Abstract: This paper describes the iterative development of a novel design studio space, the Educational Design Research Studio (EDRS), to support research of groups of designers working collaboratively on authentic educational design tasks. EDRS research aims to provide a rich description of how collaborative educational design is mediated by tools, space, people, and artefacts. This paper aims to provide insight into the theoretical and practical aspects of developing a novel research and work space that supports educational designers.
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Introduction

Educational design is a complex challenge that can be undertaken by both individual designers or teams (Ertmer, Parisio, & Wardak, 2013). Educational designers can be practitioners engaged in educational design activities (for example teachers or librarians), or by professionals (for example instructional designers, educational designers, or curriculum designers) who do not implement their own design. Especially the process of collaborative educational design conducted by interdisciplinary teams is not well understood.

This study explores setting up a design studio to study collaborative educational design work. Design studios are well established as settings for collaborative work in creative disciplines, such as architecture, art, and product design (Boyer, Cook, & Steinberg, 2012; Cennamo & Brandt, 2012). Donald Schön (Schön, 1987; Schön & DeSanctis, 1986) suggested that the architecture design studio could serve as a model for a wide variety of disciplines. However, the design studio approach has not been well studied for collaborative educational design.

Design studios can serve as working spaces, research spaces, and learning spaces. Design studios can provide a constructivist learning environment where students can learn the design methods of a discipline, for example in architecture. For certain professions such as architecture, engineering, or software design, learning in a design studio serves as a preparation for a similar future work environment while for other design professions (such as educational design) design studios are novel environments.

Design studios can facilitate the creation alternative solutions through multiple perspectives, foster designers’ to feel ownership for their learning, establish process oriented learning strategies, practice design as a social activity, and use various modes of representation
Adler et al. (Adler, Eisenstein, Oltmans, Guttentag, & Davis, 2004) suggest that design studios need to support multimodal expressions including sketching, speech, and gestures.

Working in a design studio differs from other environments in several aspects: Design studios are dedicated team spaces where shared artefacts can be generated, displayed, and stored. Design tools (both physical and digital) are readily available. Design studios aim to provide a safe space for learners to deal with uncertainty and the iterative process (Spendlove, 2007a, 2007b) in a supporting environment that encourages creative thinking and tolerates failure (Warner, 2003). Design studios provide users with spaces for experimentation, frequent formal and informal critique, and physical and digital tools to work collaboratively on complex design problems (Cox, Harrison, & Hoadley, 2009). Establishing discussions of different designs can foster new ways of seeing the problem space (Bruton, 2007) (p318).

Design studios provide a space to work on projects that are similar to those experiences in professional practice. Studios aim to enculturate participants by modelling how to think and act as professionals in their field. Design studios can provide a space to explore alternative instructional design models (Clinton & Rieber, 2010), for example rapid prototyping. Different from linear design processes, proponents of rapid prototyping suggest that a deeper understanding of a design problem is incomplete without creating and evaluating some forms of prototype (Littman & Kelley, 2005; Tripp & Bichelmeyer, 1990). Rapid prototyping suggest to verify key features of design ideas through an iterative process of building and testing small-scale low-resolution prototypes. This prototype is explored and tested in an effort to get a better handle on the requirements of the larger system. Rapid prototyping is used in a variety of design fields such as software design, architecture, product development, user experience design, etc. (Pershing, 2006; Piskurich, 2006; Saettler, 2004).
Design can be described both as a process or a product (Smith & Boling, 2009). This study focuses on design as a process which can be defined as “a goal directed, problem-solving activity (Archer, 1965; Rowland, 1993), which results in the creation of something useful that did not exist previously (Resnick, 1965). Design activities occur in a complex conceptual space in which tensions between opportunities and constraints need to be resolved (Cross, 2007).

Recent research supports the view of design as an universal activity through studies that suggest that much of what designers do is common across domains (Blackwell, Eckert, Bucciarelli, & Earl, 2009; Eckert, Blackwell, Bucciarelli, & Earl, 2010). For example, Eckert et al. (, 2010) found designers of different domains described design as a “conversation” with materials and tools. Interestingly, designers from different fields were able to comprehend each other even when unfamiliar terminology was used. Simon (Simon, 1969) stated that “design is the core of all professional training” (pp. 55-56). Designers are be described as adaptive experts who can perform routine skills efficiently, but also understand the meaning and the nature of the objects that need to be designed (Hatano & Inagaki, 1986).

Instructional design (ID) takes a design perspective of education. Instructional Design as a discipline rests on the foundations of (1) a systems design model for managing the instructional development process and (2) theories that specify what high-quality instruction should look like (Reigeluth, 1983, 1987). Traditional ID is largely based on behaviorist premisses translated into primarily linear processes as exemplified by the widely used ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. Most of the current instructional design models are variations of the ADDIE model (Piskurich, 2006).
Cognitive psychology questions the recipe-like prescriptions found in traditional ID theories (Bednar, Cunningham, Duffy, & Perry, 1992; Jonassen, 1991). In reality, the problems to be solved by educational designers are ill-structured, complex, wicked, and open-ended that cannot be reduced to a simple set of procedures (Jonassen, 2008, 2010). For any learning problem, there can be potentially infinite numbers of design solutions and solution pathways. Silber (Silber & Foshay, 2009) similarly argues that educational design is not a linear process and that designers have faced difficulties trying to apply educational design models, such as the ADDIE model, in both a linear and non-linear manner. The reason for this, he argues, is that educational design is not a systematic procedure at all, but a set of principles and a way of thinking about design problems. Educational design problems require a context-sensitive dialogue between the designer and the context (Rowland, 1993). More flexible approaches are needed to meet the requirements of complex and quickly developing learning environments. This extended perspective of instructional design can be described as educational design. Educational design includes instructional design, educational space design, online learning environment design, etc. Goodyear defines educational design as “the set of practices involved in constructing representations of how to support learning in particular cases” (Goodyear, 2005). Educational design can be understood as a subset of design (Rowland, 1993) which is being “directed toward the practical purpose of learning, i.e., the designer seeks to create new instructional materials or systems in which students learn” (p. 87). In educational design, tensions between goals and constraints arise from conflicting learning outcomes, graduate attributes, constrained resources and time, and students’ needs (Bird, Morgan, & O'Reilly, 2007). Rather than following a linear recipe for design, educational design requires a flexible framework of heuristics that connect all levels of the product. Alexander’s design patterns (Alexander, Ishikawa, & Silverstein, 1977;
Alexander et al., 1997) refer to heuristic solutions to a recurring problem in a context. Design pattern originated from ill-structured problem solving in and have since been adopted by other disciplines, e.g. software design. The goal of design patterns is to create a shared terminology to connect different levels of constructing solutions to a problem. Select design patterns can be combined to form a pattern language.

**Research questions**

There are many alternative normative models for educational design than there are empirical studies of actual design activity (Hoogveld, Paas, Jochems, & Van Merriënboer, 2002). This study describes the iterative development of a novel design studio space, the Educational Design Research Studio (EDRS), to systematically study groups of designers working collaboratively on authentic educational design tasks. EDRS research studies aim to provide a rich description of how collaborative educational design is mediated by tools, space, people, and artefacts. Educational designers need design tools and spaces that support fluid design processes. A design space needs to give educational designers easy access to design tools and the environments their designing for (for example online learning environments). Studies of collaborative design in the dedicated EDRS space aim to provide rich descriptions of collaborative design-for-learning (by educational designers) and learning-by-design (by students) processes. Design-for-learning (DFL) (Goodyear, 2005; Laurillard, 2002) is a growing area of research as technology-enhanced learning environments are gaining in importance in all levels of education (Ellis, Steed, & Applebee, 2006). Understanding how educational designers collaboratively design learning environments for flexible delivery is increasingly important. Design-for-learning promotes a shift from belief-based approaches to design-pattern based approaches and a shift from content
(teacher activity) focused thinking to learning outcome thinking. *Design for learning* (DFL) often involves the assemblage of various elements, for example, combining knowledge, ideas, pedagogical strategies, roles or tools in a lesson. Educational designers are likely to select elements that may have been previously used or are perceived as potentially productive in a given learning context. However, in order to successfully re-use designs, it is important that one understands the interplay between tools, tasks, social elements, and the influence of these elements on emergent human activities. DFL involves recognizing what and how design elements influence activities that are of significance for learning. Learning-by-design (LBD) is a project-based approach to learning which combines elements from problem-based learning and case-based reasoning (Kolodner et al., 2003).

This case study aims to provide a rich account of the collaborative design process of creating a new research facility for educational design. By triangulating multiple sources and methodologies, this research aims to answer the question of how an interdisciplinary team reframes problem and solution spaces of creating the EDRS facility through iterative co-configuration of the design components set, social, and epistemology.

**Data collection**

Data was collected over a period of eight month by the author from the minutes of weekly team meetings, artefacts (word documents, excel spreadsheets, diagrams) created in planning sessions, reports from prototype testing, personal field notes, and photos of the EDRS.

**Framework of analysis of EDRS design process**
The analysis of designing the EDRS uses Carvalho and Goodyear’s framework (2013) that suggests the use of an architectural framework to guide the analysis of complex learning environments. This analytical framework distinguishes three initial components of design: a) set design, b) social design, c) epistemic design which are then iteratively adapted through co-creation and co-configuration activities.

- Set design focuses on the physical material and digital elements that compose the setting for the design activities. It may include the tools, resources, artefacts and affordances of place.
- Social design focuses on the social arrangements and roles (divisions of labour), who is expected to do what, and with whom.
- Epistemic design focuses more directly on the shaping of activity, including the tasks and goals.

The co-creation and co-configuration dimension describes how aspects of the design object (set, social, epistemic) are customised, reconfigured and adapted by educational designers, and how the initial configurations of the design was shaped and re-shaped by participants of the design process.

**EDRDS set design**

The development and implementation of the first iteration of the EDRS took place over eight month in the offices and meetings rooms at the Centre for Research on Computer-based Learning & Cognition (CoCo) at the Faculty of Education and Social Work at the University of
Sydney. The newly created open-floorplan office for CoCo doctoral students and postdoctoral research associates facilitated frequent flow of information through impromptu discussions among team members. Research suggest that the physical work environment can influence creativity (Ceylan, Dul, & Aytac, 2008; Vithayathawornwong, Danko, & Tolbert, 2003). Studies of office designs of large companies indicate a shift from cubicles towards flexible open spaces that encourage socialisation (van Meel & Vos, 2001). In the book ‘The Art and Management of Creativity’, John Kao states that work space design is one of the main instruments to create a creative work environment (Kao, 1997). For formal and longer meetings, team members met in the CoCo meeting room (while the EDRS was still unfurnished) and in the EDRS itself later on. Senior lectures and faculty members continued to use individual offices.

The room available for the EDRS was former computer lab located on the same floor as the CoCo offices. The EDRS room is a rectangular window-less room measuring 4.8m by 6.9m (48.5 square meters). At the beginning of the EDRS development, the room contained several cubicle desks, old computer equipment, a projection screen, and a ceiling-mounted television. Before the room could be turned into a state-of-the-art multi-media design space equipped with tools for educational design, the old furniture and electronic equipment had to be removed. Some cubicle desks could be moved to learning spaces at the university library while the electronic equipment had to be recycled. The affordances of the room (long narrow layout, no windows) provided challenging constraints for the EDRS development, which aimed to create a warm and inviting space. Many design offices feature large windows and natural light. To compensate for the lack of natural light, the EDRS would use warm colours and daylight-frequency lighting.

Designing the EDRS included designing both the physical space (e.g. carpet, lighting, furniture), physical design tools (e.g., pens, paper, post-its, butcher paper), recording devices for researchers
Designing a design studio  

Schwendimann (2013)

(audio, video, and screen recording), digital design tools (e.g. projectors, interactive whiteboards, webcams, computers), digital spaces to create, share, and store artefacts (e.g. Google docs, Skype, drawing software), and digital storage and backup solutions for recordings.

Social Aspects

The EDRS is a research facility developed for Peter Goodyear’s Laureate Fellowship project. The Laureate Fellowship research group consists of the principal investigator, three postdoctoral research associates, and five doctoral students (see figure 1). The Laureate Fellowship team is part of the larger CoCo group (CoCo2002) at the Faculty of Education and Social Work at the University of Sydney. Since 2012, CoCo is affiliated with the centre for the Sciences and Technologies of Learning (STL) (“Science and Technologies of Learning (STL),” 2012). The EDRS was developed as a collaborative project by people in various roles, including principal investigator, postdoctoral researchers, doctoral students, research assistants, and diverse internal and external consultants. The EDRS development team consisted of a postdoctoral researcher (Beat), who lead and supervised the development, and two doctoral students in their role as research assistants (David and Martin). Other members of the Laureate Fellowship group supported the EDRS development team by identifying needs of researchers and potential users, brainstorming and selecting ideas, and aiding in testing prototypes. During different phases of the EDRS development, the core team was assisted by consultants on different aspects of the room. Ideas for room design (e.g. colour schema, furniture choice, furniture arrangement) were contributed by a doctoral student with a design background (Pippa) and a professional web-designer (Dorian). During the ideate phase, an external architect (Vesna) was hired to develop different layouts and stylings of the room. During the prototype phase, craftsman (e.g. painter
and electrician) offered their expert opinion on different design ideas. A vendor for security cameras provided information needed for making decision regarding the camera setup for the room. Members of the EDRS core team met with university staff from different departments for input on camera setups and learning space design.

The design is a complex process as it cannot be reduced to independent parts. The complexity of the process requires collaborative work of a multi-disciplinary design team whose members contribute different skills, viewpoints, and expertise. Team members took on different roles during the design process. The Laureate Fellowship group uses a flat hierarchy with a participatory model. The decision-making process did not follow a strict protocol but varied on a case-by-case basis. Planned expenses had to be signed off by the principal investigator. However, decisions what to buy were made by members of the team depending on their expert knowledge. Furniture was selected by the design consultants (Pippa and Dorian). Decisions regarding camera and audio equipment were made by the technical assistants (Martin and David). The postdoctoral researcher on the EDRS core team (Beat) supervised the development process and ensured alignment of decisions with identified needs, design patterns, and constraints. Members of the team reported back to the Laureate Fellowship group in weekly group meetings during which different options were discussed. Additionally, team members discussed ideas for the EDRS in weekly individual meetings with the principal investigator (Peter). The EDRS core team met as needed (sometimes several times a week) to generate ideas, evaluate ideas, and develop and test prototypes ideas (which was facilitated by the shared open-floorplan office layout).
Goals of EDRS studies

The goals and purpose for the Educational Design Research Studio facility were outlined by Professor Peter Goodyear's Australian Laureate Fellowship proposal. Research conducted in the Design Studio aims to help provide a richer understanding of collaborative design-for-learning activities of small teams of people working on existing or new educational design problems, using both their own approaches and ones that the researchers make available. As a research facility, the EDRS is equipped to make high quality audio-visual recordings of all
members of the design teams, sufficient to transcribe and/or annotate key passages in the design process, and to playback such passages for stimulated recall debriefings with the designers. The Design Studio can assist by capturing the design discourse, gestures, expressions and other important elements of non-verbal communication within the design team, and the evolving state of their design artefacts. Two unique elements about EDRS research are using a studio setup to study educational design, and studying groups of educational designers (instead of individual designers). Therefore the question arose: How can we make use of the affordances of the design studio space to study and facilitate collaborative educational design work.

The goal of our research is to develop a deep understanding of collaborative practices of design-for-learning and improve learning-by-design by providing better tools and methods that are consistent with current scientific understanding of how people learn. EDRS research will use constructs from activity theory and is influenced by anthropological studies of traditional work practices and participation in communities of practice (Lave & Wenger, 1991; Rogoff & Lave, 1984; *Understanding Practice: Perspectives on Activity and Context* *Learning in Doing: Social, Cognitive and Computational Perspectives* *Learning in Doing*, 1996; Scribner, 1985; Wenger, 1998), naturally-occurring and artificially-created knowledge-building communities (Bereiter, 2002; Bereiter & Scardamalia, 2003; Goodyear & Zenios, 2010; Kovalainen & Kumpulainen, 2005; Lai & Law, 2006; Scardamalia & Bereiter, 1994, 2006), and networks (Barton & Tusting, 2005; Dirckinck-Holmfield, Jones, & Lindström, 2009; Dong, Kleinsmann, & Valkenburg, 2009; Jones & Steeples, 2002). Data collection will include discourse, gestures, artefacts construction, tool usage, and space usage. These rich datasets will allow us to triangulate the complex interactions during collaborative educational design work.
Research in the EDRS will combine three different research paradigms which differ in their goals and in the amount of prescriptiveness:

1) In the self-directed, observational studies, groups of designers will be working on their own projects using their own tools, scripts, and representations. The research goal for this condition is to gain a deeper understanding of existing collaborative educational design practice. Findings from studying self-directed design will inform the development of methods and tools for the experimental studies.

2) In the experimental studies, participants will receive tools and methods provided by the researchers. These scaffolds will be informed by the previous set of studies, but may include tools to support the design process such as instructional design tools, or alternative design processes. Experimental studies investigates certain aspects of the design process in quasi-experimental settings, e.g. roles, representations, and tools. Participants will be assigned design tasks that are complex enough to require collaboration and division of labour (roles). Different forms of representations can be given to support educational design tasks (Conole & Fill, 2005). Analysis of the data emerging from experimental studies will highlight areas of the design challenge where uncertainties about operational details cause educational designers significant problems. Subsequent design studies, will focus on developing appropriately calibrated design abstractions, to make the design process more efficient and effective.

3) In the design studies, the goal is the iterative development of a collaborative instructional design methodology that uses the affordances of the design studio. There are many different models of design. Dubberly (Dubberly, 2004) distinguished over 100 different models for design, from architecture, industrial design, and mechanical engineering to quality management and software development. Design models range from short (e.g. the 4Ds: define,
design, develop, deploy) to complex models (e.g. Archer’s 9-phase, 229-step “systematic method for designers”). Many models are synonyms for the same processes, while others represent differing approaches to design (Mendel, 2012). In education design, most of the current instructional design models are variations of the linear ADDIE (Analysis, Design, Development, Implementation, Evaluation) model (Piskurich, 2006). Silber (2009) argues that designers have faced difficulties trying to apply educational design models in both a linear and non-linear manner. The reason for this, he argues, is that educational design is not a systematic procedure at all, but a set of patterns and a way of thinking about ill-defined problems. In particular, the process of collaborative educational design conducted by inter-disciplinary teams is not well understood. Design studies in the EDRS aim to address the question what tools, spaces, and social settings can provide flexible scaffolds for collaborative educational design activities.

This rich data set will allow the multi-level analysis of patterns of collaboration in design teams and the role of new tools, methods, and artefacts in design. Data analysis will focus on three different areas:

- **Tools**: Usage of tools (including both physical and digital design tools); usage of digital and physical space; conceptual constructs (affordances and usage of alternative visual representations; design patterns).

- **Tasks**: stages in the design process; relations between thinking about design and thinking about implementation; the status and utility of design rationales

- **People**: focuses on roles and facilitation of the design process.

The outcomes of these three sets of studies will be reported in journal articles aimed at researchers in the design studies community as well as those with more specific interests in educational design, pedagogical thinking and the learning sciences.
Design patterns

The empathise phase identified needs of researchers and potential users. The define phase built on these observations to identify design patterns, goals, and constraint for the development of the EDRS. These five design patterns below are heuristics that connect all levels of development of the EDRS facility. Design pattern were proposed by Alexander as solutions to recurring ill-structured problems in a particular context (Alexander et al., 1977; Alexander et al., 1997). Design patterns have been applied to a wide range of areas, from architecture and software design to educational design (Chatteur, Carvalho, & Dong, 2008; Goodyear, 2005; Goodyear & Yang, 2009; Retalis, Georgiakakis, & Dimitriadis, 2007). The goal of the EDRS design patterns was to create shared solution-problem pairings and a terminology to connect different levels of the EDRS design and serve as anchoring points for the decision-making processes. In combination, the five design patterns can form a pattern language.

The goal is to make the EDRS warm, comfortable, and inviting; to provide a customisable, multi-purpose space in which designers will want to work on short-term to long-term projects. The rationale for the design studio builds on five design patterns:

- **Flexibility.** For researchers: Flexible setup allows investigating a broad range of research questions. For designers: Flexible setup allows for the accommodation of different groups of designers, meeting specific needs (for example: teachers, web-designers, engineers, architects, and museum exhibit designers). Flexible room design allows fluid switching between different group settings. Different groups of designers might work in different ways, so the design studio needs to support quick customisation (by users or researchers). Given the space limitations of the design studio, the space needs to be multi-purpose to
function in different ways at different times. Different furniture arrangements and tools allow quickly customisable setups, enabling fast switching between whole and small group work; or switching between formal and informal settings. The Design Studio aims to support design projects from the short-term (a few hours) to long-term (several days to weeks).

- **Fluid usability:** The Design Studio contains different tools to support design for learning. These can include physical tools (e.g. paper, Post-its, butcher paper, whiteboard walls, etc.) and digital tools (interactive white board, tablet computers, laptops, etc.). One goal of the design studio is to allow users to switch from one tool to another, intuitively and fluidly, providing opportunities to present, investigate, manipulate, and store designs in different forms. Tools need to fluidly and intuitively connect between each other (for example, data transfer between computers, handheld devices, and interactive whiteboards) to minimise initial familiarisation phase and support effective design work. Tools need to support both short-term and long-term projects, for example in long-term projects it becomes important to store and retrieve digital and physical artefacts in each design session. It is intended that the style of the EDRS will be neutral, un-distracting, minimalist, and non-prescriptive. In addition to tools provided, designers can bring their physical and digital design tools.

- **Research centred:** The Design Studio is a research space, equipped to study collaborative design for learning. The design studio aims to meet the needs of a variety of different research projects (qualitative/quantitative; small/large group studies; short/long term studies). The room is equipped to capture, track, and store high-quality audio and video data of design processes and digital and physical artefacts.
• **Designer centred:** The Design Studio aims to meet the needs of a wide range of designers. Different physical and digital tools are provided to support effective collaborative design work. The room aims to provide an inviting, comfortable and flexible work environment. To investigate the needs of design teams, we plan to have a minimal initial setting for EDRS. Findings from the pilot study will inform the revision and upgrade of the EDRS.

• **Mobility:** The design studio will be gradually developed in iterative phases (following a design-based research and rapid prototyping approach). As the design studio could be moved to a new facility in a future stage, installations in the room should be moveable.

**Needs of researchers**

Based on a human-centred design process, the “empathise” phase ("Stanford D.school Design Method," n.d.) describes how designers identify the needs of potential users. The EDRS needs to meet the needs of researchers and a variety of different users (educational designers). The EDRS aims to meet the needs of researchers who use the facility for studies of collaborative educational design that might include aspects of collaboration such as speech, gestures, drawings, design phases, roles, or the use of the tools. The EDRS can be described as a complex environment as it includes a range of tools (digital or physical) and multiple types of social interactions, allows a wide range of different design approaches, and projects from different content areas, or a combination thereof. In user-centred design (Norman, 1988), the focus of design is to meet the needs of the user. For a need analysis, interviews with Laureate Fellowship team members indicated that researchers require high-quality audio, video, and screen recordings as well as collecting physical and digital artefacts. Mixed methods research often combines data
from video, audio and the results of the work of participants (Ares, Stroup, & Schademan, 2009; Benigno, Byrd, McNamara, Berg, & Farrar, 2011). Handwritten text would serve as the benchmark for the quality of video recordings. Audio should be recorded as a separate stream for each speaker. The EDRS needs to be able to support a wide variety of different educational design activities. EDRS research views educational design as ill-structured, wicked, and open-ended (Cross, 2006; Jonassen, 2008, 2010). Consequentially, the room must allow flexible setups that can quickly be adapted and co-configured to different groups’ needs (either be the researchers or by group members themselves) and group sizes (from two to a dozen participants).

**Needs of users**

In addition to meeting the needs of researchers, the EDRS development team explored and anticipated the needs of potential users. As the design studio might be used by designers from different disciplines and include professional educational designers, teacher-designers, and students, their needs might vary greatly. However, in general, the EDRS will be used by collaborative groups who design for a new unit of study (course), redesign an existing course, design a curriculum, or design learning spaces. Potential users consist of multi-disciplinary design teams which might include lecturers, professional instructional designers, instructional design students, in-service teachers, pre-service teachers, and eLearning designers. Interviews with different potential user groups suggested that different designers might use different physical and digital tools, go through different design phases, work for different amounts of time, produce different kinds of artefacts, and vary in size. Groups might work as a whole group or break into smaller groups. The design studio aims to provide a flexible space for collaborative group work up to ten people. Designers might use design tools provided by the EDRS or supply
their own tools and devices. Participants need easy internet access to online resources, communicate (e.g. Email, social media, video conferencing), create, share, and store digital artefacts. The EDRS needs to provide technical assistance, both in person and in written form, to quickly familiarise participants with the devices and tools in the room. Design groups might resume work that started before the EDRS session and continue working on the project after their time in the design studio. Groups that use the EDRS for several consecutive sessions need to store their artefacts in ways that allows a seamless continuation of their work in each session.

**Constraints**

Design has been described as a constraint satisfaction problem (Simon, 1996) or as discourse between needs and constraints (Cross, 2007). Identifying constraints is an important part of the design process. Designing the EDRS had to meet three different constraints: Money (budget for the EDRS available through Laureate Fellowship grant), space (given room for EDRS), and time (timeline for completion of the EDRS development). Design constraints vary in their malleability. Some constraints might be revisited and changed throughout the design process. For example, the characteristics of the room (room size of 48.5 square meters, narrow rectangular shape, windowless room) might appear to be a fixed constraint, but this is only a temporarily fixed constraint as the design studio might move to a different, larger room in the future. The “mobility” design pattern anticipates this possibility. Funding is also a temporary fixed constraint as additional grant money might be secured. Needs of researchers and educational designers provided guidance for the development of the first iteration of EDRS but they will be revisited and refined as studies in the room progress.
Sharing and capturing ideas

The design activities for the EDRS took place in a variety of settings, from weekly group meetings of the entire Laureate Fellowship team to targeted meetings of the EDRS development team (MARTIN, DAVID, and BEAT). In the initial phase of the EDRS development phase, the team aimed to frame the problem space for the EDRS by identifying needs of researchers and potential users. Interviews with designers from different disciplines were conducted to capture shared needs for a collaborative design space.

The Laureate Fellowship team used a flexible array of shared and individually used tools during the EDRS design process. Minutes of weekly meetings were recorded using shared Google docs documents. Google docs spreadsheets were used to compare the affordances of different devices and budget planning. Off-site team members used Skype to participate in meetings. Outside of group meetings, team members shared information through email, Google docs, or the dedicated group space on the server (called “Piazza”). Additionally, the team shared information by email, in minutes during group meetings, and through a blog space, called “Agora”. Drafts of EDRS layouts were created using Adobe Illustrator, Google Sketch-Up, or paper-and-pencil. A shared google calendar was created to schedule team meetings, craftsmen, visitors, consultants, and EDRS participants. Individual team members used a variety of different software tools to create and organise texts, spreadsheets, and diagrams. Dedicated knowledge visualisation software, for example mindmapping software PersonalBrain and Inspiration, were used to represent and keep track of ideas of different aspects of the EDRS development.

To coordinate different design tasks, the team experimented with different project management software. One software focused on Gantt charts (Gantter) while the other tool was originally designed for software development (Pivotaltracker). Both tools were found to be too
time-intensive to maintain and not flexible enough to accommodate the range of academic work, from clearly defined short tasks (e.g. send email to ethics committee) to long-term tasks (e.g. write book chapter). After a trial period of several weeks, the team decided to coordinate organically through individual and group meetings as well as emails and shared documents.

The development team aimed to reach consensus when making design decisions. However, in some cases the group leader (BEAT) or the principal investigator (PETER) made the final decision. Decisions, which either led to hiring a contractor or making a purchase, were documented in shared Google docs.

The EDRS is presented on a dedicated website which is as part of the STL portal. The EDRS website describes the physical and digital spaces and tools available to potential users and interested researchers (Schwendimann, 2013).

Co-Creation overview

The dynamic processes of co-creation and co-configuration will be illustrated through the design of different elements of the EDRS, including designing the physical and digital spaces, lighting design, video and audio recording design, design tools, and branding (see figure 2 below).
Figure 2: EDRS physical and digital spaces
EDRS physical space design

The physical space of the EDRS aimed to provide a flexible open-space that meets the needs of a wide variety of design groups. The furniture might be on wheels to allow for quick changes of settings (from whole group discussions around a centre table to work in sub-groups). The team gathered inspirations for the room design from creative office and learning space design literature (for example (Doorley, Witthoft, & University, 2011; Groves, 2010; Myerson & Ross, 2006)) and a visit to the ETH value lab (Arisona & Aschwanden, 2011; Burkhard, Schneider, & Meier, 2009). The ETH value lab is a state-of-the-art technology-enhanced seminar room featuring five multi-touch tables and two projectors. The EDRS aimed to provide a lower-cost variant of the ETH value lab with a similar functionality.

Several people generated EDRS layout designs, including Pippa, Beat, Vesna, and Dorian. Layout designs were presented, discussed, and revised by the development team and the whole Laureate Fellowship team.

Initially, the planning distinguished between areas for whole group work (e.g. central conference table), space for small group work (e.g. smaller tables), and a separate area for individual work (behind a divider wall). Different areas could be distinguished with a colour-coded carpet (see figure 3). Luppicini (Luppicini, 2003) suggested that scaffolding instructional design through a taxonomy of guiding questions. Alternatively, different areas of the studio could be used as a scaffold for the design process, for example the informal sitting area for empathising, standing at the whiteboard wall for creative ideation, sitting at the central table for formal decision making, and using all areas for small group work for prototype development. Two SmartBoards, a central office table, and an architect’s drawing table would support different collaborative design activities. As room measures only 48.5 square meters, the layout needed to
allow multiple settings. Different design groups might work in different ways. Furniture on wheels would allow for quick changes of layouts and encourages groups to customise the workspace to meet their needs. Furniture and tools for the design studio needed to be carefully chosen to create a multi-purpose space.

An architect [VESNA] joined the EDRS team as a consultant and developed several variations of the initial room concept. Instead of colour-coded zones, the new designs built on the idea of dividing the room into different zones with a divider wall or a tree (see figure 4). Warm wooden colours would induce a biophilia effect and make the room appear more inviting. Using a tree-shaped utilities drawer or wave-shaped ceiling blades aimed to break up the box-shape of the room. Each concept would require custom-built furniture which would result in high
costs and could probably not be reused in another location (which does not meet the mobility design pattern). The architect’s ideas were postponed until a later iteration of the design studio as they were too expensive and did not support the “mobility” design pattern. While the architect’s ideas were not directly pursued any further, they helped stimulate a constructive discussion in the team how similar functionality could be achieved at lower costs.

One of the team members with a web-design background [DORIAN] translated the initial design patterns into a mood board outlining colours and materials for the design studio (see figure 5). The “Australasian eco minimalist” mood board uses natural textures. A laminate flooring in bamboo or similar tone wood would provide a durable, affordable, easy to clean surface. The bamboo colour would bring a non-office, warm, natural look. The design of the room should naturally welcoming but non-prescriptive. The features of the space should blend into the background but offer selected touches of the unexpected to elicit a positive mood in support of creativity. Warm lighting with daylight tubes, a fake skylight, and artificial plants can build on the biophilia effect (The Biophilia Hypothesis, 1993; Wilson, 2009) to counteract a lack of natural light or windows. Biophilia refers to subconscious connection between humans and nature rooted in evolutionary history.
The next re-framing of the room continued to use the “Australasian eco minimalism” mood board’s colours to keep the room non-prescriptive and encourage users to re-arrange the room to meet their needs (especially for studies that aim to observe naturally-occurring design processes). The EDRS development team tested prototypes of different layouts in the room by rearranging furniture into different arrangements. After several rounds of testing, the idea of an individual work space behind a divider wall was discontinued for three reasons: A) The wall would make the room appear even smaller; B) As research in the EDRS will focus on collaborative work, the physical layout should encourage participants to work together instead of in separate groups; C) A divider wall would hinder video recording. The new room conceptualisation focused on the furniture and divided the room into vertical levels “low”, “medium”, and “high” (see figure 6). Based on the idea of providing different physical contexts, the room would provide “high” furniture (bar stools and high table), “medium”-height furniture
(table and chairs), and “low”-level furniture (sitting cubes, beanbag chairs, couch). A curved wall around the high-level furniture would break up the boxy look of the room. The size of the room constrained the amount of furniture. Too much furniture would make it difficult to quickly rearrange furniture into new settings. Providing only minimal multi-purpose furniture might encourage users to make creative use of the existing infrastructure. The large central meeting table allows for group meetings and can double as a design work surface (eliminating the need for a separate architect’s drawing table). The initial idea of furniture on wheels was abandoned, as furniture on wheels was found too wobbly for design work. Instead lightweight furniture was chosen that can easily be moved around. The idea of commissioning custom-built furniture and a curved wall was discontinued due to high costs.

![Figure 6: EDRS layout: High/medium/low furniture (by Pippa Yeoman)](image)

The idea of different vertical levels was re-framed and simplified to dividing the room horizontally into a “formal” and an “informal” area (see figure 7). According to the ‘behaviour-setting theory’ (Brown, Shepherd, Wituk, & Meissen, 2007), people respond to certain physical
cues in their setting, for example moving from a formal conference table setting to an informal sofa setting can often produce less formal interaction (Berg & Kreiner, 1990). The “formal area” would consist of a central meeting table for whole group meetings. The informal area would consist of a sofa and comfortable chairs with a refreshment station (e.g. coffee machine). The advantage of having an informal area in the room is threefold: first, it allows participants to change settings and relax (especially important in longer projects), second, it prevents participants from leaving the room to allow for uninterrupted video and audio recording, and third, an informal area might stimulate informal discussions (which might be the most creative parts of the meeting). Anecdotal evidence suggests that many creative ideas do not emerge from formal meetings but from casual conversations during coffee breaks.

Figure 7: EDRS layout: Formal/ informal area division (by Dorian Peters)

For the planning of the building phase, the room areas had to re-conceptualised again into the areas “ceiling”, “walls”, and “floor” followed by “furniture” and “technology”. First, The remodelling of the room would start at the top with the installation of additional neon tubs and light- strips and and individual switches for each lamp to support flexible lightning arrangement.
MARTIN, with advice by the electrician, designed the ceiling layout, including outlets, lamps, and power-outlets in the ceiling (see figure 8). Second, the walls would be painted in whiteboard paint. The initial idea to cover all walls with whiteboard paint had to be revised due to the high costs of whiteboard paint and because an all-white room might appear sterile and cold. As alternative, one short and one long wall of the room were painted in a light brown colour with regular paint (following the colour schema). A stepladder needed to be added to the room to allow users to reach higher areas of the whiteboard walls and to facilitate researcher’s access to the ceiling-mounted cameras. Different room layouts were tested in a rapid prototyping phase and lead to several re-framings. Rearranging existing furniture in the room provided informative feedback about the usability of different ideas. A new carpet would be placed on top of the existing vinyl flooring. The initial idea of installing a laminate floor was given up in favour of a carpet to make the room appear warmer and to reduce the echo effect in the room (to improve audio recordings). We decided for a carpet as an acoustic buffer instead of a laminate floor because of the echo effect in the room. After the carpet got delivered, furniture and technology (cameras on the ceiling, SmartBoard, projectors) could be installed, but it became necessary to have the door trimmed as it could no longer be closed. In March 2012, furniture was installed in the EDRS. In July 2012, the design studio was officially opened with a ceremony attended by board members, faculty, staff, and students.
Figure 8: EDRS layout: Ceiling/walls/floor (by Martin Parisio)
EDRS digital spaces design

In addition to designing the physical spaces of the room, the design team also started exploring ideas for the digital spaces of the EDRS. The EDRS aims to offer a variety of digital design tools including tools already familiar to educational designers (for example google docs and Evernote) as well as novel tools. The team evaluated different drawing, text editing, and knowledge visualisations tools. Teams need be able to share their documents between people and across devices. The digital space should allow teams to create, share, and store their artefacts. Between OSX devices in the room (three Mac minis), documents can be exchanged wirelessly using the Airdrop functionality.

EDRS lighting and ceiling design

The design of the EDRS needed to address the constraint of a window-less room. Three ideas were explored: A) changing the frequency of the existing lamps, B) installing additional lights, and C) mounting an artificial skylight. The initial idea was to replace 4-6 acoustic tiles in the ceiling with backlit panels featuring an artificial sky with clouds to bring a sense of the outdoors into the windowless room (biophilia effect). After testing a self-constructed mock-up prototype, we decided against installing an artificial skylight for two reasons: First, commercial artificial skylights are expensive, and second, tests with our prototype demonstrated revealed that the artificial skylight causes a blue hue in the room which is detrimental for design work that involves colours as well as video recordings for researchers.

To improve the lighting in the room, several changes were implemented. First, additional fluorescent tubes were installed to provide better lighting throughout the room. Second, to build on the biophilia effect and the idea of artificial skylights, the existing fluorescent tubes were
replaced with new ones that emit light close to natural sunlight (with correlated colour temperature of 5000 K to 6500 K). Testing in the room led to two more changes: To reduce the glare from the fluorescent tubes, new diffusers were installed to create a softer light. To reduce the shade cast by the fluorescent tubes and illuminate the upper parts of the whiteboard walls, LED light-strips were installed along the ceiling. The light-strips had to emit light at the same frequency as the daylight fluorescent tubes to avoid different light tones in the room. Lastly, a control board was installed to provide individual control over each set of fluorescent tubes and each LED light-strip in the room to allows flexible lighting scenarios, for example for whole group work, presentations, movie presentations, etc.

Inspired by the urban-style of design offices that use remodelled factory buildings, the architect (VESNA) and (independently) the painter suggested revealing the ducts and cables as stylistic element. In a trial, the acoustic ceiling panels were removed. The team concluded that revealing the pipework made the room look too busy, darker, and created the illusion of an even lower ceiling. The team decided to leave the ceiling tiles and have them painted with white paint.

Systematic tests with a various devices in the room identified the need for additional outlets both along the walls and in the ceiling. Outlets in the ceiling provide power for the cameras and allow moving them to different positions on the ceiling to meet the researchers’ need to record different parts of the studio.

**EDRS video recording design**

The goal for selecting video cameras was to find a cost-effective solution for high-quality recordings. The challenge for video recording, similar to audio recording, was that participants in EDRS will freely move around the room. The Laureate team researchers needed a camera setup
that met three conditions: First, every area of the EDRS needed to be covered by at least one camera. Second, video data should be of sufficient resolution to identify small artefacts, such as handwriting or sketching. Third, the camera setup should allow recording continuously for up to six hours at a time as participants might spend several hours in EDRS in the morning and continue their work in the afternoon.

The initial idea was to use security cameras that allow researchers to observe activities in the room in real-time. The team got a first impression through a visit of the psychology department which uses security cameras to record group sessions in several rooms. The team leader could monitor events in all rooms on one monitor. However, we noted that the psychology department is not using the security cameras to analyse details as small as handwritten text. The group session rooms were all small compared to the long stretched room of the design studio.

Next, the team met with a campus security representative to talk about their experiences with security cameras. A visit to the campus security control centre illustrated how different camera types (e.g. 360-degree vs narrow angle; fixed vs operator-controlled) serve different purposes. This meeting revealed that campus security has different needs that EDRS: They need real-time video feeds, the option to quickly zoom in and out, and only require a resolution good enough to distinguish human faces. At EDRS, we will analyse video recordings only after a session has been completed but require high resolution capture detailed enough to read handwritten notes.

The team further pursued the initial idea of using security cameras and evaluated a range of different security camera vendors. Two vendors were invited for a demonstration in the studio. The in-room demonstration revealed the optical limitations of camera lenses: Wide-angle lenses do not allow zooming in to small details. We used handwritten text as our benchmark for details.
we wanted to capture. Three reasons lead to the team to consider different alternatives: First, the security cameras did not provide high-resolution footage meeting our criteria; second, security cameras are expensive; third, streaming large amounts of video data to a server might exceed the capacity of the existing cables.

Looking for a more affordable alternative, we considered using off-the-shelf video cameras in combination with off-the-shelf photo cameras to capture still-shot images. As the cameras had a narrower angle, several cameras would be required to cover the different areas of the long-stretched room. The idea was systematically tested and led to a setup with three ceiling mounted video cameras complemented by four photo cameras running a script that takes high-quality pictures every ten seconds. Several metal rods were attached to the ceiling on which the cameras could flexibly be attached with gorilla-pod camera grips. Extended testing revealed battery life and storage capacity as a limitation for longer recording sessions. Batteries were replaced with power supply adapters to allow recording for extended periods of time. Further study of the memory capacity allowed setting up a plan when to change memory cards during long recording sessions.

The EDRS core team evaluated two different options for video capture: Option 1: Real-time (synchronous) video recording using Mobotix 360 degree surveillance cameras, or option 2: Asynchronous recording using off-the-shelf video cameras (see table 1). Evaluation of both options indicated that neither solution would produce pictures in a resolution high enough for close-up analysis. To complement the video recordings with high resolution pictures, we installed several photo cameras with customised operating systems to take still shots in frequent intervals of ten seconds.
<table>
<thead>
<tr>
<th></th>
<th>Video camera option 1 (synchronous)</th>
<th>Video camera option 2 (asynchronous)</th>
<th>Photo camera</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pro</strong></td>
<td>- Real-time video feed</td>
<td>- Cheaper (off-the-shelf)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Software allows focusing on certain areas and zooming in</td>
<td>- Higher resolution</td>
<td></td>
</tr>
<tr>
<td><strong>Con</strong></td>
<td>- Expensive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Analysis will happen only after the project (real-time feed no required)</td>
<td>- Requires manual activation and removal of SD cards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Low resolution: Does not allow reading handwriting</td>
<td>- Requires manual synchronisation of recordings from different cameras and audio</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- No real-time zooming</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Requires post-production to turn pictures into a quicktime movie and align with audio feeds</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Require manual activation and replacement of SD cards</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Require customised firmware to allow automated still-shot</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Different video recording options
The systematic evaluation and testing led to the purchase of three Sony digital video recorders and four Canon digital photo cameras for time-lapse recordings. All cameras can be mounted in different positions on the ceiling to target specific areas of interest, e.g. the whiteboard wall or the central table. In addition to the cameras, screen recordings of the three Mac minis can serve as artefacts for analysis. Using the full recording capacity of the EDRS with three video cameras, four still-shot-cameras, and eight voice recorders produces a large amount of data. This lead to the questions how to process, store, and backup such large amounts of data. A high-end iMac computer was purchased to serve as the video processing computer. Data will be stored on high-speed redundant external hard drive with scheduled backups to low-speed high-volume drives. To make data accessible to researchers, recordings can be stored on portable external harddrives.

Designing a solution for high-quality low-cost video recording in the EDRS illustrated that there is no single and simple solution to meet the researchers’ needs, e.g. High resolution. Only a combination of approaches (video recordings, still-shots, and screenshots) that takes the affordances of each recording strategy into account is versatile enough to capture activities on the EDRS and generate a rich data source for research. Video recordings show actions in motions and big picture overviews while still-shot cameras and screenshots provide high-resolution pictures for analysis of details. Using off-the-shelf cameras can offer a low-cost solution for high-quality recordings but it requires time-intensive setup and post-production. Researchers need to anticipate which areas of the room they want to focus on and decide if video or still-shot recordings will best capture design groups’ activities.
EDRS audio recording design

In addition to video, the design studio needs to capture high-quality audio from multiple participants. The initial idea was to use the in-built camera microphones and Microcone microphones which can record of up to six separate audio feeds. The EDRS core team evaluated a Microcone microphone and concluded that it would only feasible for stationary participants sitting around a table. As the EDRS participants will freely move around the room, a more flexible and cost-effective solution was needed. Two alternatives were considered. First, wireless microphones would allow simultaneous recordings in real-time. However, wireless microphones are expensive and researchers did not express a need for real-time analysis. Second, off-the-shelf voice recorders would prove a cost-effective solution but require manual activation and manual synchronisation of multiple audio recordings in post-production. Testing the voice recorder option indicated that the recorders could either be flexibly assigned to a specific participants or be placed in locations of interest across the room (for example in the centre of the table). To distinguish individual speakers in a group discussion, lapel microphones could greatly improve audio quality. Eight Olympus voice recorders with lapel microphones were purchased for the studio.

Further testing supported the idea of using a combination of group recordings (recorder on the table) and individual recordings (recorder and lapel microphone attached to specific participants). Recordings of up to eleven audio feeds (eight voice recorders and four video cameras) taken from different locations in the studio and from individual participants via lapel microphones allow researchers to flexibly switch back and forth between group discussions and individual discussions. To improve synchronisation of multiple audio and video feeds in post-
production, a loud clap at the beginning of the recording serves as an audio marker. Voice
recorders can be identified at the beginning of a recording by saying the name of the sources, e.g.
“central table” or “participant one”.

**EDRS projectors and Smartboard**

In December 2011, several alternatives for interactive whiteboards were considered
(SmartBoard, TwoTouch boards, eBeam technology). Despite the high costs, SmartBoard was
found to offer the best functionality for the design studio. However, the initial plan to get two
interactive whiteboards had to be revised to only installing one. From November 2011-February
2012, different options for video recording were tested in the design studio (different types of
security cameras, off-the-shelf video cameras, still-shot photo cameras). In April 2012,
projectors, Apple TV’s, Mac minis, and the SmartBoard were installed. The EDRS allows
synchronous projection of three different sources. Having three separate projection devices
allows three groups to work at the same time or make cross-comparisons between different
digital content. Two ceiling mounted projectors use the whiteboard walls as projection surfaces.
Each projector is connected to a Mac mini and an Apple TV. Based on the design pattern of fluid
usability, the EDRS aims to provide designers with easy to use ways to share artefacts, move
across different devices, and store digital artefacts. Google docs allows accessing documents on
any platform and editing simultaneously; Airdrop functionality allows sending documents from
one OS X device to another; documents on the interactive whiteboard can be saved to memory
drives (using the USB ports of the attached Mac mini); the remote controlled switch matrix
allows to quickly change which device (e.g. iPad, laptop, Mac mini) is displayed on which
projector; Each of the two projectors are connected to an Apple TV which allows Mac OsX
devices to stream wirelessly via AirPlay to the projectors.

An initial testing phase of two different interactive whiteboard providers (TwoTouch and
SmartBoard) lead to the decision that the SmartBoard provides a more intuitive user interface
and better multi-touch recognition. The SmartBoard is connected to a Mac mini provides an
interactive surface for presentations and group activities. The SmartBoard was equipped with a
webcam and speakers for video conferences.

Initial testing lead to several changes: A Bluetooth enhancer was installed to better reach
the matrix behind the ceiling tiles. To better document tools in the room for users and
researchers, the different devices (light switches, keyboards, mice, and trackpads) were labelled
and a user manual for the EDRS generated.

**EDRS drawing spaces**

The EDRS aims to offer educational designers the flexibility of several different drawing
spaces. Physical drawing spaces include notebooks, butcher paper, post-its, and over 33 square
meters of floor-to-ceiling whiteboard wall space. After month of planning and considering
different alternatives, the electrician and painter completed their work within one week. The
whiteboard wall painters were faced with a novel problem. Never before did they have to apply
the special whiteboard paint in a windowless room in the centre of a building. To provide airflow
to the room, they set up a fifty meter long air-tube along the hallway. Painting the EDRS allowed
them to test this new venting method. Due to the success of the new method, the painters will use
this technique again in future for other projects. The wall provides generous space for drawings,
writing, and brainstorming sessions. Multiple users have access to the wall at the same time and
can work synchronously. The advantage of the whiteboard wall is that it serves as a shared space for artefacts that either remain on display for the duration of a project phase or can be erased and replaced by others. On the other hand, the projectors can be used to quickly access and share dynamic information. Digital drawing tools include drawing apps on iPads which connect wirelessly to the projectors and an interactive whiteboard. Out of the combination of two separate ideas, the whiteboard wall and the projector, a novel versatile hybrid of digital and physical space emerged. Users can use the whiteboard wall or the projection by itself, or use physical markers to annotate projected documents. To capture artefacts on physical drawing spaces, the still-shot cameras continuously capture pictures of the room. Screen-capturing software on the interactive whiteboard can be used to capture the development of artefacts. Designers can store and share their digital artefacts using web-based storage services.

**EDRS branding design**

In March 2012, the search for a new name for the EDRS began and a logo was commissioned. A range of alternative names for the room were considered by the group, for example Sydney Idea Lab, Design Research Studio, The Studio, Sydney Design Studio, The CoCo Studio, and The idea cave. In an anonymous voting process, the group decided to keep “Educational Design Research Studio” as the official long form and “The Design Studio” as the short form. A designer [DORIAN] was commissioned to create a logo for the design studio. The group considered several different design suggestions and voted for the favourite design (see table 2 below).
<table>
<thead>
<tr>
<th>Logo</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Logo 1" /></td>
<td>The symbol contains a C and D for collaborative design. It could also be a C O hinting at it’s CoCo origins. The symbol also resembles Phi, the greek letter that represents the golden ratio - a fundamental principle of design in all its forms. The team considered this logo as “too formal”.</td>
</tr>
<tr>
<td><img src="image2.png" alt="Logo 2" /></td>
<td>The centre represents a spark of creativity. The circle represents a group of people huddled, designing collaboratively. The team viewed the centre symbol as too ”busy”.</td>
</tr>
<tr>
<td><img src="image3.png" alt="Logo 3" /></td>
<td>Same as above but with the symbol in the centre. The team liked this logo but wanted to reduce the amount of text.</td>
</tr>
<tr>
<td><img src="image4.png" alt="Logo 4" /></td>
<td>Same as above, but with less text. Final EDRS logo.</td>
</tr>
</tbody>
</table>

Table 2: EDRS logos
Co-Creation/ Co-configuration

The process of creating and iteratively reframing the problem and solution space of the EDRS through co-creation and co-configuration can be described as a dynamic dialogue with feedback loops between needs, design patterns, and constraints (see figure 9 below). The Laureate Fellowship grant proposal outlined the overall goals of the research project. The empathise phase focused on identifying the needs of people involved in the project. Translating overall goals into specific research studies informed the needs of researchers, for example what kind of data needs to be collected, what kind of infrastructure is needed, etc. In addition to researchers’ needs, the EDRS has to meet the needs of potential users (educational designers) [See “Need’s of users” and “Need’s of researchers”]. The subsequent define phase built on the empathise phase to describe goals, design patterns, and constraints. Design patterns for the EDRS development are abstractions of researchers’ and users’ needs informed by the literature on space design and educational research. Constraints include money (budget available through grant), space (given room for EDRS), and time (timeline for completion of EDRS development). During the ideate phase, the team explored the solution space and generated alternative specific ideas that address issues identified in the empathise and define phases. In the light of new ideas, needs, design patterns, and constraints had to be revisited, refined, and/or reframed. Parallel to the ideation phase, the team moved into a preparation phase: Requesting quotes from craftsmen and preparing the room by removing old furniture (in November 2011). Using a rapid prototyping approach, selected ideas were further explored and tested, for example different layouts, lighting options, camera and microphone concepts. The prototypes had to negotiate between the design patterns, needs of researchers and users, and constraints (especially time and
money). Ideas that successfully met these criteria were implemented in the first iteration of the design studio. During the design process, the EDRS team had to both look backwards (revisit earlier ideas and definitions; meet set goals, needs, and patterns) and look forward to anticipate issues in testing, evaluation, and implementation. Through fluidly working upstream and downstream can the design team align the various elements of the EDRS development process.
Figure 9: EDRS development co-creation process
Discussion

This study described and analysed different aspects of the eight-month long development process of creating a novel facility for research of educational design. The EDRS aims to support design-for-learning and learning-by-design activities but the development of the EDRS itself can serve as an exemplar of collaborative design. Similar to design-for-learning, the goal of the EDRS is to provide learners/users with a flexible set of tools, resources, and spaces that can be flexibly co-configured to meet their needs. The design of the EDRS required the initial setup and iterative co-configuration of physical and digital spaces and tools, groups, artefacts, knowledge management, decision-making, and design processes.

Historically, design has often been treated as a linear process. Silber (Silber 2007) suggested the view that design occurs in cycles. However the EDRS design process suggests neither a linear nor a cyclic development but a parallel or even non-linear fluid processes. This non-linearity is acknowledged in the more contemporary conceptualisations of design, such as the one proposed by the IDEO design company where design is described as a system of spaces (Brown, 2008). Brown suggests that design projects tend to loop back through inspiration, ideation, and implementation, particularly the first two, more than once, as ideas are revised and refined. Design operates within the area of high epistemic uncertainty where both the problem and the solution spaces are not clearly defined. The collaborative process of designing a design studio for studies of collaborative educational design demonstrates how design is a flexible interaction between spaces, tools, knowledge, and people. Over time, elements of this dynamic system and the relationships between those elements change and co-configure each other. For example, the group composition changed by temporarily including external
Designing a design studio

Schwendimann (2013)

consultants; knowledge management used different tools and artefacts to meet the groups’ developing and changing needs.

The problem and solution spaces for the EDRS had to be frequently revisited, revised, and reframed throughout the eight month development process. Reframing is an important cognitive aspect of design (Dong, Kleinsmann, & Deken, 2012). As looping back and changing earlier decisions can cause upstream and downstream ripple effects through a project, aligning goals and solutions within a constraint-based space can become an increasingly complex challenge. As Goodyear (Goodyear, 2005) noted “hence the need for iteration, revision, patience and a tolerance of ambiguity” (p8). Identifying the needs of researchers and potential users formed the basis of the design process and shaped and refined the goals of the EDRS development. For example, the physical layout of the EDRS as well as the way the group conceptualised the room had to be revised several times after systematically testing different ideas in the room. A particular challenge was to anticipate and define the needs of a wide variety of different EDRS users. The group adopted an iterative development approach to repeatedly revise the current EDRS setup to accommodate newly identified needs of users and researchers. Design decisions in the EDRS development process could be based on, either one or a varying combination of, evidence (after prototype studies), design-patterns, constraints, or executive decisions (by project leaders).

By adopting a rapid prototyping approach, the EDRS development team could quickly test new ideas to make decisions about pursuing an idea further, abandoning an idea, or implementing selected elements of an idea in a different way. Prototyping ideas revealed downsides that could not have been anticipated without physically testing the idea. After testing, certain elements of an idea would often be carried on in a different form or stimulate
thinking in a new direction, for example testing the prototype of an artificial skylight lead to the idea of installing daylight fluorescent tubes instead.

The EDRS design occurred within a complex multi-layered constrained system. The members of the EDRS development team were not all trained designers but they demonstrated “designerly ways of knowing” (Cross, 2006) and moved through identifiable design stages, such as empathise, define, ideate, and testing ("Stanford D.school Design Method," n.d.). Team members had to negotiate and compromise between given goals (as outlined in the grant proposal), identified and anticipated needs of potential users and researchers, available financial resources, available physical space, and time. Constraints require designers to generate alternative ideas and find creative compromises. Similarly this design pattern has been extended to the EDRS where minimal furniture and multi-purpose tools in the EDRS are expected to facilitate creative co-configurations of tools and spaces.

The core group remained for the entire time of the initial EDRS development phase. Over time, the group members created a shared vision for the EDRS through the processes of discussion, brainstorming, testing, negotiating, and compromising. As ideas for the EDRS were constantly shifting and developing, it was important to keep the members of the team a constant.

The extended research group often served as a sounding board for new ideas proposed by the core development team but also generated new ideas and helped refining needs for users and researchers. External experts were invited to join the group temporarily as consultants to provide advice on specific design questions. Mirroring the iterative rapid prototyping approach for the EDRS development, the team experimented with numerous different tools for knowledge sharing and task management. The goal was to find ‘lightweight’ tools that were
flexible enough to support the spectrum of different activities of the team. The solution which emerged combined both shared tools (such as Google docs) and individually used tools (such as Word or Excel).

An initial set of five design patterns, inter-connectedly forming a design language, served as the guiding principles throughout the EDRS development process. The goal of design patterns and design language is to create consistency across different levels by identifying solution-problem pairings. The development of the EDRS required the team to move fluidly back and forth between thinking about the design process level (e.g. constraints, needs, goals) to the product level (e.g. furniture, recording equipment, digital and physical design tools, colours). Applying the same design patterns to the different levels of the design process supported more consistent decision making which is especially important in a collaboratively working design groups. Clearly defined design patterns facilitate communication between team members and outside consultants.

**Significance**

The EDRS development serves as rich case study describing design as a dynamic and iterative process within a malleable constraint space. This study illustrates the elements and complex relationships between people, tools, and goals in the process of design a new research facility. The EDRS was collaboratively created by an inter-disciplinary team that flexibly moved between different design phases, used a varying array of tools, and repeatedly revisited and reframed both problem and solution spaces. A better understanding of collaborative design can lead to the development of better tools and methods to improve both the process and the product of design.
Findings from EDRS studies contribute to a deeper and refined understanding of collaborative educational design, especially design-for-learning and learning-by-design processes. Empirical studies conducted in the EDRS will provide an extensive account of educational design cognition and sets of implications for the tools and methods of learning systems analysis and design.

**Outlook**

From the beginning of the development process, the EDRS facility was conceptualised as a prototype which would be iteratively be developed further as a deeper understanding of users’ and researchers’ needs would emerge. Usage of the EDRS by a variety of different groups of educational designers will provide evidence for which elements of the EDRS require further development, addition, or removal. EDRS research will explore the affordances of different tools (both physical and digital), roles, phases, and representations. A multitouch table is under development to serve as a collaborative design tool and as a central hub that facilitates sharing and moving documents across devices in the EDRS. In the future, the EDRS might be moved to a different location with different affordances. The EDRS core development team will have to revise previous design decisions and constraints.
References


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