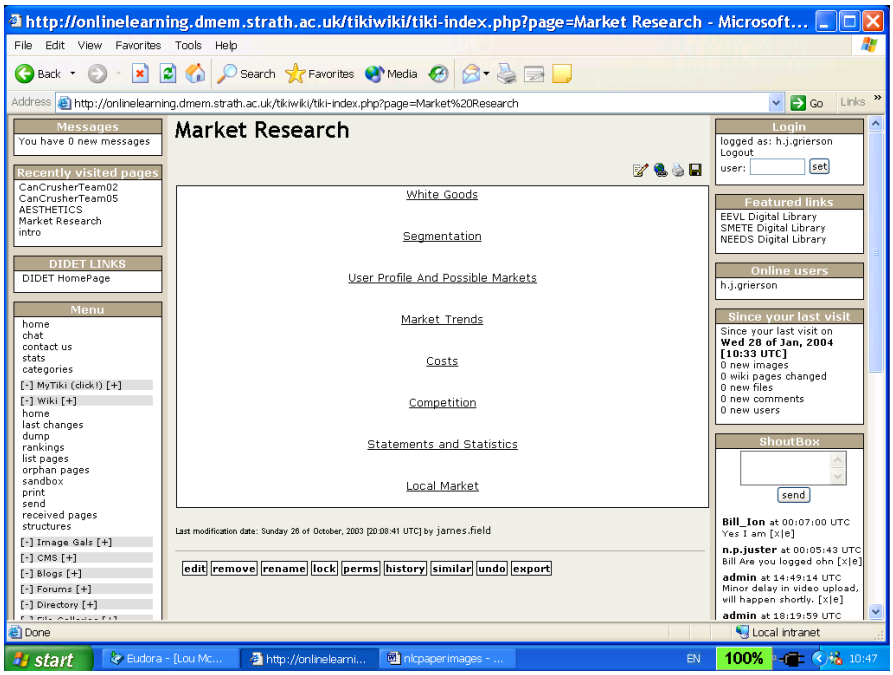

Figure 2 – Team 2's index page to structured information

Metadata: Keywords and descriptions

Analysis of each team's wiki site at the end of the first week revealed that only half the teams had supplied keywords and descriptions (metadata) while uploading resources. Although more resources had been created with linked metadata in the second week, students reported some concerns about providing metadata during the evaluator interviews and team presentations: 'we didn't really know how to use keywords'; 'it takes too much time to write keywords and descriptions'. At feedback sessions, later in the project, some students also reported that the value of providing keywords had not been made clear enough at the beginning of the project; 'we needed more information on keywords, why they were necessary and some training'. The provision of metadata had not been made compulsory by tutors. Some students reported that this reduced their motivation; 'teams should have been forced to input keywords and descriptions if we were meant to use them'. Unfortunately, Tiki-Wiki was configured such that students could upload resources without attaching metadata and, in addition, metadata could not be added retrospectively.

Analysis of the keyword metadata that was supplied revealed that most students had used the terms supplied by the tutors in the project brief or subdivisions based on these terms. In the project brief, teaching staff supplied terms for each of the topics to be investigated (e.g. market research: white goods, kitchen appliances, segmentation, user profile, trends, costs, competition). Factors determining students' choice of keywords were explored in week two using the reaction cards. The majority of students (80%) provided keywords that they felt described the content of the resource file that they had uploaded; 'I see the keyword as a summary of the file so that people know what it is before they look at it'; 'obvious/relevant/appropriate description of the file'; 'the keywords…were simply a concise explanation of the file'. A quarter of the students also selected keywords based on an intention to share resources: 'we thought of the words we/or others might use when searching'. Analysis of description metadata showed three categories of information had been provided: descriptions of the type of information supplied (e.g. list, guidelines, report), descriptions of the content in terms of subject matter (e.g. data about forces, mechanisms), and descriptions of the source of the information (it came from government publications, from standards). The most common descriptive category was about content.

Concept Templates

At the concept generation stage students were required to document all three of their design concepts using a teacher-supplied wiki template (see Figure 3). This template asked for an image of the concept, a written description and references to all resources that had influenced the development of the concept. Students were very positive about the concept templates. On the reaction cards they stated that they 'provide a simple layout' of the concept, 'it is easy to compare concepts' and that 'the most important information goes into the template'. The template seemed to provide a useful summary of the concept for students.

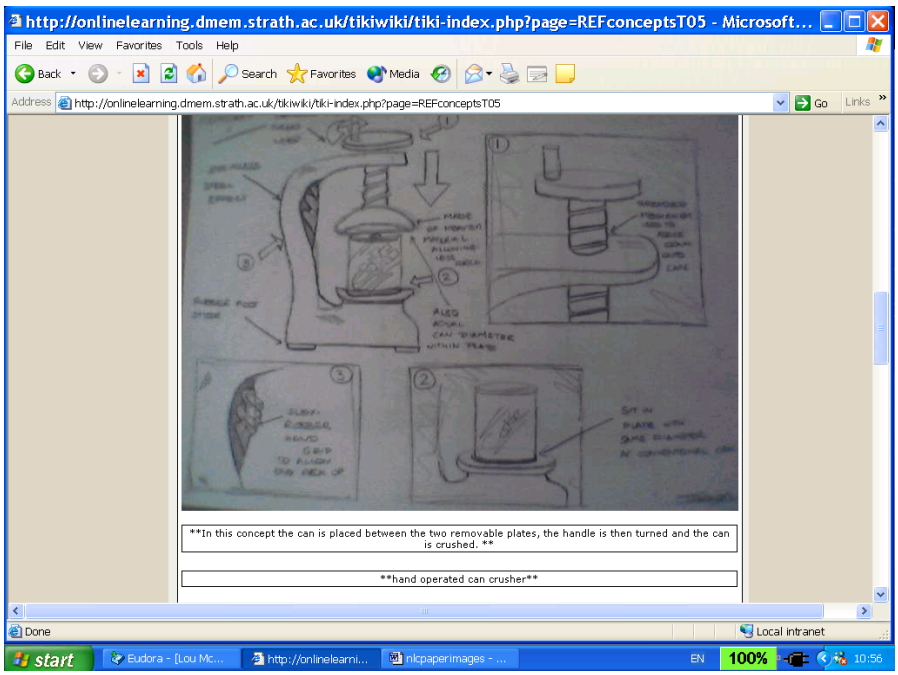

Figure 3: A concept template including box for image description and box for keywords. (Note: reference box not shown in this image).

Students' views: searching and sharing resources

Searching using wiki links

There were two ways of searching through the resources - keyword searches and searching through the structured wiki resources using the index pages and the hyperlinks. Of these two methods, students showed a preference for 'browsing' the structured wiki pages rather than using keyword searches. When asked "How did your team search for information?" in week 3's reaction card, all the respondents noted they had looked through the resources via the wiki pages whilst only 44% attempted keyword searches. The reason given for this by students were that the wiki pages were easily accessible and more familiar due to their experience of using the WWW both academically and for personal searches.

However, one disadvantage of the wiki pages reported by students was that they often had little understanding of the structure of the information created by others and of the relationships between the resources at the various levels. Hence they had to look through a number of wiki pages both to ascertain the structure and to find the resources they were searching for. During the evaluator meetings, some teams reported frustration on 'getting lost' when exploring resources created by other teams. Some students recommended that a rationale for the structure of the site and/or a summary of what information exists at each level be provided on the index page 'to guide you through the pages'. Unfortunately, students had not used the WikiGraph facility which automatically creates a map of the interlinked pages of resources (see Figure 4) and would have provided some of the information recommended by students. Also, having a 'graphic' representation of the structure of, and links across, information might suit design students who tend to prefer visual information.

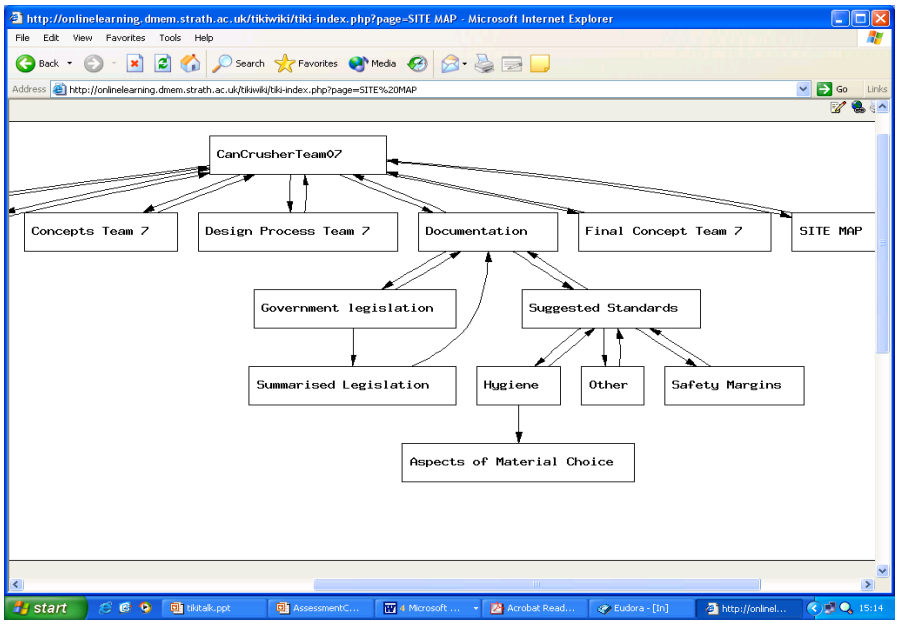

Figure 4: Example of a WikiGraph (site map)

Searching using keywords

The keyword searches of other team's wiki resources proved less useful than expected. Searches were matched against the keywords and descriptions provided by other students. The text or content of a resource was not searched using keywords. Students found that searches were either too general or too specific for their purposes. Also, the searches frequently provided material that was of little value; 'when keywords were used [to search for resources in the file galleries] we often didn't get the content we wanted'. We return to this issue later.

The range of sources utilized in concept generation

Although the range of materials accessed in order to create concepts was broad, overall the range of sources actually used was quite narrow and was mainly based on information from the Internet, books and magazines. Notably, digital resources available online through the university library (catalogues, journals, scientific and technical databases) were not consulted. Evidence for this was that the teams did not reference these resources on their concept templates or report them when asked on the reaction cards. There was also low use of resources sourced through nationally available digital repositories such as SMETE, NEEDS and EEVL. The majority of the students reported on reaction cards that information relating to the project was 'not easy to find' or that the search results were 'too general'. They also reported that they did not find these national repositories easy to search; 'did not find it very useful because I didn't really know how to use them'. Some students maintained that "…it is easier to use sources I am familiar with."

Removing obstacles to sharing

During evaluator interviews there was a unanimous agreement across students that Tiki-Wiki helped students share resources; 'TikiWiki let us share resources without having to meet'; 'often we find it hard to get all of us together'; 'having access to team resources at any time from anywhere without the need to meet face-to-face progressed project work well'. Overall, students reported that having all the information online made it easier to share resources within their teams and to share the resources created by other teams.

The views of teaching staff: organizing and sharing resources

Structure of student resources

A brief focus group with the teaching staff was carried out at the end of the project. During this focus group staff reported that many high quality resources had been generated as a result of the project. Some teachers maintained that a selection from these resources could be harvested to benefit future cohorts of students. Teaching staff noted, however, that not all teams had structured

their wiki pages as well as might have been expected. Some maintained that students had not sufficiently considered how others might use their resources; 'they didn't seem to be thinking about it – ordering it, editing it or guiding others through it'. Others noted students' reluctance to review and edit information; 'irrelevant information often lay within the wiki pages'. During the team demonstrations of the wiki sites for assessment staff expressed similar concerns: 'some teams had failed to prioritise the information they have found, they had not organised the information hierarchically'.

Searching: wiki pages and keywords

At the end of the project teaching staff acknowledged that insufficient preparation had been given to students in the creation of keyword and descriptive metadata. Also, in retrospect it was realised that the structured wiki pages (which could be browsed) had undermined the value of metadata as a tool for searching. One member of staff commented that 'ideally students would have used browsing mode [of wiki pages] for inspiration and keyword searching for targeting'. However, staff gave two reasons for the lack of success with the keyword searching. First, there was insufficient emphasis by teaching staff that keywords were important. Second, because few resources with keywords were created it was not possible to carry out productive searches.

Interacting with resources and design learning

Observation of team concepts, and the presentations by students, confirmed to teaching staff that all teams had used resources sourced by other teams to inform their concepts. Analysis of TikWiki concept pages revealed that 50% of the teams referenced resources in their templates. Staff reported that the best concepts were those generated by teams that had interacted with a wider range of resources. This was also evidenced in the assessment reviews; teams that appeared most knowledgeable were those that reported having browsed resources in the early stages of concept generation and/or had having regularly revisited these materials to further develop their concepts. Staff reported that 'the shared resources had helped improve the concept designs compared to previous years'. However, all staff agreed that, although many high quality resources were generated as a result of the project, students could have made even more use of these to inform their concepts.

6. Discussion

How do design students store and interlink resources?

This study has shown that inter-linked wiki pages can be used by students to organise their resources hierarchically in relation to a specific area of concept investigation. This organization or structure helped other teams to access and share resources not created by them. However, both staff and students identified that there was room for improvement. Staff suggested that students could have been more critical in their selection of resources and could have given more thought to how these resources were prioritized and linked together in a hierarchy. This suggests that more attention be paid to how students map out or structure the ideas embedded in the resources with reference to their design concept. This would require that students receive more preparation about information structuring. For example, a teaching session might be provided, after resources have been collected, where students reflect on which information is most important and how this information might best be structured. Concept mapping exercises might help with this.

How do online resources support the development of students' design concepts?

The results of this study also show that the shared workspace/digital repository positively influenced the way that students used information to develop concepts and the quality of those concepts. Firstly, better concepts were generated by teams that interacted more with the stored resources (gathering, editing, analysing and applying) and, those that reflected on the resources regularly during the design process (browsing initially for ideas and returning to target more specific information). Secondly, the three concepts provided by each team were hosted on the TikiWiki site. This allowed students to access them and to benefit by viewing and learning from some of the concepts that teams chose not to develop. In the past, only the final concept was developed and early concepts were normally discarded and there was little opportunity to reflect back on them.

Do interlinked pages and metadata descriptions facilitate the sharing of resources across teams?

In terms of searching for resources relevant to their concepts within TikiWiki the teams primarily searched through other teams' interlinked wiki pages. Metadata searching was less used and was reported as being less helpful. Three reasons might account for this. First, not many teams supplied metadata (keywords or descriptions) hence some were not fully alert to TikiWiki's keyword searching facilities. Secondly, the keywords supplied by one group of students uploading information to TikiWiki might not have matched with those of other groups subsequently searching for information. Keywords are only useful when the resources are referenced to an agreed and controlled vocabulary. In this study, staff had provided students with some terms on each of the topics to be investigated and students had used those terms (vocabulary) or related terms as metadata. However, insufficient emphasis was placed upon the students' use of this supplied vocabulary even though the project team had identified some of these issues at the project planning stage. In future projects students need to be supplied with, or work together to develop, an agreed set of keywords. Moreover, if these resources were to be reused by future cohorts of students they might also have to work with the same controlled vocabulary. Thirdly, students may just have preferred browsing the wiki pages rather than searching using keywords. This might seem strange given that google is their preferred way of searching the internet. However, google searches the text of resources and this is different from TikiWiki, which was set up to search only the keywords and descriptions. Moreover, the descriptions were not as rich a source of information as resource text. Hence search results would have been less effective in TikiWiki even though the design resources were located together. In future, more emphasis could be placed on students providing rich descriptions of resources as metadata or TikiWiki could be re-configured to search text within files.

How might digital resources be shared and reused?

Another idea suggested by teaching staff was that the rich set of resources created by students in this project might have potential for reuse with future cohorts of design students. However this raises a further issue: how to reuse resources stored in repositories by one cohort of students with subsequent cohorts without depriving the second cohort of the valuable learning experience gained from searching, storing and organizing resources themselves. Future evaluations will explore this issue.

7. ACKNOWLEDGMENTS

Thanks to our Strathclyde colleagues Neal Juster, Bill Ion, Andrew Lynn and Lou McGill for their input.

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