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1) Acknowledgements

This report describes the work on the Information Spaces for Creative Conversations project, funded by JISC as part of the Transforming Curriculum Delivery Through Technology programme. The project has been a collaboration between Middlesex University and City University London.

2) Report Summary

2.1. Project Overview

The overall challenge of this project was to address a recurrent problem in design education: that students are sometimes disengaged from key 'creative conversations' and that this problem can be exacerbated by learning technologies present in the classroom or the students' wider networked world. An aim, therefore was to support design-related activities in the classroom or studio with as little from the conversations through which so much is learned, and to provide students with resources for reflection, review and sensemaking outside of classes and studio sessions.

The project trialled, through a series of case study interventions, the use of technology to support students studying design-related subjects. The emphasis has been on encouraging learners to engage conversationally with peers and tutors, principally in face-to-face classroom and studio settings as part of a pedagogic approach founded on learning through conversation. The technologies used have been deliberately low-tech, combining traditional materials and writing surfaces, with technology for displaying digital materials and capturing and recording activities for later feedback and reflection.

We have set up 'information spaces' where learners can discuss their ongoing design work with peers and tutors, supported by both physical and digital materials, and the ability to write, draw, sketch and present information on a range of horizontal and vertical surfaces. Activities, conversations, and some of the artefacts produced in such a setting are captured through audio and video recordings, and digital photographs that are then made available to learners through a blog style forum. Captured materials provide students with a means of 'replaying' a design session as part of the process of reflecting and making sense of what took place, and the blog format allows reflective contributions to be posted, and supports learners assembling materials that can form the basis of future design conversations.

Overall the interventions have proved to be very valuable and point the way to further improvements that will be deployed over the coming years to enhance delivery. A key factor that appears to limit the effectiveness of the approach used here concerns what we have termed the learners' 'readiness to engage' in a conversational mode of learning and interacting in a learning setting. Work is ongoing to better understand this area and investigate the appropriateness and feasibility of creating a greater readiness.

2.2. Project Outputs

The project outputs fall into a number of categories. Where appropriate these are available on the project web site (http://idc.mdx.ac.uk/iscc).

- ☐ Draft and published papers, including:

  B. Fields, et al. (2010) Conversational spaces for learning and designing. CHI2010 workshop on Next Generation of HCI and Education. Accompanying poster

A. Bardill, et al. (2010) Design Tribes And Information Spaces For Creative Conversations. International Conference On Engineering And Product Design Education.

See – http://idc.mdx.ac.uk/iscc/publications

- Case study descriptions.

  Information Space Technologies: Year 1 explorations at Middlesex

  Information Space Technologies: Year 1 explorations at City

  ISCC Year 2 – The Case Study Landscape

  Information Space Technologies: Year 2 Case Studies at Middlesex

  Information Space Technologies: Year 2 at City University

  See http://idc.mdx.ac.uk/iscc/case-studies

- Notes, tips and guidance.

  See http://idc.mdx.ac.uk/iscc/pandt

2.3. Impact and Benefits to the Community

The project generated benefits in a number of areas:

- For delivery of case study modules. The interventions made in case study modules provided clear opportunities for learners to engage in productive conversations without undue distractions from complex technology, but with the ability to bring digital materials and physical materials into a conversation and to review and reflect on a session afterwards.
- For staff – including new staff joining case study modules
- For students of these modules
- For staff involved in commercially-oriented work within the university that provides learning experiences for project students.
- At both City and Middlesex, we have demonstrated the pods to potential commercial partners, as well as visitors, staff, and potential students on open days.
- Presentation about the project at City, at the 'Learning at City' conference, open to all University staff[1].
- At City University London, Dr Sara Jones has been awarded a small amount of funding (3K) for a Learning Development Project to investigate application of lessons learnt on the ISCC project in other contexts across the School and University[2].
- The work of the project has been presented at a number of events, for example at a meeting the JISC Learning and Teaching Practice Experts Group (13 July 2010).[3]

2.4. Main Lessons Learnt

Key findings include

[1] See http://www.city.ac.uk/ldc/events/Conference.html
[2] See http://www.city.ac.uk/ldc/staff_development/Learning%20and%20Teaching%20Awards/Learning%20Development%20Projects.html
[3]

- Provision of such an information space did create an environment in which students were able to engage effectively in a creative and productive conversation;
- Reliable, trustable capture of conversations was a key element, allowing students to engage without the distraction of note taking, and supporting later reflection and sense-making;
- Providing structure and constraints in a conversational setting (e.g. through the use of simple timers to demarcate the different phases of a conversation) proved effective in making conversations time-efficient and focused.

It has been possible to offer a number of points of guidance for setting up such spaces.

3) Main Body of Report

3.1. What did you do? (Methodology)

Project aims and objectives

The project explored and trialled the configuration of 'information spaces', physical learning environments suitably augmented with technology, to support learning through conversation. The primary focus of the project was to support learners in several design-related disciplines, and these were explored through a series of case study interventions.

The project had three main objectives, which were: supporting and encouraging more productive conversations between learners and their peers and tutors; Allowing learners to be more engaged in the process of design and the critique of their own work and that of others; Ensuring wider impact, uptake and sustainability by providing technology interventions that are appropriately packaged, easy to deploy and well integrated with the pedagogic approaches they are intended to support.

In support of these objectives, the project sought to configure and evaluate:

- Novel learning spaces that support flexible, multi-modal face-to-face interaction and dialogue to enhance collaborative and creative activity in the context of delivering a design curriculum.
- Technologies to allow learners to work and learn flexibly using a range of display surfaces and interaction technologies suitable for engagement in exploratory design thinking. For examples, in the scenarios of interest, the participants are able to take a snapshot of activities taking place in one space (the table) and render them visible in another (the wall) as a record that can be referred to later on in the conversation (when the state of the table surface will have changed).
- Tools to allow learners to capture using a range of appropriate media (audio, video, still photography) the events, artefacts and conversations that take place in a design session. A common problem is that learners need to take something away from a session in order to reflect and contemplate it at a more relaxed pace. Note-taking is the traditional means of doing this, but in a fast-paced session that makes use of many visual media, this is often inadequate.
- Support for reflection and review during and after design sessions. Video and audio recordings will be used to capture feedback and formative comments given to students by tutors and peers. The recordings will provide opportunities for later review and reflection, thus allowing the conversation to extend in both time and space, supporting the ability to engage and reflect after the session has finished and beyond the physical setting of the classroom or studio.

Project activities

Over the two years of the project, a number of case study interventions have trialled different configurations of 'information space' technology, and different ways of embedding such technology in the learning situation and pedagogic process. In a paper at one of the key relevant conferences we have outlined the approach that is being supported (Bardill et al., 2010). Each of the case studies involved incorporating technology into a classroom or studio environment where students would be engaged in design-type activities in a variety of different contexts. The learning situations covered a range of design-oriented subjects (modules on human-computer interaction, product design, and creativity in design), levels (second and third year undergraduates and MSc students), learning activities (shorter and longer activities, individual and group working), and

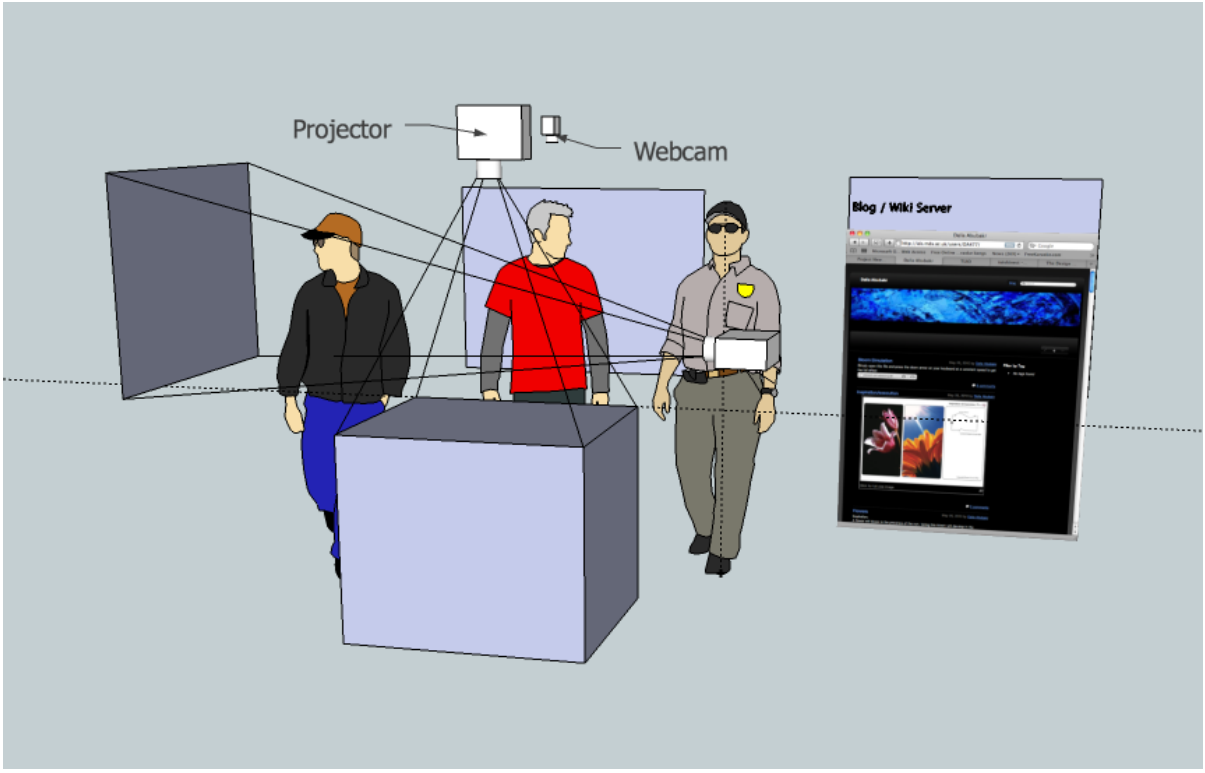
technical interventions.[4] The table below summarises some of the principal features of these studies, and further details can be found in subsequent sections.

Case study	Work pattern	Technical setup	Issues addressed and key observations	Key benefits observed
Pilot study: MSc Interaction design projects (MDX Trent Park & Hendon) 8-10 students / weekly 1-day session	Individual design project over 12 weeks. Projects student-defined with regular peer & tutor critique / review.	Early explorations with writeable surfaces, video/audio/still capture, online delivery of captured materials.	Key project concepts identified: table-based display & interaction for conversation; importance of writing and physical artefacts; value of capturing for reflection	Table presentation space helped **students** to get out of 'presentation mode' and into 'creative discussion mode' at key points in their project work.
Case study 1: UG Y2 computing/HCI module (MDX, Hendon) 100+ Students / classes of 20 / weekly 2-hour sessions	Team (5-6 students) design project over 12 weeks. Project tutor defined with regular tutor involvement / critique.	Single information space used by each team in turn for discussion with tutors.	Supporting team collaboration Readiness to engage	Blogs/Wikis gave **students** a way of sharing project-related materials with team colleagues. Gave **tutors** an overview of teams progress.
Case study 2: UG Y3 Product Design projects (MDX, Trent Park) 30-40 students / weekly 1-day session	Individual design project over 18 weeks. Projects student-defined with regular peer & tutor critique / review.	Information spaces for teach 'thematic group' Spaces used independently by students outside scheduled classed to support preparation and deflective group discussion.	Independent, non-tutor-directed use to complement tutor-led sessions Importance of structuring creative sessions (e.g. using a timer) Value of after-class reflection and tools to support this (e.g. personal blogs and podcasts)	Video recordings gave **students** a way of replaying sessions for later reflection. Video recordings gave **tutors** a way of capturing assessment feedback, providing a useful resource for students, tutors and external examiner.
Case study 3: MSc module Creativity in Design (City) ~15 students / weekly 2-hour session	Team (4-5 students) project over 8 weeks. Teams work autonomously with occasional tutor input and feedback.	Three spaces to support three teams simultaneously Used horizontal as well as vertical writing / projection spaces	Differently oriented surfaces supporting different activities	

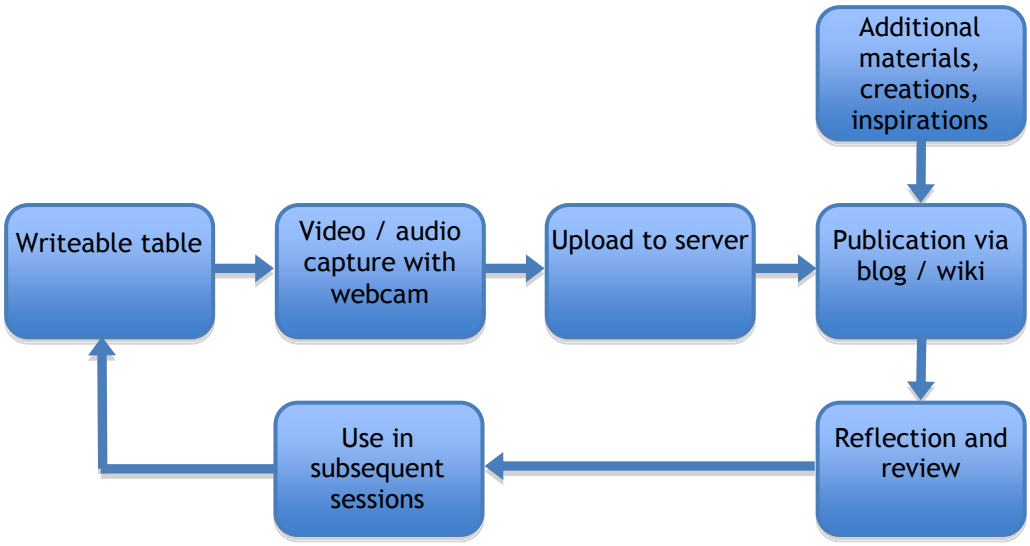
[4] See the Case Studies section of the project web site (http://idc.mdx.ac.uk/projects/iscc/case-studies) for more details.

		Use of novel interaction technologies		

The figure below shows some of the principal elements of the technical setup: Projectable and writeable table surface, projectable and non-projectable vertical whiteboard surfaces, a webcam to record on-table activity, blogs or wikis used to deliver video recordings after the session. The figure illustrates a sophisticated configuration with multiple surfaces that closely resembles that used in Case study 3. The other cases are simpler variants of this setup in which different surfaces are available, with projection onto the table being used extensively in all cases. In the Pilot study, projection onto the table was occasionally supplemented with a wall-mounted screen; Case study 1 used only the table presentation; Case study 2 used the table and occasionally wall-mounted whiteboards and projection surfaces.



The schematic diagram below identifies some of the key processes and information flows that enable the information spaces trialled in this project. Particular technologies that have been used (e.g. the use on Apple's Podcast Producer for video capture and processing, Apple's blog server or Moodle as a platform for delivering captured material) will be discussed below.


Additional materials, creations, inspirations
Writeable table
Video / audio capture with webcam
Upload to server
Publication via blog / wiki
Use in subsequent sessions
Reflection and review

Technology and interventions

In each of the case study settings, students were involved in creative design project work in which their learning of how to engage in a practice could be enhanced through conversation, with collaborating team members, with other peers, and with tutors. The technical interventions in these learning settings were aimed at encouraging and enhancing conversation, and supporting later reflection on the conversations that took place in class. Typically students, when in class, work in small groups, face-to-face around a table, either exploring design ideas or receiving critical feedback from tutors and peers. The table is highly significant here, providing a space in which participants all have access to information and artefacts on the table, and which constitutes a "shared workspace", allowing participants to maintain a shared "definition of the situation" (Suchman 1996).

A typical scenario in which a student is reporting to peers and tutors and is receiving critical conversational feedback. The discussion makes use of projected digital materials as well as handwritten notes and sketches, and is recorded for later review and reflection

Several elements of the technology were common across all case studies:

- Writable surfaces. Learners are encouraged to write, sketch and annotate as a design conversation proceeds. Typically this means writing on a table topped with a whiteboard or other writable surface. Other writable surfaces are often used (e.g. conventional flipcharts and vertical whiteboards), but the table can have particular significance because of its central location in the conversational space.
- Projection and display. Students will often bring digital materials to a design meeting or a review and critique session. These could be digital objects that are being designed, photographs and other visual materials being used as illustration or sources of inspiration, or could be representations of earlier phases of the design exercise (e.g. a record of decisions made and targets agreed in an earlier session that are being referred to in the current one). A typical case study setup provided a

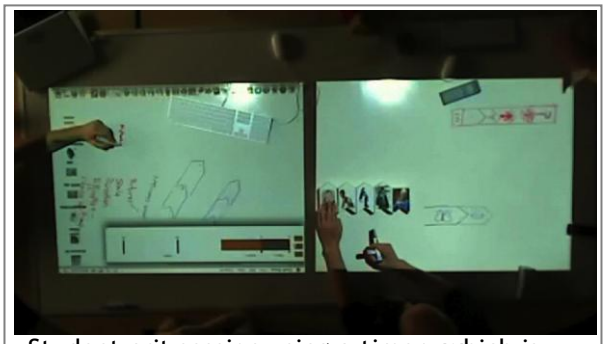
Still image from a video recording of a crit in which tutors and peers are giving critical feedback to a student. The projected images as well as written and drawn material provide important prompts for the conversation that unfolds.

downward-pointing projector allowing materials to be displayed in the same space as students are acting and writing – that is, onto the writable table surface. One consequence of this is that digital materials, physical artefacts, and drawing and writing produced in a session are all present in the same visual space, at the centre of the conversational arena.

- Recording and capture. One difficulty reportedly faced by students in critique and review sessions is that the pace and tempo of the sessions makes it difficult to keep up with what is happening and what is being said (for instance, see the advice about peer note taking in Orr et al. 2007). If the student is also expected to make notes to record feedback they are being given, their ability to engage in the critical creative conversation is compromised. Therefore all sessions are video and audio recorded from ceiling-mounted cameras to support later review after and outside of the classroom session. In addition to video recordings, it was often found to be useful to use still images, for instance to capture detail that would not appear in sufficiently high quality in the video, or events that would be outside the area captured on video.

Student's blog showing a posting containing a video record of a crit session as well as a still photograph of detail of annotations on the table surface produced during the crit.

- Replay, annotation and reflection. A recording of a session is only useful if it can be replayed at a later stage in a way that supports remembering and sensemaking as a part of the process of reflecting on a crit session that took place in class. The software explored for recording and capture included Apple's Podcast Producer framework. This software makes the process of capturing video straightforward, and automates the publication of videos as podcast postings on a blog. Each student is provided with a personal blog onto which the video records of their own sessions are posted. Videos can be conveniently replayed at a later time, helping students to recall the feedback given and comments made in what can be a somewhat intense situation. As well as being a repository for video podcasts the individual blogs function in the usual way, allowing students to post materials and capture reflections and ideas to construct a web log of the development of the project. This provided students with both a personal thinking space, and a space in which to


Student crit session using a timer, which is displayed as a 'progress bar' at the bottom of the left projected display. The timer shows how much time has elapsed and which phase the session is in (reporting, discussion, target setting).

collect materials in preparation for a crit.

The setup in the City case study differed slightly from that used at Middlesex. Individual students at City did not have blogs, rather videos were uploaded into moodle wikis shared by groups of 3 or 4 students. These wikis also formed the basis for a substantial part of their assessment: they were asked to keep online design diaries/sketchbooks, and then provide links to these and a commentary explaining what they had done in the moodle wiki.

- Structuring conversations. An early observation was that without some constraints, crit-style conversations are often allowed to drag on, and the session for one student can easily take an unfair portion of the time available. Furthermore, though, an initial analysis of video recordings showed that three key elements exist in many crit sessions: (i) the student reports on their recent activities (ii) the student, tutors, and peers engage in open discussion to explore the developing design idea, (iii) the group collectively try to agree targets, goals or objectives for the next phase of work. A digital timer was created using Flash, which shows elapsed time since the start of the crit; the overall time for each crit is divided into three phases for Reporting, Discussion, and Target setting. The overall length of the session, and the time allocated to the three phases can be changed to suit the needs of a particular class. The timer would then be displayed on one of the projections, and therefore made visible to all those present. The timer becomes a shared object that can coordinate the contributions of those taking part.
- Integration. While the Apple Podcast solution provides a simple and easy-to-use way of capturing and delivering in-class recordings, it is a system that is not directly integrated with other learning technologies. Case study 3 explored the use of the institutional Moodle environment to deliver captured video to learners. The obvious practical disadvantage was that this route requires more human intervention to capture and upload video, with the consequence that the upload may, on occasion be delayed or may not happen at all. However, depending on the particular learning context, the integration with an existing VLE may prove to be highly beneficial.
- Simple interaction and control. One of the early motivations for the kinds of interventions that this project has trialled is to deploy technologies in a learning situation in a seamless and straightforward way, providing simple access to information with the minimum of distraction from the learning tasks at hand. A key factor in achieving this has been to make interaction with the blogs, projected materials and the video recording controls as simple as possible through the use of easy-to-use software (e.g. Apple's Podcast Producer), and through appropriate hardware devices. The case study interventions have experimented with several interaction devices, including wireless keyboards and mice, an eBeam[5] and a Nintendo Wii controller, the Wiimote Whiteboard software and infra-red pens[6]

[5] http://www.luidia.com/
[6] http://www.uweschmidt.org/wiimote-whiteboard

- Packaging. To further enhance the ease of use of the technology, purpose-designed 'pods' containing a projector, Wi-fi-enabled computer and video camera were constructed. This made the technology easily transportable and convenient to set up in a range of configurations (e.g. hung from the ceiling to project downwards, or resting on a table to project onto a conventional screen). Students in one of our case studies (Case study 2) were able to 'check out' a pod for use outside of the formal crit sessions to support peer discussions, preparation for crits and group review and reflection after a formal session. In another (Case study 3, and to a lesser extent Case study 1) students were able to (and did) book the room containing the pod setup, in order to use the information space for discussions and group working outside of the scheduled classes.
- Multiple surfaces. While the main focus of attention, both in the setup of the case study trials, and in the way crit, review and design sessions are conducted, has been on the horizontal table surface, the use of other surfaces has been explored as well. In one of the trials, learners working autonomously on design projects were provided with three surfaces – one table, and two vertical whiteboards. All surfaces were writable, and two (the table and one whiteboard) could be used to display projected material.

Pod containing Projector, Webcam, and Apple Mac Mini computer. Computer connects wirelessly to a server to support Podcast production and hosting. User can interact using Bluetooth mouse and keyboard.

Design session in which students use three writeable surfaces: table projection, vertical projection, whiteboard.

Research and evaluation

The evaluation approach taken on this project was a qualitative one that sought to build up a rich understanding of what happens as a result of the interventions made. As part of the investigation, a variety of different data collection approaches and research instruments were used, and the main ones were video recordings of class or studio sessions (recorded as part of the service provided to students); questionnaires; interviews and focus groups; blogs and related materials produced by students.

A number of tools and approaches have informed the analysis of this dataset. One of these has been the Creativity Support Index (Carroll et al., 2009), an instrument to help developers understand the value of 'creativity support tools'. While the Information Spaces trialled here might not constitute 'support tools' in the way some authors use the term, this research instrument has provided a useful set of analytic categories. The CSI framework involves rating a support tool on the following criteria, which are then combined to produce an overall score.

- ☐ Exploration
- ☐ Collaboration
- ☐ Enjoyment
- ☐ Results Worth Effort
- ☐ Immersion
- ☐ Expressiveness

While we have not used the framework in the quantitative way its authors describe, the above dimensions have provided us with a starting point to analyse interview and observational data in a more qualitative way.

A number of complementary approaches and research instruments were employed in order to build up an understanding of the value that the information space setup can add to the learning process. These instruments included:

- ☐ **Analysis of captured video and audio data.** In all case studies, a large quantity of video material was captured as part of the routine process of recording design sessions. This material has provided a rich resource for analysis.
- ☐ **Questionnaires**. In case study 3, students completed an online questionnaire, the focus of which was on acceptability of the information space technology, and the degree to which it supported creative processes effectively.
- ☐ **Interviews with individuals and groups of students.** In all cast studies, focus group-style interviews were conducted with groups of students.
- ☐ **Analysis of the content of student blogs**. The blogs produced by students in Case study 2 were analysed.
- ☐ **Observations of in-class activities**. While informal observations were a valuable source of insight and understanding that informed other areas of the analysis, they were not a formal component of the analysis. Observational findings will not, therefore be reported in any more detail here.

Case study	
1 & 2	**Analysis of video.** In these studies, a large number of students were involved (100+ and 30+ in the two studies) and very large quantity of video data was produced (well over 100 hours of video), so a detailed transcription and analysis was not feasible. Following an initial broad sweep through the whole corpus of data, interesting themes and lines of enquiry were identified by comparing across different video recordings. This allowed a smaller subset to be chosen for more detailed examination of the emerging themes.

As themes began to emerge across different areas of the data, relevant portions of the video record were explored in more detail and transcribed for more detailed analysis and for illustration.

This iterative approach is consistent with a number of standard ways of treating qualitative data (e.g. thematic analysis[7] or video analysis (Heath et al., 2010)). The approach does not begin with a defined set of codes or categories, but rather allows themes to emerge from the data that relate to a more broad set of concerns for the analysis. The concerns and themes that emerged through the video recordings are summarised in Appendix A.

Interviews

Semi-structured interviews were carried out with 6 students in Case study 1 and 5 in Case study 2 immediately following a crit session, with the aim of understanding their reactions to and opinions of the information space technology and the mode of its use. Students were selected for interview and focus groups to as to achieve good coverage of the different laboratory class sessions that ran, and of the different tutors who facilitated these sessions. The interview plan included questions relating to how students feel in a crit session; attitudes to the technology and opinions about its usefulness; conduct in the sessions and activities beforehand and afterwards; use of blogs.

Interviews in case study 1 with individual students were followed up 6 with focus group sessions, each with 4-5 students who had worked together as a team for the modules coursework activity. The focus groups covered similar ground to the individual interviews, and data was treated in a similar way.

The interview plan is summarised in Appendix B. This shows the major topics that were covered and the main questions asked. Notes were taken during the interviews and the analysis of these notes proceeded in much the same iterative manner as the analysis of video recordings. Themes common across the transcripts of different students' interviews were identified and highlighted.

Blog content

Web blogs of 21 product design students in Case study 2 were analysed with the aim of better understanding how the blogs were used, and the role they played in class and out of class. Key elements of the analysis were:

- Frequency of blog posts
- Day of the week, time of the day (how close to weekly crit day)
- Purposes of different posts. The main types of postings were found to be Inspirational data; Informative data; Planning data; and Deliverables.

The interviews proved to be a very useful way of filling the gap between blog entries and video recording of crit sessions of each interviewee. For example, in the blog of one student (coded as TP-3), it was possible to find planning data that explains what the student intended to do in the next couple of days. This was followed by another blog post including pictures of prototypes being developed. On the other hand, in the video of the student crit session, TP-3 showed these pictures of the prototype to tutors for feedback. The interview revealed something about the working routine of TP-3: a common pattern

[7] See, for example, http://hubpages.com/hub/Qualitative-Thematic-Analysis.

	involves viewing the crit session of a video the day after, then setting goals to achieve for the following week. Then he posts the content that he would like to show to tutors the day before the crit session so as to elicit another round of feedback.
3	**Analysis of video** Video recordings were analysed in detail in order to understand (i) the role played by multiple writeable and projectable surfaces within the creative process, and (ii) the ways in which the information space technology supported or inhibited the creative process. A coding scheme was developed that coded video for instances of ▪ the use of each of the available surfaces ▪ which participants were present and were active or passive ▪ other media and materials that were used ▪ technology supporting the creative process ▪ technology blocking the creative process or inhibiting flow **Interviews** Focus group interviews were conducted with students on the case study module in order to understand their reactions and attitudes towards the use of the information space technology. The interview data has provided a rich set of illustrations of students' reactions that complements the findings of the questionnaire study. **Questionnaire** A questionnaire was constructed, largely on the basis of the CSI framework described above, with the aim of gauging students' views of how well the Information Space setup supports processes of creative design. The students involved were studying a postgraduate course in Creativity in Design and were therefore well equipped to assess the effectiveness of 'creativity support' technology. The questionnaire was administered online through moodle to all students registered on the case study module, and the questions that appeared are in Appendix C. The detailed results of the survey are not repeated here, but can be found in the relevant case study document.[8]

3.2. What did you learn?

The findings of the project are summarised below and are categorised under four headings that cover: the overall contribution of technology to the enhancement of learning conversations; the importance of reliability and trustworthiness of the technology and technical and organisational infrastructure; the value of adding structure to conversational sessions; practical issues, problems and solutions for setting up information spaces. These findings are illustrated with quotations gathered in the interviews and focus groups. A more complete description of these findings and the data on which they're based can be found in the project Case study descriptions.[9]

[8] *Information Space Technologies: Year 2 at City University* – http://isc.mdx.ac.uk/iscc/case-studies
[9] http://idc.mdx.ac.uk/iscc/case-studies

Provision of such an information space did create an environment in which students were able to engage effectively in a creative and productive conversation.

- Simple technologies can encourage conversation. The immediacy and simplicity of traditional tools (e.g. pens for writing and sketching) meant that acts of writing or drawing fit very smoothly into a design conversation. It would appear that if technologies are simple – effortless – to use, then fluid sketching as part of a process of 'reflection-in-action' (Schön, 1983) can happen, just as easily as it does with pen and paper. If not, they can disrupt the process. In CSI terms, the problems caused by difficult-to-use technologies are mainly around immersion, enjoyment and results being worth effort.

  > *'Standing round the whiteboard was dynamic and we could all contribute simultaneously while ideas were flowing.'* [Case study 3 participant]

  Some experiments with more sophisticated digital tools (including touch sensitive table surfaces, digital pens, and tablets) appeared suggest such tools provide more sources of distraction and interrupt the conversation. Furthermore, in many settings a move to a more digital environment would make more difficult the mix of digital and physical objects, media and content that is important in many exploratory design conversations. Some tools (such as the eBeam pens) are usable, robust, and highly developed. However, in some situations, such technologies appear to offer less flexibility and expressiveness than traditional pens.

  > *'The ebeam was pretty good - we liked that - but just need to iron out a couple of the clunky aspects'*
  >
  > *'eBeam was exciting but we found the pens just didn't work well enough.'*
  >
  > *'I loved the tool [eBeam] - loved the way that could integrate the low tech stuff we/I feel comfortable with, with the benefits of electronic capture.'* [Case study 3 participants]

  [Supported by observations, especially from Product Design students in Case study 2.]

- The convenience of being able to engage in conversation, knowing that what took place will be recorded and made available appears to stimulate students' participation in conversations. Some students found the ability to replay a conversation after the session enormously valuable, as it removes the need for note-taking that would tend to require a student to disengage from the conversation.

  > *"The feedback session is so valuable, but it is hard to remember everything after the session ends so I used to record parts of the session using my phone … so I was so delighted when I know that sessions will be recorded for me"*
  >
  > *"Previously, I used to take notes during the sessions, then get back home and read notes to know what to do next, now [by using the pods] the situation is different … I can focus and talk more confidently to tutors during sessions knowing that I can get back to the recording anytime later"*
  >
  > *" I keep watching my crit session over and over … I watch it 4-5 times every week to stay on track and don't lose focus of my project"* [Case study 2 participants]

  [Supported strongly by comments in many interviews, especially from Product Design students in Case study 2.]

However, other students, especially those in Case study 3, regarded the video recording to be less useful because of the length of time taken to review video recordings, and the fact that personal notes was felt to be adequate.

> *'perhaps if we had lost something or there had been conflict we could have used them to review.'*
>
> *'I never used them. Wouldn't have time to watch it. Couldn't really rely on the video being good enough audio and video quality. We took notes of everything we knew we would need to use.'*
>
> *'The time it takes to review video means that this can be something to deprioritise'*
>
> *'We did not view them, we found photographs of our white boards most useful'* [Case study 3 participants]

There are several likely reasons for this apparent difference in attitude to the recording technology, including the fact that discussions in Case studies 1 & 2 were tutor led, and often more concerned with review and feedback.

- Multiple surfaces can support different activities. Some surfaces (especially the table) tend to be used as a creating discussion space where brainstorming and similar activities take place.

> *"When things being projected on a table, everybody automatically gather around it and it is just different"* [Case study 2 participant]

Vertical surfaces, including projections and traditional whiteboards, can to be used to display longer-term information, for instance project plans, decisions made, review of previous sessions. While this use of the horizontal and vertical surfaces has been observed routinely in some of the studies (particularly the pilot study and Case study 2) it is by no means a universal pattern. In case study 3, teams often conducted creative activities (e.g. brainstorming), on vertical surfaces, as well as using them to share material they had found during the previous week(s) or search for new sources of inspiration. At the same time, these students appeared to make relatively less use of the table surface (though that may be simply a result of a less convenient setup of the table relative to the wall surfaces).

In CSI terms it appears that the provision of multiple surfaces (including more than one projected space) is potentially good for exploration - if only due to having lots of space.

> *'Good to have several surfaces for display' (from the moodle evaluation)*
>
> *'The actual set-up of having three surfaces was good for collaboration'* [Case study 3 participants]

[Supported by observations of in-class activities in Case study 2 (MDX), 3 (City) and earlier pilot studies at Middlesex with Postgraduate Interaction Design students.]

- Writable surfaces were used to support collaboration and facilitate the discussions during crit sessions by both tutors and students. They were used for various purposes such as summarising important points that are being raised during the conversation, writing down ideas as a way of approving it and noting that it could be an option to be considered in the future. Also, writable surfaces were used for drawing illustrative diagrams and drawings to achieve common understanding of proposed ideas.

One potentially interesting distinction that can be drawn is between writing or drawing (whether using digital or physical pens) onto a projected surface, and onto a non-

projected surface (such as paper or a whiteboard). Annotations of a projected digital image has proved useful when commenting on, critiquing or modifying designed artefacts or other digital representations. Writing and drawing on non-projected surfaces (or surfaces where projection was not being used), on the other hand, was often used to on brainstorming and similar generative activities.

[Supported by analysis of captured video and audio, especially from Product Design]

- As mentioned earlier, each student (in case Study 2) or team (in studies 1 and 3) had a blog/wiki to support them through various design phases. They used the blogs to post different information such as information for inspiration, planning and delivery of their design projects. This information also helped both students and tutors to have more structured conversations during crit sessions. Students show this information to peers and tutors during sessions using the downward projection to achieve common understanding of proposed designs. On the other hand, these blogs were used during crit sessions to remind both tutors and students of early phases of the project and previous discussions that had taken place earlier in the term.

  " I put it [my work] on blog so that no one later on could claim that it is his work" [Case study 2 participant]

  [Supported by interview comments and Analysis of the content of student blogs and captured video, especially from HCI and Product Design students in Case study 1 and 2.]

- As a result of designing purpose-made 'pods' to enhance the ease of use of the technology, students had more control over technology and were more motivated to carry on discussions outside class times. Students in Case study 2 were able to check-out the pods and use them to conduct informal crit sessions for students only. These sessions allowed students to further reflect on their progress and improve their peer-reviewing skills. [

Students using the Pod, placed horizontally on a table, projecting onto a conventional screen to conduct a "student only crit" session.

  "Everything was open to us, we easily got Pods to use by our owns[outside crit hours] … we sit down as a group on Mondays or Tuesdays to give each others feedback … it is just like the crit session but without tutors" [Case study 2 participant]

  [Supported by video analysis and student interviews in case study 2]

- Readiness to engage. Across the case studies, a wide variation in use and acceptance of the technology was observed. This could be attributed to a number of factors (including level of students and disciplinary differences). Overall, these differences can be characterised as a variation in a 'readiness to engage', both with the information space, and with pedagogic approach to learning through conversation. In case study 2, response from students tended to be very favourable, with a high level of acceptance of the conversational way of working, and a high value placed on parts of

the technology, especially the recording of sessions and the ability to review at a later time.

> *"[the pod is] useful, can go back and learn from what have been said as everything is there"*
>
> *"it's a quick and effective, all what you need to do is write on table and look and care about what is being said as I know I can get back to this information anytime"* [Case study 2 participant]

One of the reported issues here among some students in Case study 1 was that the sessions had a much more 'formal' feel than was intended, with students feeling that they were being 'assessed', both officially by staff and also by peers. The sessions in question were not part of the assessment, and encouraging free conversation without the students feeling they are being monitored is an area for future consideration.

It would appear that an important factor influencing readiness to engage with technology was the instructions and guidance given to participants. In Case study 3, where students were given little guidance on the use of video, and where the use of video was discretionary, relatively little use was made of the ability to record. Use of video recording and the table surface tended to be regarded as an overhead where the learning curve and effort of use was not outweighed by the benefits.

> *'the screen on the table top became a space to discard what we were not looking at.'* [Case study 3 participant]

In the other case studies, however, recording was more strongly encouraged and supported by tutors, and was therefore used and accepted more readily. [Supported by in-class observations, and after-class interviews, particularly in case studies 1 & 2]

Reliable, trustable capture of conversations was a key element, allowing students to engage without the distraction of note taking, and supporting later reflection and sense-making;

- To a much greater degree than was initially anticipated, reliability, especially of the capture and recording mechanisms, was vital for producing trust and confidence that allows students to accommodate the technology into the routine of their learning practice. If students are certain that sessions will be recorded and delivered via the blog, and that the audio, video and still photographs will be of sufficient quality, then they can start to modify their activities in class (e.g. by taking fewer notes, or making notes on the table surface) and afterwards (e.g. by planning to review the session, either individually or as a group). In one of the studies, video recording was working poorly in the first session. The result was a lack of trust in the recording infrastructure, trust that proved hard to restore subsequently. [Supported by interview comments in Case studies 1-3.]
- Usability is essential, especially if use of technology is discretionary. Easy access to recordings is a key to supporting later reflection. Minimising the time and effort associated with the technology, especially for recording sessions in-class, proved to be important, especially during the switch from the crit for one student to the next in a busy session. Once configuration and reliability issues with the server and related infrastructure were resolved, the Apple Podcast Producer system proved to be very easy to use. [Supported by interview comments, in all Case studies.]
- An unanticipated mode of use of the technology arose when students wished, outside of the scheduled class sessions, to make use of the recording and projection technology. The packaging of the main technology elements (computer, wireless

networking, webcam, projector) into a Pod allowed students to borrow everything they needed to set up an impromptu information space that allowed them to conduct and capture meetings, design discussions, and reviews of crits that had taken place.

> *"[After the crit sessions] we usually get coffee, sit down then [we] talk about our projects, what we all think, view stuff on the blog and discuss … [we] help each other and think about what was said [during the crit sessions] and give personal opinions … [these informal sessions] make us feel closer"* [Case study 2 participant]

In case study 3, although the pods themselves were not portable and usable in other spaces, the overall space and the technology in it could be booked outside of scheduled class times. Students did make use of this facility in order to continue brainstorming and design discussions.

[Supported by observations and interview comments in Case study 2.]

Providing structure and constraints in a conversational setting (e.g. through the use of simple timers to demarcate the different phases of a conversation) proved effective in making conversations time-efficient and focused.

- Structuring and managing conversations can facilitate rather than stifle conversations. The Flash timer used in crit sessions proved to be highly effective in managing crits and helping sessions to run to time. More surprisingly, rather than proving to be onerous or unduly restrictive, the timer and the discipline it encouraged proved to be popular with students and tutors, allowing sessions to be more focused and useful. Interestingly, conventions emerged about the way the timer allows and legitimises certain actions.
- For instance, one such convention was that when a crit is in the reporting phase, the student reporting should have the floor, uninterrupted. Once the timer 'ticks over' into the discussion phase, then others may interject. It was observed that, during the report-back, tutors and other students may use written notes on the table as reminders of points to raise in the subsequent discussion, and these notes will often cross-refer to the annotations of others.

  [Observations, especially in Pilot study with Interaction Design students and in Case study 2.]

Lessons for technological setup

In the course of the case studies, a number of technical issues and difficulties were encountered, and these are simply enumerated below.

Integration with existing systems: Although the information space technologies were often operated in isolation and separate from rest of the institutional infrastructure, clear potential exists for greater integration. One potential area is to integrate the delivery of captured video into existing VLEs, and this was explored in Case study 3, where videos were delivered through Moodle. Where Moodle is used routinely for other aspects of learning, this route is potentially highly convenient for students. However, there is likely to be a greater overhead involved in recording and uploading videos. Another area where integration could be a benefit is in the management of student accounts and logins. Although not investigated here, it clearly would have been beneficial if the podcast production and blogging system were integrated with the institution's Directory system that manages student login accounts.

Another aspect in integration is that the information space should be integrated into the wider digital world, by providing access to all of the facilities one would normally expect in a networked environment. For example, easy access to the web, VLE content, relevant lecture notes, as well as blogs and records of previous sessions, and so on proved to be important.

Audiovisual setup: a number of issues and challenges arose around the use of audio and video. One of the most troublesome was ensuring that audio recordings were of sufficient quality and were not susceptible to background noise (significant in a lively class) and the hum of computer and projector fans. The key issue here was the choice of microphone, and an adequate and relatively cheap (though slightly cumbersome) solution was the use of wired boundary microphones placed on the table. An alternative solution that appears more convenient (though is sometimes less reliable) was to use wireless bluetooth microphone/speaker combinations intended for telephony and conference calls.

Video recording was also an important issue, with the choice of hardware again being significant. However, relatively cheap webcams proved more than adequate for recording activity in a design crit session. Such a camera, however, is inadequate for recording the detail of writing on a table, and so video recordings were routinely supplemented with still images taken with a compact digital camera and uploaded to the same blogs as the video podcasts. Videos and still images appear to routinely present problems for projection: careful setting of the display profile (on a Macintosh, at least) is essential in order to project images that are clear and bright enough to be useful.

Display technology: While a projected on-table display can be a highly effective way of creating a shared resource to which a group of learners and tutors can orient themselves, it, the size and quality of a display can affect its usefulness. When large amounts of visual materials are being used (for instance, when a student in a highly exploratory phase of a project is collecting example materials and sources of inspiration to show to the group), a much larger and better quality display area would be a significant improvement. As discussed above, some of the quality issues can be addressed by careful adjustment of the display profile, but in the end, a larger, higher resolution display will be needed.

Packaging technology: As has been mentioned elsewhere, the decision to package the technology used in class for display and capture into a 'pod' proved very effective, allowing a degree of portability and flexibility, as well as allowing students to take control and use the pods outside of scheduled classes. Many options for this kind of technology package are possible, and the specific combination used here (Mac Mini, Apple Bluetooth keyboard and mouse, Logitech Webcam, InFocus projector) is less important than the general idea. Indeed, technology, especially projection technology, is developing extremely quickly, with newer and better performing products becoming available all the time, so it would be unhelpful to make specific technology recommendations here.

The software and server elements of the package are also worth noting. The decision to use Apple's server technology and the Podcast Producer framework was highly beneficial during the project. However, other frameworks and products are now available that may offer similarly convenient functionality in a way that is more flexible and integrates more easily with other blog, server, or VLE technology. An example of this is Kaltura[10], which would be an excellent candidate technology for developing the approach in future.

Overall strategy: Some of the key elements of the overall approach were providing low-tech innovations that allow a mix of physical objects and digital materials, traditional and more novel tools, appears to have been successful. A deliberate decision was made to not

[10] http://corp.kaltura.com

include digital, touch sensitive surfaces and similar technologies[11] as core elements of the technology, as these would tend to reduce the ease with which physical artefacts could be brought into the conversation, or traditional writing with pens could support and annotate it. While this approach has been successful in preserving the convenience and ready-to-handness of physical objects and traditional tools while adding the convenience and persistence of digital media, it would be appropriate in the future to explore the addition of other technologies. For instance, controlling table-based displays through touch or the use of infra-red pens would be both technically feasible and would allow several people to work collaboratively without the constraints of a single mouse and keyboard.

While not a core element of the technology, the project did pilot the use of a touch-sensitive surface to support group working and team discussions. A prototype table surface, known as Mezatop was developed and tested.[12] One of the limitations of Mezatop, and of a number of similar devices when used in the context of a project like ISCC, is that the usable display area is relatively small when compared to typical whiteboards, tables and projection screens, and might therefore be restrictive as a tool to support design, brainstorming, and so on.

Mezatop multi-touch surface in use by a group of users.

Logistics and constraints: Important constraints exist in most institutions that may limit how technology can be installed. In one of the studies, health and safety and other constraints dictated that the pods had to be permanently attached to the ceiling, which limited the flexibility of the configuration (e.g. pods couldn't be loaned to students or moved to other locations), and sometimes less convenient (e.g. when computers in the pods needed to be restarted). In another study, however, the constraining factors were fewer, and a more flexible setup was possible.

An overall lesson is that one should to be prepared to set up a space differently depending on the requirements (e.g., for flexibility and portability) and constraints (e.g. health and safety, listed buildings, and similar regulations).

3.3. Impact

The key, and most obvious, stakeholder groups whose activities have been affected by the project interventions are the students and tutors involved in the case study programmes. Both these groups have benefited, in varying degrees, across the different case studies, from the interventions in the anticipated way. The technology along with the pedagogic approach that it supports, of learning through conversations with tutors and peers, appears to allow student so become capable practitioners able to communicate their ideas. Providing students with a record of the conversations through which critical feedback has been constructed, provides students with a resource for reflection and understanding that would otherwise not exist. The interview study has shown that students do make use of this provision and do find it to be a valuable way of conducting their work and learning from feedback and critical intervention. However, making a comparison with what went before is problematic for several reasons that have been

[11] Such as the Microsoft Surface or MERL Diamond Touch interactive tables.
[12] See http://mezatop.com

discussed elsewhere (though clearly when pedagogic approach, supporting technology, and content of the students' work are all subject to evolution, making comparisons over time is highly difficult and unlikely to yield insights).

This project has been part of an ongoing process of making a conversational approach to learning a more embedded part of a number of modules and courses, across at least some of the case study sites. Accordingly students will continue to feel the benefit of this approach in the case study modules in future runs and in other modules (for instance, the third year module that follows on from the Case study 1 module is adopting a similar approach). Also new members of staff are beginning to adopt the approach (e.g. Product Design and Computing tutors at Middlesex who were not involved in the project are exploiting the technology and the underlying approach in their classes in the current academic year and beyond the lifetime of the project).

At City in particular, the opportunities offered by the ISCC technologies have been communicated widely through stakeholders with an e-learning responsibility, and this, combined with the closer integration with both the physical infrastructure and the corporate VLE has generated interest from others seeking to adopt or trial a similar approach.

4) Conclusions & Recommendations

Providing simple, unobtrusive technologies for display, annotation, capture and delivery can help to encourage conversation in a learning situation. Key elements here are: the provision of a shared and writeable display surface that affords a more conversational way of working than tends to be the case with 'presentation-style' displays; a simple means of capturing the discussions that take place; a mechanism for reviewing and replaying the captured conversations as an aid to subsequent reflection.

Allowing a mixture of physical and digital artefacts and providing means interaction through an appropriate combination traditional and high-tech tools allows immediacy (e.g. of writing with a pen) as well as the benefits (e.g. persistence and the ability to replay) of digital media.

Structuring and managing conversations (e.g. by using a timer and by dividing a conversation into time-limited phases) can facilitate rather than stifle the encounter between a student and their tutors and peers.

Multiple surfaces (e.g. horizontal vs. vertical, projectable vs. non-projectable) afford different activities that reflect the different types of information present in a design space, and the different ways one interacts with this information.

Ensuring reliability and usability, especially of the capture, recording and delivery mechanisms, is vital for producing the trust necessary for learners to engage effectively. Unreliable recording technology sends a clear message students should take notes or make their own recordings, thus creating a reason for disengagement from the conversation. Difficult-to-use recording and playback mean that recordings may not be made or may not be used afterwards.

Across the studies, a wide variation was observed in students' readiness to engage with the technology and with the conversational mode of designing and learning. Several factors were found to better prepare students to make effective use of the conversational spaces: commitment over several modules and over a period of time to a discursive way of working (e.g. Product Design students work on similar project activities throughout their degree, working with greater autonomy as they progress); communicating a clear purpose for the technology, so that students know why they are using it (e.g. in Case studies 2 and 3, videos were made available for later reflection and review); clear instructions on how

to use the technologies (e.g. a set of guidance notes for students and tutors have been prepared based on reported difficulties faced by students in the Case studies 1 and 2).

5) Implications for the future

Continued dissemination (e.g. at conferences in the new year, such as EPDE'11, which is highly relevant to the project), both to the research community working in areas such as design education and the design of collaborative technologies. In addition it is hoped that approach of the project can be publicised, through workshop-style presentation, to a larger audience in design teaching community. We are fortunate, at Middlesex, that the Researcher working on the project will be continuing in an Academic Assistant role, funded by the University. This will allow her to further develop the technology and pedagogic approach over the current academic year.

Enhanced information space setup that will be used during the current academic year. The new setup provides a more reliable platform with more useful and effective display capabilities.

Further development of the physical and technological setup has been supported by the School. One of the limiting factors identified in the case studies was that for certain activities (e.g. elements of a product design project where students have large amounts of visual material) having a large, high-quality projection on the table surface is important. Progress has already been made on constructing a more substantial information space setup that incorporates multiple projections and video recordings and a larger table projection using a wide-angle projector (such projectors having reduced in price substantially during the course of the project). The space will be further enhanced with more usable control mechanisms, including infra-red pen-based devices to interact with the displayed content (for instance using the Nintendo Wii controller and Wiimote Whiteboard software). Similar developments of the software elements will also continue. For instance, in an ongoing trial, the current blog arrangement is being supplemented by using the Prezi[13] product, which will give students a way of organising elements of digital content in a virtual space – analogous to a virtual whiteboard or table – for use as resources in a crit conversation. Product design students will use the enhanced space for crit and review sessions early in 2011.

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[13] http://prezi.com

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7) Appendixes

7.1. Appendix A: Concerns and themes in video analysis

The analysis of video in Case studies 1 and 2 did not begin with a formalised coding scheme, but was rather informed by a broad set of concerns and themes. The initial set of concerns included the following:

Use of technology during sessions

Use of recorded video (high demand at TP, very low demand at Hendon)

Frequency of use of blogs

Technical constraints

Personal constrains (student readiness)

Design phase and use of technology

Use of available space (private vs public)

Conditions for Collaboration. Crook (1998) & Engestrom (1992) discuss "three levels of interaction that are central to successful collaboration":

- Intimacy among participants
- Rich supply of external resources
- Histories of joint activity of those interacting

Patterns of collaborative action:

- Agreement
- Disagreement
- Generating new ideas
- Supporting new ideas
- Interruption.

7.2. Appendix B: Interview plan in Case study 1 & 2

The following questions and issues guided the conduct of interview and focus group sessions in Case studies 1 and 2.

General

- What do you think of the idea of recording the crit session, and having writable surface, blogs, etc?

Conversation

- How comfortable do you feel to participate during the recorded sessions (probe around if recording stopped them from saying an idea or vice versa)?
- How formal do you feel it is (crit sessions with tutor(s) vs group meeting)?
- Do you take notes during the crit session, if yes why?
- Does your note taking habits ever changed since the beginning of the term?

- What motivates you to participate the most?
- Technical setup and physical layout?
- Is it useful?
- What would you prefer to have, regardless what is feasible and what is not?
- Standing vs. sitting crit sessions?
- Shape of table and where to sit?
- Before and after Crit sessions?
- Do you prepare for a crit session, if Yes how?
- What do you discuss straight after the crit session?
- Do you go back and watch the video (if yes when)?
- Did the video ever helped? Do you remember a specific example?
- Do you find the high resolution pictures useful, do you check them?

Blogs

- Do you use blogs?
- Do you use the personal, group blogs, or both (use each for what)?

7.3. Appendix C: Online questionnaire used in Case Study 3

The following questions were asked, in the form of an online questionnaire on moodle to the students in Case study 3. The questions are based on the Creativity Support Index framework discussed above in Section 3.1, as well as on more general understandings of creativity and the process of creative design.

Answers to questions 1-6 were given as ratings on a scale from "Highly disagree" to "Highly agree".

1. It was easy for me to explore many different options, ideas, designs or outcomes using the pods

2. The pods allowed other people to work with me easily

3. When I was using the pods, I was very engaged in the activity - I enjoyed using them and would use them again

4. What I was able to do was worth the effort I had to exert to do it.

5. My attention was fully tuned to what I was doing while using the pods, and I forgot about the pods themselves*

6. I was able to be very expressive and creative while using the pods*

7. Which phases of the creative process do you think were best supported by the pods (tick all that apply)?

Preparation

Incubation

Illumination

Verification

8. Which kinds of creativity do you think were best supported by the pods (tick all that apply)?

Exploratory

Combinational

Transformational

9. In the pods, what activities did you use each of the surfaces for and what information did you put on them?

10. What, if anything, were you able to do with the pods that you could not do with other tools or environments?

11. What were the best and worst things about the pods? How would you improve on them for next year?

12. Do you think you or your team mates ever suffered from evaluation apprehension while using the pods? Can you give (anonymised!) examples? How could this be prevented?

13. Do you think you or your team mates ever suffered from production blocking while using the pods? Can you give examples? How could this be prevented?

14. Do you think you or your team mates were ever social loafers while using the pods? Can you give examples? How could this be prevented?

15. How did you share media and communicate with other group members between sessions? What were the best and worst things about this?

16. Did you find the videos of pod sessions useful? If so, how did you use them? If not, why not?

17. If you have any further comments about any of the technologies you used in this course, please add them here.