Analysing F2F Collaborative Design and Learning: Experiences in a Design Studio

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Abstract: This paper presents our proposed methods developed to contribute to our understanding of a complex and heterogeneous activity: face-to-face collaborative design and learning. We build on principles of multimodal learning analytics and synthesis research to explore different dimensions of collaboration including the analysis of discourse, tools usage, inscriptions, gestures, physical mobility, focus of attention, decision making, design processes, conversational turns, positioning and other social interactions. We propose that to understand what occurs in a heterogeneous and complex collaboration situation we should see it as a whole: a complex and physically, socially and epistemically situated activity.

Keywords: design for learning, heterogeneous ecology, design, face-to-face collaboration

Introduction and Background

For four years, we have conducted a wide variety of experimental user experiences aimed to analyse face-to-face collaborative design and learning in a Design Studio. The Design Studio (Thompson et al., 2013a) is a physical space located at the University of Sydney dedicated to support groups of people engaged in design activities. The room features a variety of tools, including multitouch digital surfaces (a tabletop, an interactive whiteboards, tablet devices), large projected screens, writeable walls, materials to write or build designs and movable furniture. Like the Design Studio, many other innovative spaces for learning are emerging in universities, libraries, schools, museums and other informal settings. Additionally, the Design Studio at the University of Sydney features an array of video cameras, microphones and observation consoles that can be connected to a central server and synchronised to record designers' activity. In this way, groups working collaboratively in this setting have produced large amounts of multi-modal data. We have been developing methods of analysing this 'big data', (big in terms of depth rather than breadth) (Thompson et al., 2013b), to describe and understand the complex (heterogeneous) collaborative activity occurring in the Design Studio. The collaborative design activity can be seen as a whole: a complex and physically, socially and epistemically situated activity (Goodyear et al., 2014; Martinez-Maldonado et al., 2015), from which streams of data that indicate the epistemic, social, and physical aspects of activity can be collected separately, and then in the explanation, put back together. As such, we have adopted the Activity-Centred Analysis and Design (ACAD) framework (Carvalho & Goodyear, 2014). Informally, we have applied methods most closely aligned with multimodal learning analytics (MMLA, e.g. Blikstein, 2013), extracting multiple streams of data and developing and applying multiple methods of analysis. More recently we have applied a *synthesis research* approach (see Kemp & Boynton, 2011, Thompson et al., under review) to formally align multiple perspectives, using the ACAD framework, in order to produce a model of the complex activity of designers in the Design Studio. In order to contribute to the *methods and techniques to research heterogeneous ecologies* track, we will outline the informal development of methods of analysis of the heterogeneous ecology of tools, tasks and social interactions, followed by an outline of the synthesis approach.

A Place for Learning

Based on the Design Studio, for the purposes of this paper, we imagine a learning place to which learners come for special projects. It is connected, with a wireless network enabling the digital devices already available to be used, as well as the personal devices of the users. The furniture is flexible: the learning place is configurable for single groups (large or small) or several smaller groups. The users of the learning place include pre-service teachers. They practice teaching in an innovative learning environment, and they also use it as a design studio for their own educational design work. Other users are teachers who come for professional learning, and school students who come to work on projects that involve some kind of design. The type of task that a group of pre-service teachers may undertake in the learning place is to do the detailed design of learning tasks for two selected weeks of their practicum, which must include technology in some way.

The Activity-Centred Analysis and Design (ACAD) Framework

The development of the Activity-Centred Analysis and Design (ACAD) framework began in 2011, drawing on ideas from architecture and design to understand the complexity of learning situations, and to find ways of abstracting key re-usable designs. The framework differentiates between elements that can be designed and the activity of learners, posing that educators may have a plan for certain components of a learning situation: the resources, tools and artefacts to be used (*set design*), the tasks proposed (*epistemic design*) and the social arrangements and roles (*social design*). What has been designed may influence the activity of learners but it does not really determine such activity. At learntime learners are likely to reconfigure what has been proposed in new ways (*co-creation and co-configuration activities*). ACAD may help teachers (as educational designers) in their planning stages, offering a way of framing the complexity of learning under different potential combinations for each of the designable components (working in groups, or pairs; using paper or technology; etc.). This abstraction of the structural composition of a learning situation is useful, as it highlights connections between different elements in set, social and epistemic design, and how these, in turn, may influence activity. Overall, the framework reminds teachers that activity is at the centre, while reaching forward to the learning outcome and backward to the design.

To use this in our imagined classroom, the learning place, the main consideration would be to reconsider the description of the task given to the pre-service teachers. We could consider outlining the task in terms of the specific tasks involved, the roles and rules associated with the group's work, and the elements of the physical and digital learning environment that they would have at their disposal, as outlined in the ACAD framework. In *our* consideration of the task given to the pre-service teachers, the importance of the activity of the learners (pre-service teachers) is now obvious, in addition to the design that is produced. We need to consider what we could conclude from the analysis of just one stream of data? We would ask whether we should collect more, and whether it is possible to do it in a way that is automated? That combines observations of student work with information about their digital traces and their social interactions? Mulimodal learning analytics (MMLA) provided us with a field in which to situate the development of our methods toolkit.

Multimodal Learning Analytics – the development of a methods toolkit

The development of a methods toolkit began in 2011. The aim was to develop resources to be able to account for the activity of designers, or of learners undertaking design tasks. The initial focus of analysis was the *discourse* during collaborative design, particularly automated methods of extracting data that could be inserted into the Collaborative Process Analysis Coding Scheme (CPACS, Kennedy-Clark & Thompson, 2012). This coding scheme has evolved from systemic functional linguistics and includes measures of the macro-levels of speech (action and content) and the micro-levels of speech (attitudinal, tense, modality and pronouns). Thus far, automated methods of extracting pronouns and tense have been developed (Thompson et al., 2013c; Thompson et al., 2014). Patterns of pronouns, tense and the Content of speech (Kennedy-Clark & Thompson, 2013) have also been found to reliably indicate aspects of social activity (such as the identification of a team leader) as well as aspects of epistemic activity (such as the progress through the phases of design work.

Examination of the use of the tools and the physical space has resulted in some development of methods for analysing the use of the hetereogenous ecology of resources. This has included the usefulness of measures such as focus of attention (Thompson, et al., 2013a), and tool use over time (Thompson et al., 2013a; Thompson et al., 2013b). In Thompson et al. (2013b), it was found that *focus of attention* was a useful measure to determine successful collaboration in combination with tool use, as we observed an alignment in the focus of participants' attention on particular tools, as well as the adoption of specific tool specialisation roles by team members. In Thompson et al. (2013b), we also found that students adopted roles around the use of tools, and that these were essential in the development of ideas during the *ideation phase* of design. Other studies have examined the production of inscriptions during design work, using the tools available in the Design Studio, and the way in which the participants enacted gestures and other non-verbal communicative modes such as posture and gaze (Wardak, 2014). We also developed two coding schemes that can be applied to discourse and inscriptions, that account for the epistemic aspects of activity of collaborators in the Design Studio (he iterations of design ideas (Thompson et al. 2013b) and the Design Process Coding Scheme (DPCS) (Thompson, 2015).

Finally, we analysed the different collaborative behaviours of group members in the Design Studio in relationship with the ways groups use multiple tools and the available spaces to achieve their goals (Martinez-Maldonado, et al., 2015). The analysis included the visualisation of physical movement of designers in the Design Studio through the use of heatmaps, the analysis of tools usage, tools used in conjunction and different strategies to work collaboratively according to the positioning (e.g. working face-to-face or side-by-side).

It is in the examination of multiple measures of progress through a design that we begin to understand the complex nature of the use of heterogeneous ecologies such as the Design Studio. As we developed these

measures, we realised that the existence of a framework, such as the ACAD framework (Carvalho & Goodyear, 2014), in which to place the multiple analyses, would help us understand the relationships between findings, and also help us compare different ecologies in the future (Thompson et al., submitted). The use of MMLA in combination with the ACAD framework is useful in our imagined classroom, the learning place, because then analyses can be related to the outcomes of the learners and applied to (re)design work. The orchestration of such a learning place can be overwhelming, and the automation of indicators of successful and unsuccessful collaboration could mean that teachers could intervene when needed. When used for creative, collaborative work, the usual indicators do not apply for instructors to quickly assess the progress of groups. The development of indicators of learner activity that are related forward to learning outcomes and backward to the design give the instructors context for the feedback that they are able to give to learners. If we were to use this in the learning place, we would need to collect the traces of learner activity, and we would need a tool that could visualize this efficiently and effectively. There should be a combination of indicators collected and presented to the instructor, with support for interpretation, both in real time, and after the event for more considered feedback. The use of MMLA prompted a number of further questions - does it make sense for one person to be responsible for multiple analyses? If multiple experts carry out analyses of the activity of learners, then how do we bring these perspectives together? This led us to use synthesis research as the methodology.

Synthesis Research

Synthesis research is a method that has been utilized in ecology since 1995, and involves bringing together multiple experts in different areas, to address a research question that cannot be entirely answered by an individual perspective (NCEAS, 2014). Broad topics such as the ecological effects of climate change have benefited from the coordination of experts in many areas of the natural sciences, as multiple perspectives are necessary to make sense of complex natural systems (for further discussion see Kemp & Boynton, 2011). Synthesis research has been adopted in ecology in response to: (1) a sudden increase in available data, (2) a search for coherence, (3) an interest in applying the data for management of resources, (4) the complexity of the challenges faced, and (5) the need to train new scientists to solve these problems (Kemp & Boynton, 2011). Synthesis research is inherently interdisciplinary, as experts from different fields come together, bringing their data and perspective, to develop a new explanatory model that accounts for how diverse observations work together (Kemp & Boynton, 2011). The synthesis approach is aligned with the multidisciplinary perspective of the CSCL paradigm as well as several other studies adopting multi-perspective data analysis (e.g. Stahl, 2014). It is this focus on developing a new model to explain observed patterns, developed from the analysis of multiple data sets, that distinguishes synthesis from these other approaches, which attempt to align findings, rather than develop a new model. In this respect, synthesis can be seen as both a challenge as well as an opportunity to create new understandings of existing problems (Kemp & Boynton, 2011).

Similar to ecology, the field of the learning sciences combines many disciplinary approaches to the study of learning. Researchers in the learning sciences originate from disciplines such as computer sciences, psychology, education or sociology, to name a few. These researchers may focus on understanding the processes of learning as they relate, for example, to the people in the environment (teachers, learners or others); or the computers and the roles technology plays in the environment; or the architecture and layout of learning spaces; or cultural and social aspects and so on (Sawyer, 2006). In our initial work using synthesis research, we have used the ACAD framework (Carvalho & Goodyear, 2014) to design research that involves multiple streams of data extracted from a study comparing the effects of three scaffolds in an LBD4L (Thompson & Yeoman, under review) task. The methodological perspectives that we have included are: (1) orchestration and the use of tools; (2) multimodal analysis of the role of inscriptions; (3) analysis of collaborative design behaviour through conversational turns; (4) conversation analysis and the impact of positioning on social interactions; (5) process mining – decision-making and the design process; and (6) discursive psychology and non-verbal social interactions – the role of gesture to describe the co-configuration and co-creation behaviour of learners (Thompson et al., under review, Thompson et al., 2015).

The use of synthesis research is useful for the analysis of our learning place because we are forced to consider the classroom as a heterogeneous ecology, a complex system. Interdisciplinary understanding of such systems is far more common, and is useful. This step can really only happen after the event, but what we need to add to our classroom is time for the instructors to work with a variety of experts, to undertake this synthesis step, and to use this in their redesign of the task for pre-service teachers.

Conclusions

In the development of methodologies to research heterogeneous ecologies, our work has focused first on developing multiple measures that indicate aspects of collaborative design activity, and consequently on a

method that allows us to put these together in a way that describes the complex activity in a way that is of some use to future designers. Our approach has included the use of the ACAD framework to guide the application of multimodal learning analytics, and the addition of the synthesis method of research in order to bring the multiple analyses together, using the ACAD framework as a guide. The main guidelines include outlining a task using the ACAD framework using this to clearly separate the design from the expected activity of the learners, and the identification of 'easy' indicators of progress through the task. We need to treat the analysis as a way to continue our understanding, and feed the information back into redesign of the task, rather than a justification of a specific approach. Of most importance is the time that should be allowed to accommodate these extra steps in the design, and also the synthesis step. In our imagined classroom, the learning place, learners have the opportunity to participate in tasks in which their activity is central to the interests of their instructors.

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