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Engaging stakeholders in the learning analytics design process

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under the supervision of Simon Buckingham Shum
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Certificate of Original Authorship

I, Carlos Gerardo Prieto Alvarez declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Connected Intelligence Centre at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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List of Publications During Candidature

Proceedings

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- ☐ Prieto-Alvarez, C.G., Martinez-Maldonado, R. and Buckingham Shum, S. (2018). Mapping Learner-Data Journeys: Evolution of a Visual Co-design Tool. Proceedings of the 30th Australian Conference on Computer-Human Interaction (OzCHI '18), Melbourne, Australia, Dec. 2018, ACM, New York, NY, USA, pp. 205–214. DOI: https://doi.org/10.1145/3292147.3292168

- ☐ Prieto-Alvarez, C.G, et al. (2018). Collaborative Personas for Crafting Learners Stories for Learning Analytics Design. Workshop Participatory Design for Learning Analytics at International Conference on Learning Analytics and Knowledge LAK'18. Sydney, Australia, ACM: 647-652. ISBN: 978-1-4503-6400-3

Book Chapter

- ☐ Prieto-Alvarez, C.G., Martinez-Maldonado, R. Anderson, T. (2018). Co-designing learning analytics tools with learners. Learning Analytics in the Classroom: Translating Learning Analytics Research for Teachers, Taylor & Francis Groups: 93-110.

Workshops

- ☐ Carlos G. Prieto-Alvarez et al (2018). Learning Analytics Design Cards (LA-DECK): Unpacking inter stakeholder co-design through strategic cards. Australian Learning Analytics Summer Institute. Melbourne, Australia. Website: http://ladeck.utscic.edu.au/events.html

- ☐ Carlos G. Prieto-Alvarez et al (2018). Participatory design of learning analytics. International Conference on Learning Analytics and Knowledge LAK'18. Sydney, Australia, ACM. Website: http://pdlak.utscic.edu.au.

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Glossary

LA: Learning Analytics

DBR: Design Based Research

DT: Design Thinking.

UCD: User Centred Design

HCI: Human Computer Interaction

PD: Participatory Design

EdTEch: Educational Technology

MDSI: Master of Data Science and Innovation

GA: Graduate Attribute

UTS: University of Technology Sydney

SP: Surveillance and Privacy

TLX: Teaching and Learning Expertise

LD: Learning Design

DL: Data Literacy

PWR: Power Relationships.

Abstract

Learning Analytics (LA) is a new promising field that is attracting the attention of education providers and a range of stakeholders including teachers, learning designers, academic directors and data scientists. Researchers and practitioners are interested in learning analytics as it can provide insights from student data about learning processes, learners who may need more help, and learners' behaviours and strategies. However, problems such as low educator satisfaction, steep learning curves, misalignment between the analytics and pedagogical approaches, lack of engagement with learning technologies and other barriers to learning analytics development have already been reported. From a human-centred design perspective, these problems can be explained due to the lack of stakeholders' involvement in the design of the LA tools. In particular, learners and teachers are commonly not considered as active agents of the LA design process. Including teachers, learners, developers and other stakeholders as collaborators in the *co-design* of LA innovations can bring promising benefits in democratising the LA design process, aligning analytics and pedagogy, and meeting stakeholders' expectations. Yet, working in collaboration with stakeholders to design LA innovations opens a series of questions that are addressed in this thesis in order to contribute to closing the gap for effective co-design of LA innovations. The questions addressed in this thesis are the following:

1. How can co-design techniques assist in the integration of diverse stakeholders in the LA design process?
2. What are the roles of the co-design practitioner/researcher in the LA design process?
3. What are the challenges in engaging stakeholders in the LA design process?

Based on co-design principles, and following a Design-Based Research process, this thesis explores the critical challenge of engaging educators and students, the non-technical stakeholders who are often neglected, but who should ultimately be the main beneficiaries of LA innovations. In this research work, three case studies have been used to test, analyse and verify various co-design techniques in diverse learning contexts across a university to generate a co-design toolkit and recommendations for other co-design practitioners: i) learners and educators engaged in simulation-based healthcare scenarios,

ii) learners, educators and other stakeholders in a Data Science Masters program , and iii) educators interested in providing personalised feedback at scale.

This thesis presents three contributions to knowledge for effectively collaborating with educational stakeholders in the LA co-design process:

1. Inspired by archetypal challenges reported in classic and contemporary co-design literature, and in current LA research, the thesis identifies, exemplifies and reflects on five key challenges for LA co-design: power relationships, surveillance, learning design dependencies, asymmetric teaching/learning expertise, and data literacy.
2. By adopting and adapting well established co-design techniques, across the three case studies, the thesis provides empirical evidence of how these techniques can be used in LA co-design, reflecting on their affordances, and providing guidance on their usage. These detailed findings are distilled into a *Learning Analytics Co-design Playbook*, published under an open license to assist adoption and improvements.
3. Recognising the importance of the co-design practitioner in ensuring that the design process is participatory, the thesis documents and discusses the key functions and skills that this position requires. The role is further complicated when the practitioner is not only a *facilitator* serving a project, but also a *researcher* of co-design. This motivates guidelines on the role of the co-design practitioner/researcher when working with stakeholders, and simultaneously studying the LA co-design process, tools and methods.

1 Introduction

Learning Analytics (LA) is an emerging research area focused on optimising learning using data as an active component (Sclater, 2014) This area is rapidly growing and multiple educational stakeholders, education providers and vendors are becoming increasingly interested in designing and deploying LA innovations in authentic educational settings. Recently, there has been some interest in the LA research field to exploit students' data to optimise the design process for deploying 'better' tools to support learners (Chatti et al., 2014; Ferguson, 2012). Yet, there is a risk that LA tools may be imposing a number of assumptions that do not necessarily meet the students or educators' needs (Dawson., Gasevic., & Mirriahi., 2018). A critical issue that has been identified in recent projects is the absence of learners' or their teachers' active voices in the process of designing the LA tools (Buckingham Shum, Ferguson, & Martinez-Maldonado, 2019; De Laet & Broos, 2018; Drachsler & Greller, 2012). This suggests the need for a deeper understanding about how LA innovations are being designed and how educational stakeholders can participate in and contribute to the design process (Nunn, Avella, Kanai, & Kebritchi, 2016).

Including learners and educators as active participants can bring benefits such as a better understanding of authentic teaching and learning needs and expectations, the development or adaptation of analytics tools that fit the educational intentions, an increase in trust among stakeholders, and the development of effective strategies to responsibly utilise sensitive data (Beattie, Woodley, & Souter, 2014; Slade & Prinsloo, 2013, 2015). Giving voice to learners and other stakeholders can open up an opportunity to make the design process a democratic journey where participants can express their concerns and provide context for the designed LA innovations to actually address what is important for them. The overall objective of getting learners and educators on board in the design process is to ensure that their values, expectations and needs are well represented (Davis & Nathan, 2015; Friedman, Kahn, Borning, & Huldtgren, 2013; Vermaas, Hekkert, Manders-Huits, & Tromp, 2015).

Neglecting the involvement of learners and educators in the decision-making process may pose challenges for the adoption and acceptance of LA innovations (Beattie et al., 2014). For example, emerging LA tools may be considered as a risk by learners who may perceive that they no longer have the freedom to influence their learning environment and follow their own learning strategies (Beattie et al., 2014; Roberts., Howell., & Seaman., 2016). This means that learners may feel they do not have a voice in the ways LA tools are going to be used and, instead, they may feel *alienated* from the learning process.

There have been some initial attempts to include learners and teachers in the design process of LA, based on co-design principles. For example, some researchers have focused on understanding and define what collaboration with learners entails (Dollinger & Lodge, 2018). Techniques such as fabulation and replayed enactments (Holstein, McLaren, & Aleven, 2017), speed dating and storyboards (Holstein K, 2019) have been used in the attempt of understanding teachers' needs and expectations. Another example has included consultations via focus groups and interviews with learners (McPherson, Tong, Fatt, & Liu, 2016; Roberts. et al., 2016). Others have used guiding questions to promote inter-stakeholder conversations (e.g. teachers, researchers and technical staff) for each contribute to the design of the LA innovation based on their expertise (Luis Pablo Prieto, Rodriguez, & Martinez-Maldonado, 2018). Some LA researchers have drawn attention to well established participatory design approaches such as value-sensitive design (Chen & Zhu, 2018), and user-centred design (De Quincey, Turner, Williams, & Kyriacou, 2016) to design LA innovations that endorse learners' values and address authentic needs. In sum, the interest from the community towards stakeholders' involvement has been growing. Yet, there still is much work to do since the examples mentioned above only represent a 'first wave' towards establishing human-centred design practices in the field of Learning Analytics.

The analysis of the current work at the intersection of co-design and LA led to identifying a current gap in the LA field: *There is a lack of active stakeholders' collaboration in the design process of learning analytics.* This gap can be described in more detail as three sub-problems:

1) There is a lack of understanding of how co-design techniques can support practitioners and researchers in designing LA innovations with educational and technical stakeholders. In particular, there is a dearth of tested strategies that other LA researchers or designers could adopt to design human-centred learning analytics (Dollinger & Lodge, 2018; Mollie Dollinger, Danny Liu, & Arthars, 2019).

2) There is no clarity about what the role of the person in charge of the co-design process is in the context of LA development. The person who runs the co-design techniques plays a different role to researchers, designers and other stakeholders. In educational contexts there are particular contextual conditions that may facilitate or hinder the adoption of educational technology that should be taken into account in the co-design of LA innovations (Tsai, Moreno-Marcos, Tammets, Kollom, & G., 2018). The lack of detail about the responsibilities and roles of the co-design practitioner can make the LA co-design process difficult to manage, and increases the chances of failure. When the facilitator is also a researcher, as in the case of this thesis, it will likely introduce additional roles and responsibilities.
3) There is uncertainty in terms of the particular challenges that can emerge while co-designing for learning analytics. Since learning analytics is a field where the technical challenges of data analysis meet learning design and pedagogy, there may be distinctive challenges to bringing diverse stakeholders into co-design, which are not encountered elsewhere.

1.1 Research Questions and Contributions

The research goal of this project is to address the gap (and the three associated sub-problems) mentioned above by *engaging key educational stakeholders in the learning analytics design process*. The three research questions (RQs) used to guide this research are as follows, with an indication of the potential contributions:

- **RQ1 – How can co-design techniques assist in the integration of diverse stakeholders in the LA design process?**

  The aim is to demonstrate the adoption of established co-design techniques from other fields, as well as how such techniques can be adapted to the specific demands of LA design, to give voice to, and integrate, diverse stakeholders' perspectives.

- **RQ2 – What are the roles of the co-design practitioner/researcher in the LA design process?**

The aim is to identify the roles played by the co-design practitioner/researcher in facilitating the use of co-design tools in design sessions, and their responsibilities when managing the co-design process.

- **RQ3 - What are the challenges in engaging stakeholders in the LA design process?**

  The aim is to characterise, and evidence, key challenges when engaging stakeholders in the LA design process. While some of these challenges may be unique to LA, others may be common to educational technology in general, or alternatively, may be common to analytics co-design beyond education.

In addition to the above contributions to this applied field, several *contributions to practice* are anticipated, by distilling the research findings into accessible forms:

1. provide a toolkit for practitioners/researchers to adopt/adapt co-design techniques for upstream/downstream learning analytics design;
2. clarify the key role and skills to be a co-design practitioner as guidelines to assist new practitioners/researchers in the field;
3. informed by the challenges of introducing LA co-design, offer recommendations for LA designers and researchers seeking to introduce co-design.

1.2 Thesis Organisation

The research work presented in this thesis document is structured into 8 chapters starting. The thesis narrative and connection between chapters in relation to our research objective are explained in Figure 1-1 as a block diagram. The first block called *Context* introduces the current theory and background literature that inspired the current research work. The following blocks can be read in sequence placing the Research Questions on top and linking the following blocks using arrows and labels corresponding to their chapter/location in the document. The diagram can be used as a guide for the reader to find specific sections and content, map research questions to contributions across the thesis and have an overview of the research work.

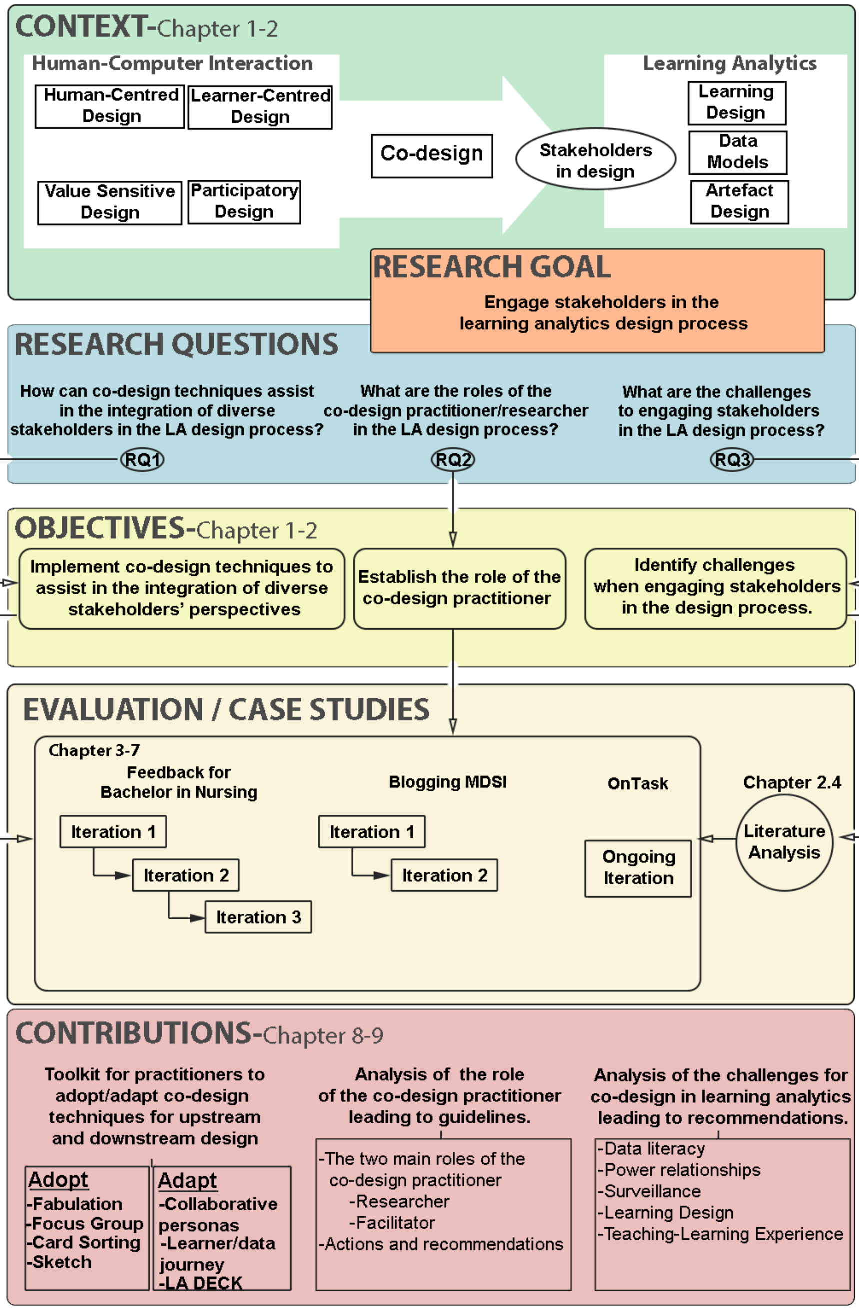

Figure 1-1: Mapping the document through a block diagram.

Chapter 2 Background and Related Work: This chapter provides the basis for understanding collaboration in design, the current methods, tools and techniques that made possible collaboration in technology for education; and the current efforts from the LA community to bring co-design into their projects.

Chapter 3: Five Challenges in Co-designing Learning Analytics: This chapter presents the challenges in co-designing learning analytics that can be identified from the literature. Hypothetical scenarios are used to illustrate the challenges and the implications for practitioners/researchers in the field.

Chapter 4 Methodology: This chapter presents the Design-Based Research (DBR) approach adopted in this thesis. Additionally, the chapter explains how Design Thinking was used to enable the iterative co-design of LA innovations. The chapter finalises by introducing the case studies, research sites and describing the analysis techniques used to generate evidence to address the research questions of the thesis.

Chapter 5 Case Study 1-Automated Feedback for Nursing Students: This chapter describes the first case study involving the design of a LA tool that provides automated feedback to nursing students. The chapter describes the context of working with clinical simulations as the medium for instruction, and the stakeholders involved such as learners, teachers, nursing academics and researchers. It also describes the co-design techniques used in each of the three iterations in the case study. These include adaptations to persona profiling and collaborative sketching and a proposed new tool, the Learner/Data journey. The results are explained in each iteration guided by the RQs. The chapter finalises with the analysis of emerging challenges when co-designing with nurse students and academics.

Chapter 6 Case Study 2- Analytics for data science students blogging: The second case study is presented in this chapter. This case study provides an authentic scenario involving students, teachers, data scientists and designers from the Masters in Data Science and Innovation program. The chapter describes the need for a new LA tool to track graduate attributes development and improve their communication skills. The chapter also describes the co-design sessions, the design of a new card-based co-design tool called LA-DECK and the effectiveness of other co-design techniques used. The chapter finalises by describing challenges emerging through the case study using design vignettes as a way to summarise critical incidents involving the use of co-design techniques, and the role of the practitioner.

Chapter 7 Case Study 3-Ontask: In this chapter, we present a case study where co-design techniques (LA-DECK and focus group) are tested under an authentic scenario with the purpose of re-designing for an existing LA system called OnTask. Part of the testing scenario in this case study is to adapt the current LA-DECK tool to enable academics to create rules that are used by the system to provide personalised feedback at scale. The LA-DECK OnTask version provided interesting results helping in understanding the limitations of co-design techniques when used by non-technical stakeholders.

Chapter 8: Discussion: This chapter presents a discussion based on the results found in the case studies. The discussion is being separated following the three research questions. The first section discusses the effectiveness of the co-design techniques, the need for a playbook to support future practitioners/researchers; and a series of recommendations to adopt and adapt co-design techniques in future LA projects. The second section discusses the roles taken by the co-design practitioner/researchers; the actions required for practitioners to ensure the co-design process is being implemented in the most effective way; and the notion of making decisions in collaboration. The third section revisits the expected challenges in co-design for learning analytics and discusses emerging characteristics when dealing with them through our case studies.

Chapter 9: Conclusion: This chapter summarises all findings in relationships with our three research questions. First, it includes the conclusion of using co-design techniques to engage stakeholders in the learning analytics design process. Then, the role of the co-design practitioner/researcher including the importance of acting according to the context and stakeholders involved. Finally, it includes important things to consider when confronting the emerging challenges in co-design practice.

2 Background and Related Work

Chapter overview

Co-design is a structured process for collaboration with stakeholders that has been explored for many years in the field of software development. From the original implementation using Participatory Design (PD) techniques, to bringing the concept into LA, there are theoretical considerations that the co-design practitioner must understand to better implement co-design into LA design. The highlights of the chapter can be summarised as follows:

1) Co-design is commonly considered to be a structured process to investigate users' opinions, their intentions and the context in which a tool will be used. While some research areas use PD and co-design interchangeably, for this thesis, co-design is defined as an approach where students, educators, researchers, developers and designers are all included across different stages of the design process.

2) Co-design emerged from participatory design methods with recommendations and guidelines for collaboration between diverse diver stakeholders. Since co-design proved to be useful in other fields, there is an opportunity to bring co-design into LA and engage stakeholders.

3) There are a few examples in the field of LA where researchers suggest active collaboration with learners and teacher. However, these are only initial experiments without a clear explanation of what techniques could be useful to engage stakeholders, what is the role of the practitioner and what challenges can emerge from this practice.

This project is grounded in core principles from three different areas of research and development, namely, Learning Analytics (LA), Co-design, and Human Computer Interaction (HCI). Co-design and HCI provide a range of methods, tools and techniques useful for stakeholders' inclusion in LA. Engaging stakeholders in design for LA goes beyond merely providing a place for conversation, and concerns systematic ways to welcome and elicit stakeholders' values, concerns and expectations in the design process. This is where co-design provides well-known practices opening a new range of opportunities on understanding stakeholders' collaborative environments in data-centric fields like LA. Engaging stakeholders brings a new perspective for educators, researchers and designers on how to benefit everyone involved by having a voice through co-design. The following section (Sec. 2.1) presents a brief history of the Scandinavian movement and subsequent work which defined collaboration in design. Then, current efforts to bring co-design methods, tools and techniques into education are described in Sec. 2.2. Finally, current co-design research for LA design is revised in Sec. 2.3.

2.1 Collaboration in design

The terms **Participatory Design (PD)** and **Co-design** have been used by different communities to describe processes in which diverse stakeholders are included in parts of the whole design journey. Co-design is commonly considered to be a structured process to investigate users' opinions, their intentions and the context in which a tool will be used, including privacy concerns. While some research areas use PD and co-design interchangeably, for this thesis, we define co-design as an approach where students, educators, researchers, developers and designers are all included across different stages of the design process.

(E. Sanders & Stappers, 2008) proposed a helpful figure showing the relationship between PD and Human-Centred design, mapping related approaches in a 2x2 quadrant.

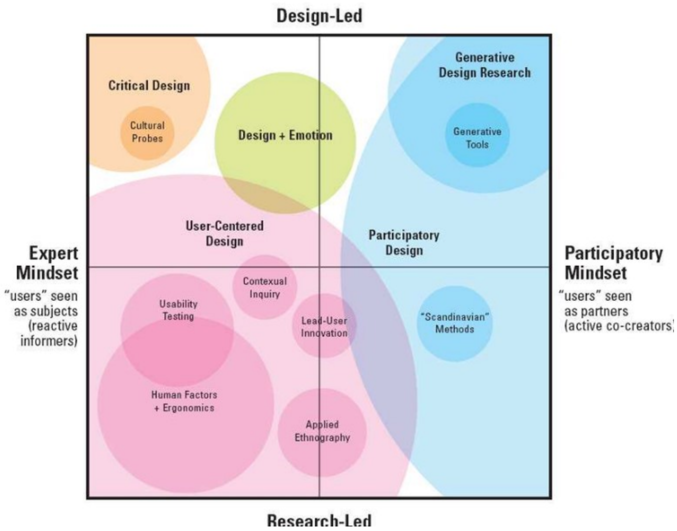

Figure 2-1: Sanders and Stappers (E. Sanders & Stappers, 2008) map showing how Participatory Design relates to User-Centered Design and related design research fields

Adding the co-design circle to this framework, this thesis sees the co-design field as emerging from the application of the two fields, as shown in Figure 2-2. Co-design brings together both research fields with the objective of providing a space for designers/ researchers to implement design methods combing both a *participatory* and *expert* mindset (X-axis). With respect to the Y-axis, the dynamics of users working with researchers place co-design in a middle point where producing a design object (*Design-led*) is as important as generating a knowledge contribution (*Research-led*).

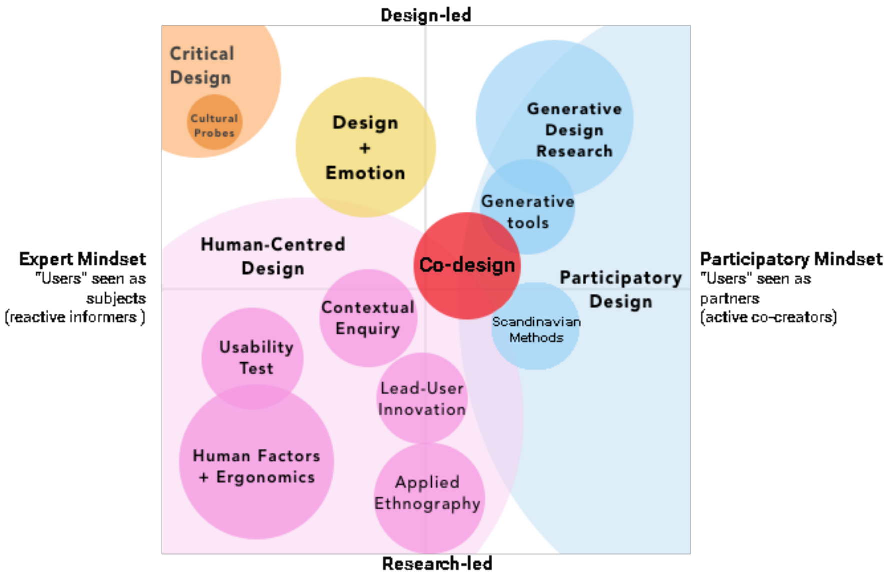

Figure 2-2: Positioning Co-design as a research field, based on (E. Sanders & Stappers, 2008).

Participatory design methods, in general, focus on how the interactions occur between stakeholders and how the design process benefits from them (Tone Bratteteig & Wagner, 2016). The first efforts to bring stakeholders into the software design process were seen in the Scandinavian design literature, an effort between researchers and developers to work with metal unions and labour groups (Floyd, Mehl, Reisin, Schmidt, & Wolf, 1989). From there, the research community has moved towards bringing participatory design to new areas where new methods are required to come out with a more democratic outcome (E. Sanders, 1999)

Some efforts have been made through the years to ensure user participation in the design process of technology and innovation in general. Software companies started to incorporate methodologies to engage stakeholders as a response to some work practices where designers attempted to fit people to the requirements of the technology. A good example is the Soft Systems Methodology (Checkland & Scholes, 1990) which incorporated a collaborative design approach using socio-technical concepts across different initiatives, testing different ways to allow users to be part of the design process and generating contextual information along the way.

The first example of a conceptual contribution to users' participation in software design is STEPS (Software Technology for Evolutionary Participatory Systems Development) method. This method focuses on different cycles that combine the development and application of the digital tool. The most interesting aspect about this method is that it helps designers to focus on custom development of new tools made from scratch. This method is based on the technical aspects of software engineering and builds on the importance of design as a process shaping the technical artefact and its context of use. Besides explaining the inner workings of co-design, this contribution highlighted the idea that participatory design models should be complemented with specific tools and techniques to facilitate the design process (Floyd et al., 1989). With STEPS as a first approach to participatory design systems, it is possible to understand that research in co-design is mainly focused on the process, user intervention and information management.

Another method from the Scandinavian design efforts in co-design is MUST (Danish acronym for *methods of initial analysis and design activities*). This collaborative design process allows the designers to build a theory that enables them to relate the implementation of the software to its use context, as users develop an understanding of how the software can support their work practices. The idea behind this method is to bring a business perspective while implementing a socially sensitive approach to software design. The meta-method concept is very similar to the one described in STEPS but provides a set of guidelines to help designers to frame the different situations where the product could be used (Kensing, Simonsen, & Bodker, 1998). In addition, MUST clarifies that an integrated participatory project (Kensing et al., 1998) consist of 4 elements: Concepts, principles, projects organization and techniques Figure 2-3 (Bratteteig T, Bødker K , Dittrich Y, Mogensen P, & Simonsen J, 2012).

One of the guidelines followed in MUST (Kensing et al., 1998) that other methodologies overlook, is how knowledge is being shared across participants. The importance of knowledge sharing requires researchers to use ethnographically inspired techniques to ensure that participants are genuinely accounted for.

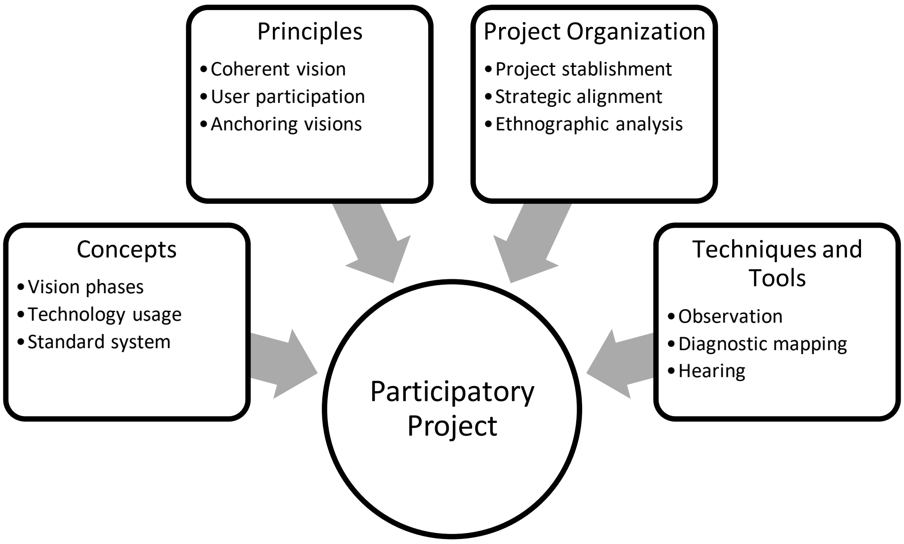

Figure 2-3: Resources in MUST Method (Bratteteig T et al., 2012).

Providing stakeholders with an active voice through participation facilitates understanding their needs and making black boxes of design a more transparent and democratic process where the direct stakeholders (a person intended as the main beneficiary) have a say on what is important for them. User inclusion started to be an active component in different design areas in particular user-centred design and participatory design. These became the first design areas documenting experiments with stakeholders, the relationship between design and psychology theory on user actions and the need for theory development in collaboration (Clement, 1993; Norman & Draper, 1986). As seen in Table 1, every design approach brings benefits and obstacles to user inclusion in the search for providing an active voice, but co-design and PD make it a priority providing more tools and examples for easy adoption. This places researchers in a position where no single design approach can be applied without considering its limitations, which applies equally to co-design for learning analytics.

Table 1: Benefits and obstacles from different user inclusive design approaches.

Design research areas	Benefits	Obstacles
User-Centred Design	-First to use goals as a metric. -Enables context creation. -Acknowledges user limitations and abilities. -Specified design process focused on product outcomes (Norman & Draper, 1986).	-Use is a limited component on learning scenarios. -Good design can conflict with learners' goals, and their goals can change. -Difficulty to translate certain types of data into design. (Kujala, 2003; Nielsen, 2008)
Value Sensitive Design	-Create concepts around user perceptions. -Support empirical data. -Considers direct and indirect stakeholders (Friedman et al., 2013)	-Design process largely left open-ended. -Data from mixed methods not explored enough (Dantec, Poole, & Wyche, 2009).
Learner Centred Design	-Scaffolding system -Motivation and engagement on learning artefacts -Context for learning and teaching. (Bakharia et al., 2016; Good & Robertson, 2006)	-When too diverse, it may end up in two different systems. -The chain for decisions many times depends on the institution. -Data use is not considered part of the original design (Soloway et al., 1996).
Design thinking	-Individuals and interactions over processes and tools -Responding to change over following a plan. -Design model process is well specified on multidisciplinary participants -Enables data driven decisions from quantitative data analysis. (Ambler & Lines, 2012; Dean Malmgren & Wettersten, 2017)	-None of the major agile methodologies explicitly includes documentation of the design process required for research context. -Collaboration and inclusion methods are unclear -Data management is not specified (Lee, McCrickard, & Stevens, 2009; Salah, Paige, & Cairns, 2015)
Co-design, Participatory design	-Context-aware, -Involves collaboration at various levels. -Provide a democratic iterative approach. -Supports mixed methods -Tools and techniques well documented (Muller, 2003; Scariot, Heemann, & Padovani, 2012)	-Tracking collaboration takes more time and effort. -Different perspectives may never find an endpoint. -Design process is not well established (Scariot et al., 2012)

One critical challenge that comes from LA design is to define what data and analytics are important for empowering stakeholders such as students and educators (Part of the discussion in Chapter 3). This problem may in principle be solved by using a co-design approach implemented as an iterative process based on well-established methodologies such the ones presented in Table 1. But given these differences between methods, it may be necessary to adapt tools, techniques and methods from all of them using a flexible method like design thinking and design-based research (used as our methodology for this research).

From the fields described in the table 1, the most relevant difference between co-design and PD from the other user centric fields is that techniques for collaboration, context and value of stakeholders being active participants are part of the methodology placing collaboration as the priority. Learner centred design places learners as the main stakeholders which is in this research project interests, however, the application of this does not includes a clear methodology and is mostly applied to learning design and non-data intensive tools like LA. Design thinking evolved from user centred practices but minimizes the interest in users' values/expectations and is not commonly explored in learning context, this makes DT a good reference to break the design process into agile iterations but still must be complemented with the core principles of PD/co-design if active stakeholders collaboration is expected.

There are differences between working for commercial software and other non-business driven fields, in this case, education and co-design have their own issues and research work to do as explained in the following section.

2.2 Co-design for education and educational technology

There are different ways to implement co-design for educational technology. Some of these come from areas where digital tools in education were developed following standard methodologies in software development like spiral, extreme programming or iterative research. The first difference between those standard methodologies is that the target of co-design methods typically are socially embedded systems (depend on human relationships with technology), rather than technological embedded systems (design to fulfil a task) (Liam Bannon, 2012). The second difference is how data is being used to inform decisions and support developers when understanding design problems (Xiang Zhang, 2016).

In educational settings, most of the design work commonly relies on researchers or educational technology vendors in which a team of visual designers, business specialists and educational theorists may come up with proposed solutions that can be disconnected from the actual educational needs (Herold, 2015). In cases where projects become a big effort between different university departments, the role of designers is being undertaken by multi-professional teams (Luckin et al., 2013). In some cases, educational designers only enact specific roles such as instructional designer, educational or curriculum designer, while others (i.e. teachers, students, or library media specialists) engage in design work primarily by configuring or adapting certain functions already designed for them. In short, the final educational tools are often envisaged and developed by other actors but the learners and educators themselves.

A body of research is growing regarding the potential of using participatory design in the learning sciences, and educational research more broadly, to help define goals, pedagogical expectations, ways to assess learning and actively involve different stakeholders (DiSalvo, Yip, Bonsignore, & DiSalvo, 2017). However, none of the chapters in that edited volume addresses the issues that educational data and analytics specifically raise, the focus of this thesis (Section 2.3, elaborated in Chapter 3). Similarly, the study done by Tanes, Arnold, King, and Remnet (2011) indicated education systems need to be designed to support deep insights into processes of relevance and combine learning outcomes with learners' perspectives. A major recommendation is to ground educational technology design on learning theories where students are part of the process like learner-centred design (Luckin et al., 2013).

One of the most notable examples of integrating design frameworks for co-design in education is CARSS (Context, Activities, Roles, Stakeholders, Skills). This framework was developed to guide other researchers through the "*often-complex process of designing educational technology with young people*" (Luckin et al., 2013). As a main contribution, this approach provides a practical and realistic charting of the requirements and challenges of involving learners and other stakeholders in the process (Good & Robertson, 2006).

With a framework like CARSS (see Figure 2-4, the design process can be managed by five main components: context, activities, roles, stakeholders, and skills (Good & Robertson, 2006).

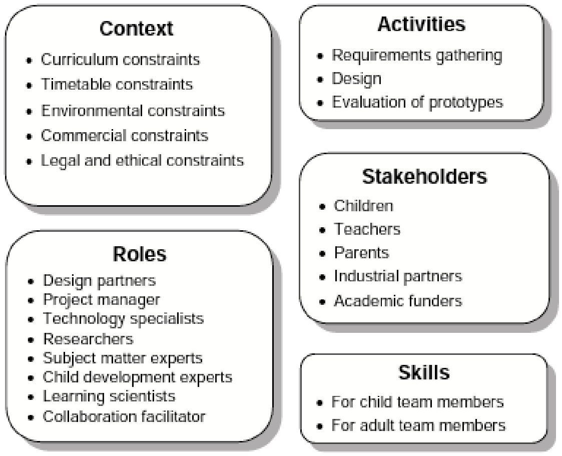

Figure 2-4: CARSS (Good & Robertson, 2006)

Working with the particularities of educational technology, it is possible to use CARSS and MUST as first approaches to bring participatory methods for extracting/analysing qualitative data while being inclusive towards learners and educators. The shortcoming in using co-design methodologies like CARSS and MUST is the lack of scaffolding stages that may be required for inclusive LA design, and making the process iterative requires the adoption/adaptation of multiple methodologies while creating new co-design techniques.

Co-design is still a growing field where research points towards contemporary practices for stakeholder involvement. We can take those insights and evolve the co-design methods into the design practice of learning analytics (Hoadley, 2017). The following sections present a number of examples where researchers put in practice collaboration in learning analytics design hinting to the need for co-design practices in the field.

2.3 Co-design for learning analytics

Human-centred practices and co-design are witnessing a growth in interest within the LA research community. Some recent examples of this growing interest include the special issue on *Human-Centred Learning Analytics* published by the *Journal of Learning Analytics* (Buckingham, Ferguson, & Martinez-Maldonado, 2019), the call for co-design contributions in *The Internet and Higher Education* special issue on *Learning Analytics in Higher Education: Stakeholders, Strategies, and Scale* (Gašević, Tsai, & Drachsler, 2019), and the journal of *Interaction Design and Architecture(s)* special issue call on *Co-creation in the design, development and implementation of technology-enhanced learning* (Treasure-Jones & Dennerlein, 2019). These research initiatives acknowledge the lack of work to advance human-centred approaches and co-design in the learning analytics field, and communities are now seeking concepts, and practical methods/tools, to bring co-design into LA projects.

The first attempts to include learners in the design process of LA are based on adopting well established co-design principles and methods. Researchers in learning analytics have focused on the first phases of the process, where understanding and definition stages happen (Dollinger & Lodge, 2018). Techniques such as Fabulation and Scenarios have been used in the attempt of understanding teachers needs and expectations (Holstein et al., 2017).

Another example has conducted student's consultations via co-design sessions with learners (McPherson et al., 2016; Roberts. et al., 2016). This work reported that while learners were interested in LA tools, their expectations were extremely diverse, so co-design practitioners must be aware of this challenge and be prepared with methods to negotiate this with learners. In Luis Pablo Prieto et al. (2018), collaborative decisions are introduced using guided questions to stakeholders based on their field of expertise using orchestration theory (Luis P Prieto, Rodríguez-Triana, Martínez-Maldonado, Dimitriadis, & Gašević, 2019). This initial experiment worked as a contribution to the contextual inquire process that may benefit co-design as a whole process.

A small number of case studies have begun to test collaboration in different degrees, with teachers the main stakeholder, such as the work of Mavrikis, Gutierrez-Santos, and Poulovassilis (2016) and Martinez-Maldonado, Pardo, Mirriahi, Yacef, and Kay (2015). Treating teachers as the primary stakeholders is understandable since they are often the main users of new LA tools. However, there is clearly scope to extend this practice to give voices to learners, and to help integrate these with the views of educators and developers. This may be more challenging than the future work proposed in these papers, since there is a poor understanding of the relationships between the techniques, methods and actions required for effective co-design.

Other concerns such privacy and surveillance are being explored by Slade and Prinsloo (2015), in this case, simple consultation in the spirit of co-design was used to understand concerns and improve the way privacy management was being implemented at their university. Other concerns refer to the inclusion of legal and ethical constraints that in learning analytics has been an area of interest for content negotiation and user trust in collaboration (Beattie et al., 2014; Slade & Prinsloo, 2013).

2.4 The role of the co-design practitioner

Previous research has established that the role played by participatory design facilitators is a curiously understudied question in the literature (Selvin, 2011; Selvin, Buckingham Shum, & Aakhus, 2013). It is as though the complex process of bringing diverse stakeholders together is accomplished simply by introducing PD tools, with no interest in the specifics of what that human facilitation entails:

> "Most PD studies treat practitioner concerns at a distance, if at all, or touch on them only at the level of project planning, selection of tools and techniques, or discussions of a project's functioning as a whole, rather than practitioner choices at the move-by-move level.
>
> […] When they touch on practitioner issues at all, much research treats the practitioner as something of a cipher, an anonymous actor that chooses and applies tools and methods and organizes a project. Most more experiential accounts of PD projects focus more on participant reactions, uptake, and outcomes, rather than the role of practitioners."
>
> (Selvin & Buckingham Shum, 2014) pp.7)

In the literature review that the above quote introduces, it becomes clear that very little work has paid close attention to the role and skillset of the practitioner. For this reason, through RQ2, this thesis sets out to document and reflect on the role of the co-design practitioner, and (detailed in Chapter 4) builds on the Knowledge Art framework to analyse the data (Selvin & Buckingham Shum, 2014).

2.5 Summary

This chapter has introduced co-design as a concept, how it is being introduced in education and educational technology, reviewed the currently small body of evidence from projects piloting such methods and tools specifically in LA, and highlighted the lack of understanding around the co-design practitioner's role.

The literature makes clear that co-design entails making changes in the design process, which in turn, requires adaptation and learning from stakeholders who are not used to engaging with each other, and (in the case of non-technical people) with strange software design and analytics concepts. Hence, when human-centred, co-design processes are working well, requirements analysts and software designers should no longer make decisions purely on technical grounds, but must learn to listen to end-users. Data scientists should no longer design analytics without listening to educators about what they need to know from a dashboard. Students and educators are now being asked what they would like to see in software, or data gathering, but may not be able to articulate this clearly without help. Co-design action researchers need to be ready to question their ways of working, to ensure that their agendas are not in conflict with the needs of the people they are studying/serving.

The challenges of helping stakeholders learn these new ways of working are well understood in the broader human-computer interaction and co-design fields. This thesis seeks to clarify the nature of this learning, and evidence how it takes place, specifically in the context of co-design conversations for learning analytics.

3 Five Challenges for Co-designing Learning Analytics

Chapter overview

Co-design with learners, teachers and other academic stakeholders is a considered method that designers have been implementing in EdTech to give learners and teachers an active voice in design. However, this is a new concept in learning analytics that will bring practical challenges for co-design practitioners, since the combination of data concepts and educational theory bring their own domain specific constraints. The highlights of the chapter can be summarised as follows:

1) Asymmetric *power relationships* may exist in co-design for LA since hierarchies in academia still place teachers and administration at a higher level than students. This gives teachers more influence over design decisions.

2) There are archetypal challenges existing in EdTech that may emerge the same way in LA. A key one relates to LA dependencies with the *Learning Design* (LD). The concept of the task-artifact cycle in HCI explains why LA design may lead to LD design, and vice-versa, in a mutually shaping loop.

3) There are distinctive challenges that are only relevant for the LA field when implementing co-design. *Data literacy* among stakeholders explains how conversations are shaped based on their understanding of analytics methods. Asymmetric *Teaching/learning expertise* explains how learners' limited understanding of pedagogy may lead to poor or unfeasible proposed changes to the learning environment. *Surveillance* concerns are likely to arise from the tracking of learners' data.

3.1 Overview of the challenges

This chapter distills five key challenges that confront efforts to introduce co-design methods into LA design. As will become clear, some are educational versions of pervasive co-design challenges, while others are more distinctive, especially for Educational Technology (EdTech) design. This thesis will demonstrate how the different challenges arise in the course of the three co-design case studies (Chapter 0, 6 and 7), and revisit them in the concluding discussion (Section 8.3), providing a response to RQ3: *What are the obstacles/challenges to engaging stakeholders in the LA design process?*

Bringing co-design research practices into a multidisciplinary field like learning analytics opens a realm of possibilities when planning the design road to follow for researchers/practitioners. However, issues and constraints for effective collaboration will appear since context, scenarios, stakeholders and objectives differ from traditional approaches to technology design (Dollinger & Lodge, 2018; Sharma, 2006).

To identify the challenges that designers and researchers will face requires us to examine the origins of the classic movement of Participatory design/Co-design (explained in section 2.1), current design practices in EdTech, and the emerging field of Learning Analytics where data is being used to provoke reflection or support teaching and learning.

The five challenges fall into three broad categories:

3.1.1 Archetypal challenges from PD/Co-design

This category covers challenges well documented in Participatory Design and Co-design literature (Bjögvinsson, Ehn, & Hillgren, 2012). These challenges derive from organisational reporting hierarchies, but educational institutions add particular nuances. *Power relationships* hold not only between staff, but in the roles of teacher/student or master/apprentice. *Expertise asymmetries* derive not only from the pervasive disparity in computing knowledge found in all co-design (e.g. programmer/academic), but in the disciplinary knowledge typically enshrined in the student/instructor relationship, although academics often bring complementary or conflicting pedagogies and academic expertise.

3.1.2 Archetypal challenges from EdTech design

This category describes challenges encountered when designing software that intersects with learning theories, pedagogy, and assessment, i.e. *Learning Design*. Working in the space of design for learning technologies makes the co-design task an intricate problem where solutions are aimed to help students through their learning process. Working with learning design concepts requires additional effort for researchers/practitioners to understand how the LA tools should support learners and teachers as the main goal. As will be discussed, in the course of LA co-design, the learning design may also be questioned, and educators may come under pressure to evolve their plans.

3.1.3 Distinctive challenges for LA co-design

The emergence of big data, analytics and AI introduce new co-design challenges for every sector of society, which takes particular forms in education. The first challenge concerns *Data/Algorithm Literacy* among stakeholders. It may be hard for teachers and students to contribute to LA if they cannot understand the teaching or learning implications of design decisions that depend on data and algorithms they do not understand, and unfamiliar types of report and visualisation. Until the emergence of data and algorithm intensive tools, education has not had to confront this until now. Related to this there is a second challenge, namely, that LA concerns a form of *Surveillance:* the data and analytics are typically activity traces (of students, or teachers), aggregated, analysed and fed back to someone. This is a new phenomenon for education, and an understandable cause of concern for many.

A third challenge in this category is that in contrast to most contexts, in which we are co-designing software to support people perform well-defined tasks, in learning, we may be seeking to effect long term changes in the learner's assumptions, beliefs, attitudes or dispositions, by triggering *metacognition and reflection* about how they engage in learning, and/or their understanding of the world.

From the above, it is now possible to identify an unusual variant, and particularly acute form, of *Expertise Asymmetry*. Typically in human-centred design, one expect the intended users of the envisaged software to contribute significant expertise in how they perform their work, and how they could do so with the future system. However, students are in fact experts in neither learning, nor teaching, resulting in a challenge we call *Teaching/Learning Expertise.* Combined with the *Data/Algorithm Literacy* challenge, the challenges of co-designing with students become clearer.

The following sections explain each challenge in more detail. Each challenge is defined, and introduced with an example. Following this, relevant *Research insights from other fields* are surveyed, including classical literature from the co-design movement and design for education. We next address *How this challenge emerges in learning analytics,* linking the challenge essence with the current state of learning analytics design, and finally propose insights on *Potential ways to address this challenge.*

3.2 Challenge: Power Relationships

Overview: In co-design, participants should ideally be treated as equal partners. However, in educational settings, there may exist implicit or explicit hierarchical power relationships such as Teacher/Student or Master/Apprentice. The key challenge in co-designing a learning analytics innovation is to respect the contributions that every stakeholder brings while addressing the potential tensions or conflicting perspectives that may appear amongst stakeholders holding asymmetric power relationships.

3.2.1 Illustrative example

Three teachers and three students attend a design session to discuss the design of a new tool that delivers personalised feedback for students. Like many design sessions, we expect these students to describe their desired features based on their first-hand experience with the learning environment. Since some of the students are taught by the teachers, the power relationships may stop students suggesting certain ideas that sound critical of current teaching, or they may pretend they study in 'acceptable' ways. Students may see faults in teachers' proposals but are reluctant to challenge them.

In co-design for learning analytics, the notion of distributed power among participants may rely on the assumption that unwritten rules are being played in favour of students and teachers rights. At the same time, influence when making decisions should not be biased in favour of higher figures of power even when the sole action of placing some students in the same room as teachers and academics may generate conflict or implicit persuasion, as exemplified in the hypothetical scenario above.

3.2.2 Research insights from other fields

Since the earliest research in co-design, roles and hierarchies have been recognised as a pervasive challenge when working in any human organization. The first projects from the Scandinavian movement in participatory design identified responsibilities and level of contribution are part of the power relationship between managers and employees (Bodker, Ehn, Knudsen, Kyng, & Madsen, 1988), and organisations still manage distribution of work in a vertical chain of command (Domhoff & Dye, 1987; French & Rosenstein, 1984).

In higher-education, roles and positions are given to people as an automatic step the moment they become part of the learning ecosystem, this includes learners, teachers, learning designers, academic directors and faculty managers in different positions of power. The roles assigned by universities influence the role of stakeholders when participating in co-design sessions since their responsibilities and agency may interfere with their ability to make decisions (Parker, 2014). Most higher-education institutions share the same vertical structure where debate and reflection differ between departments, this traditional arrangement rarely enables horizontal collaboration between areas making the hierarchies and power relationships stronger for co-design to navigate(Roselynn Verwoord & Smith, 2020).

Generally, the common state of academic institutions distributes power among administrators and teachers over students. Evidently, when making decisions, people in power positions tend to have more influence over those who are placed down the design ladder. In co-design, “power” and “influence” cannot be seen as mutually exclusive since people considered in lower positions should be able to suggest and decide at the same level than those higher in the hierarchy (Bratteteig & Wagner, 2014). Learners may find difficult to express their concerns and critique over the current learning structure when teachers are being seen as the immediate authority (Richmond, 1990). Even before expressing concerns and presenting their expectations, learners are conflicted by the possibility of repercussions and self-exposure from the basic action of having a voice (Pedersen, 2007).

Identifying hierarchies and power relationships in design is not only used to assign responsibilities but also to identify those people with authority able to call for the last decision. The notion of identifying people with the ability to make decisions in this process can help teachers and learners to focus on the things they can have a meaningful impact or at least knowing who has the required influence to execute their expectations (Overton, 2006). From this, learners may identify those people who can help them when exercising their rights and use those power constructs for their benefit.

Current research in co-design in higher education has been more limited and largely focused on the advantages and disadvantages of generating strategies for work distribution and adoption, ignoring important factors such as communication, trust and affinity that affect relationships between partners (Tore Hoel & Chen, 2016). However, recent work published by Roselynn Verwoord and Smith (2020) introduces the concept of inviting HE students as partners in design to overcome hierarchies, influence and biased decisions. Insights gathered in this work can be used to lessen the effects of power relationships in co-design for learning analytics.

In sum, we can say that hierarchies in HE institutions are similar to those found in any organization. Since classic co-design work in education has already addressed this through horizontal channels for communication, LA researchers and practitioners may learn how to place learners and other stakeholders in the same level when doing co-design to lessen the notion of power and influence.

3.2.3 How this challenge emerges in learning analytics

Current practices in LA design tend to place students in a weak position when it comes to balancing the existing power relationships in learning institutions (Prinsloo & Slade, 2016). This is mostly due to teachers and academic administrators making all decisions without allowing students to intervene. More important, power relationships play a bigger role when learners personal data is being used since data can be seen as an instrument to unfairly asses them (Stoddart, 2012). Exercising the power to use student's data without informing students is common among current practices in learning analytics and this can lead to a feeling of being powerless and exploited (Drachsler & Greller, 2016).

Power relationships in co-design for LA may be addressed the same way as in other fields by giving learners a space for communication with people in higher positions and making sure their decisions will be respected. Even when current example of co-design practice for LA are not addressing the dynamics of power relationships or giving any solution, trust and open communication regardless of collaborators' current position should be endorsed by practitioners until common agreement is achieved. Influence as an expression of power figures in design sessions may require to be balanced through artefact mediation (card-based design, post its, collaborative sketch) and guidance.

3.2.4 Potential ways to address this challenge

Following our hypothetical scenario, co-design practitioners may require providing different tools and mediums to allow students to express themselves surpassing the existing tension of face-to-face interactions. Students may have different priorities when receiving personalized feedback and have some other comments about the current practices followed by the teacher. Running sessions with one teacher one student at a time and letting everyone to have a chance to propose ideas or critique the current structure may enable more useful conversations. Facilitating other communication channels like online spaces where participants become anonymous to other participants may give enough space for everyone to express without feeling pressure over language, critique and personal preferences. Practitioners require proper tools that co-design research may not be able to deliver right now but adapting current tools can be the first approach into achieving effective collaboration.

3.3 Challenge: Surveillance

Overview: LA is undeniably a form of 'surveillance', usually at institutional scale. Even though education is a societal good, in the current context of concerns around data privacy violations and biased AI algorithms, any tracking of human activity may provoke distrust among stakeholders. Co-design processes will need to help legitimise and facilitate honest discussions around such tensions, such as what teachers want to see in students' data, what students are willing to share, and the purposes for which data are being used.

3.3.1 Illustrative example

Two students and two data scientists are invited to a co-design session to design a dashboard that helps students track their progress towards developing their writing skills. The data scientists suggest that the best way to bring accurate results is to track all activity from students' personal blogs and social media. The students express concern over being monitored all the time and fear their data could be used to judge them in unexpected ways. Students doubt that the LA tool's benefits are a fair trade for their data, and the conversation turns into a negotiation (this example is adapted from Case 2, Chapter 0).

3.3.2 Research insights from other fields

Nowadays it is common to get internet access through every piece of technology to keep us informed. Learners in particular are common users of social media, facilitating companies' objectives to get as much personal data as possible (Schneier, 2015). This trend in collecting data has spread to most websites that use data to support their business mostly based on adverts and data trading (Bernhardt, 2007). This practice in data collection has raised concerns from users including misuse of their data, lack of transparency and continuous tracking considered invasive. Implementing analytics tools in education will bring this same concern into EdTech and LA tools.

Surveillance in HE has become a more relevant subject since educational tools started to use data to support learners (Sabourin, Kosturko, FitzGerald, & McQuiggan, 2015). However, researchers and designers will find a new challenge when it comes to implementing active surveillance by tracking, measuring and reporting insights using learners' data (Macfarlane, 2013). Although it is becoming common to find these data-intensive technologies into the hands of students like smartphones, tablets and smartwatches (Chatti et al., 2014), learners concerns over trusting their data to universities becomes a challenge for researchers when implementing new tools into academic environments (Drachsler & Greller, 2016; Slade & Prinsloo, 2015; Tufekci, 2014).

Overcoming the challenge of learners' distrusting surveillance practices requires a fresh perspective on what are the benefits for learners to be tracked at all times. Learners may agree on sharing their data but the benefits of using an LA tool cannot be seen as immediate as expected (Schneier, 2015). In the long run, when the benefits are greater than the act of giving away personal data, the less relevant surveillance become for learners (Workman, 2013).

Disclosing surveillance methods with learners may spark their interest in how data is being used (Govani & Pashley, 2005). This can be a great opportunity for researchers to start conversations with learners about their data policies and analytics methods. When learners understand what is happening with their data, a trusting relationship between learners and researchers may emerge bringing a solution to their concerns towards being actively tracked (Beattie et al., 2014). If this works in HE, then learning analytics researchers can use this information to reduce the challenge of surveillance in their projects.

Another concept that merges participation and surveillance in design is what Albrechtslund and Ryberg (2011) called Participatory Surveillance. This concept brings the notion that the same users that share their data to different systems should be in charge of designing their surveillance environment. Translating this into the learning analytics field, learners can be responsible for designing the tracking and surveillance mechanisms to avoid unfair use of their data and create more accurate data representations of themselves.

3.3.3 How this challenge emerges in learning analytics

With pervasive surveillance methods like geo-tracking, prediction and social network analysis, there is a thin line between whether learning analytics are seen as frightening intrusions, or trusted support. Current practices regarding harvesting pervasive data are based on the simple assumption that learners read, understand and have enough background knowledge to make informed decisions regarding privacy and surveillance practices. As pointed by Slade and Prinsloo (2015) one of the main components inside every learning analytics product is the capacity to inform students about collection practices and help them to make sense of it.

Another expression about complete surveillance over learners' activity is the assumption that "the end justifies the means". This sets learning objectives as a priority-driven by researchers/teachers' motivations and in consequence mismatching with learners' expectations (Slade & Prinsloo, 2013). This can be considered as an invasive strategy for learners when they do not consider trading their data for a better LA tool.

The concept of learning analytics is new for learners and not knowing the inner workings of data collection may bring issues when stablishing a trustful system. An effort like Pardo and Siemens (2014) aims to start a rightful practice for the researcher/designer by defining a set of principles for LA practitioner to consider when working with learners data. The ethical principles summarise that learners should have agency over their data, and transparency when using learners' data should be a requirement in Higher education.

3.3.4 Potential ways to address this challenge

Surveillance in learning analytics can benefit from co-design practices towards learners and other stakeholders. Opening channels for active discussion on privacy, ownership and ethics should be present during the design process in addition to follow ethical principles.

Going back to the example, giving learners the opportunity to negotiate access to their data can be proposed as a first step towards trusting relationships in LA. A researcher involved in the data collection process can use co-design sessions to inform students about how their data is being used and reach a point of agreement that works for everyone.

3.4 Challenge: Learning Design Dependencies

Overview: LA tools in formal education are always used in the context of a course. The Learning Design (LD) refers to the activities, resources, intended outcomes and assessments. The well-known interplay in HCI – between how a task and tool shape each other – translates in LA co-design to reflections not only on whether the LA aligns with the LD, but whether the LD could be improved to better align with the LA. Consequently, a co-design session must manage potential tensions when the LD may be questioned, educators may resent being asked to change their teaching/assessment, and the session may feel as though it has gone off course from LA.

3.4.1 Illustrative example

An academic meets with an analytics researcher to plan the introduction of a writing analytics tool for students. The researcher must understand the academic's intended Learning Design, such as the essay task, and the assessment rubric used to grade it, and adapts the tool to match the language used in the course. However, as the academic learns about the tool's capabilities, they realise that if task changes to implement peer-to-peer reflection on the tool's feedback, the students might learn more, and decide to assign some credits in the final grade to this task to incentivise students (see Shibani, Knight, and Shum (2019)). Thus, the LA and LD have mutually shaped each other to achieve strong alignment. However, in a different course, students are critical of the poor feedback they get on their essays, which offends the academic. The researcher suggests that if they make some changes to the assessment rubric and writing task, students would receive better automated feedback, but this assessment redesign and scheduling brings implications that the academic is not willing to consider.

3.4.2 Research insights from other fields

The concept of design artefacts being closely tied to domain specific context is part of the software design community and is still a topic of interest. Carroll, Kellogg, and Rosson (1991) explained that design features depend on the task being address at the moment. When the original task changes, the artefacts must be modified which in return creates new possibilities and constraints. The concept of this continues cycle of design changes is explained as the "Task-artifact Cycle" (as seen in Figure 3-1).

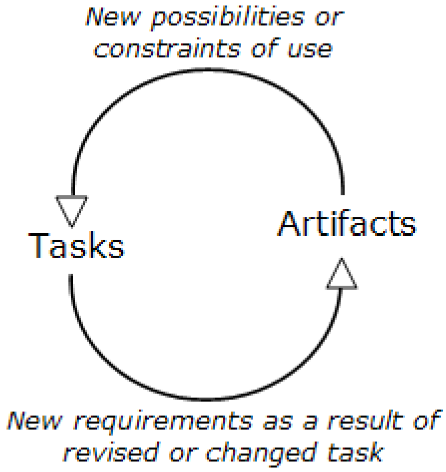

Figure 3-1: Task-artifact cycle (Carroll et al., 1991).

This poses a problem to information systems as *"computers and software can only respond to pre-defined situations or problems in a finite problem space* (Harris and Henderson 1999)". In a controlled scenario, the task would be a pre-defined set of rules that minimises the need for constant re-design. However, this does not happen when users are intended to adopt information systems as part of their routine. Translating this into designing artefacts for education, learning design will become part of the cycle the same way tasks are being described by Carroll et al. (1991) Task-artifact cycle.

3.4.3 How this challenge emerges in learning analytics

For technology in education, the task is completely tied to what the learning design demands to fulfill the learning objectives. Tools delivered for learners will find the same problem explained before as they are tied to the learning design and creates this loop. Building an effective learning design requires pedagogical strategies in addition to firsthand experience on the learning process, the learners' capabilities and the tools available for application.

Based on the Task-Artifact Cycle (Carroll et al., 1991), learning analytics artefact design is, in other words, an iterative process of continuous, mutually dependent development between learning design and the learning analytics artefact, a process that will never reach an optimum state.

As seen in Figure 3-2, changing the learning design generates new requirements for the tool needs to fulfil. Once the tool is in deployment, new constraints and possibilities of use will appear since the artefact responds to users completing their task.

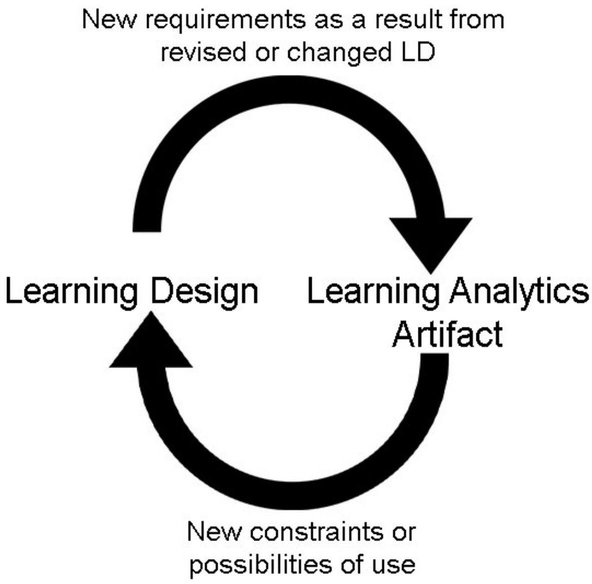

Figure 3-2: Learning analytics artifact design cycle based on the task-artifact cycle (Carroll et al., 1991).

Changing the learning design affects the way the learning analytics artefact works when deployed (Mangaroska & Giannakos, 2018). Learning design and learning analytics artefacts are strongly connected and thus, the possibility of intervening in one without changing the other is quite difficult. A co-design session with learners and teachers can therefore easily become a curriculum design session, if practitioners are not aware of how to use tools and methods to guide the conversation into the artefacts in question. Although learning design may be changing, there must be a point of agreement where co-design practitioners can synthesise the main component of the LD to initiate with the LA tool development.

In learning analytics, the community started to pay attention to what should be the priority when designing learning analytics artefacts. The intention is to make the learning design the starting point for the design process (Gašević, Dawson, & Siemens, 2015). In other examples, researchers put emphasis into how learning analytics artefacts should be shaped based on the learning design and not the other way around (Hernández-Leo, Martinez-Maldonado, Pardo, Muñoz-Cristóbal, & Rodríguez-Triana, 2019; Shibani et al., 2019). Nonetheless, strategies to bring this to co-design sessions with developers, learners, administrators, and other stakeholders is limited if the practitioner wants to create a solution for this dependency.

3.4.4 Potential ways to address this challenge

There is an opportunity for co-design to bring together learning designers, developers, teachers and other stakeholders involved in the design process of LA artefacts to effectively collaborate. This may offer a solution to constant re-design, and reduce discrepancies between the learning design and the intended LA tool. Returning to our example, the researcher must find a way to agree with the teacher to make sure learners' writing tasks are being assessed according to the learning design. The same analytics tools that worked for the first teacher may not work the same way for the second one, hence the need for a co-design process that reunites the teacher's perspective with the researcher's intention to modify the writing analytics tool.

3.5 Challenge: Asymmetric Teaching & Learning Expertise

Overview: Learners are rarely experts in either learning/teaching strategies, however, they should still have a voice since they will use the learning analytics tools, and bring first-hand experience of the course that may not be evident to other stakeholders.

3.5.1 Illustrative example

A practical example of this challenge could be seen when inviting learners, learning designers and developers to design a writing analytics tool. When designing a tool for this purpose, learners may request a feature that allows them to proofread their document every time they need it. The idea sounds like a practical solution to their needs as new writers; however, the learning designer might identify that this is not the proper way to fix their learning needs in terms of developing writing skills. The learners' suggestion has a value when understanding the actual problem they are trying to solve and the goal there are trying to achieve. The learning designer must apply their knowledge to make this happen by suggesting a tool that teaches learners how to be a better writer instead of making them rely on learning analytics tools for instant proofreading. To what extent should learners be aware of the multiple learning strategies? How valuable their opinion is when it comes to the design process?

3.5.2 Research insights from other fields

Collaborative practices like Participatory Design and Co-design rely on user knowledge in their field as a guide to come with design features. Expertise knowledge plays a big role when participants suggest critical components during the design process and this same expertise knowledge influence what participants can suggest (Christiaans, 1992). In co-design for EdTech and LA. In education, the expert knowledge relates to teaching and learning practice that most learners are not fully aware of. Learners not being aware of the teaching and learning practice will pose a challenge when co-design practitioners ask learners to co-design learning components related to their LA tools.

In HE, learners are considered stakeholders that become aware of the different learning techniques from a firsthand experience while navigating their academic life. Learners experiment with learning theory and methods from an empirical standpoint but rarely spend time understanding the theory behind them. This responsibility relies on the teacher and learning designers who provide their knowledge to support their students' learning environment (Dunkin, 2002).

The fact that most students are not experts in learning and teaching practice does not mean that they are not able to provide useful information when doing co-design. Learners are able to use prior knowledge/experience when facing a new challenge, formulate plans using known strategies and recognize their own strengths/weaknesses as learners (Rubio, 2015). This information can be used by the teacher to improve their practice and come up with better design features for their tools.

Some examples of how teachers can improve their practice with learners first-hand experience with the teaching practice are being explored in the field of students as partners in HE. In the co-design work described by Lubicz-Nawrocka. and Simoni (2018), learners and teachers collaborate to improve their curriculum using focus groups and interviews as co-design methods. As a result, teachers are able to understand students' needs based on their experience throughout the year and put together a plan for the following session. Another example is described in Bovill (2019) co-design sessions with learners. In this example, teachers and students collaborated to modify their curriculum and classroom collecting information from surveys and face-to-face sessions with students. This not only helped teachers to improve their learning materials but also to build positive relationships between staff and students, and between students and students

3.5.3 How this challenge emerges in learning analytics

The challenge of working with learners to the extent where their limited expertise in teaching and learning practice have not been addressed in detail in LA. Most of the current efforts leave all topics related to teaching practice to co-design sessions with teachers (Holstein K, McLaren B, & V, 2019). However, the lack of learners' involvement makes the whole implementation a one-side story suggesting that teachers' goals are the same as the learners' goals and expectations which in other cases have been proved to be misaligned.

Co-design practitioners in LA can take what has been found in HE through co-creation to start inviting learners into discussing their learning tools and experiences with the learning process. A first step is to have face-to-face session using focus groups and interviews with learners and then using this information to improve the learning aspects of learning analytics tools.

3.5.4 Potential ways to address this challenge

While the relationship between learners and teachers keeps evolving according to the context and stakeholders' capabilities, co-design may bring a path that facilitates collaboration between diversified groups by sitting learners and teachers in the same co-design sessions. Teachers can inform their practice by listening to learners struggles with the curriculum, learning material and learning spaces. Learners can use this opportunity to learn the reason behind implementing certain teaching strategies and use this information to provide better recommendations for their learning analytics tools.

Coming back to the example explained in the beginning, teachers can use co-design techniques to sit with learners and understand their perspective on issues with learning how to improve their writing. Even when students suggestion is not an effective solution according to the teachers' experience and knowledge, teachers can use this information to come up with a better strategy where an LA tool can support students as they expect to happen. As a side benefit from co-design, teachers can use this opportunity to explain learners how the learning design works helping everyone in the process to make more informed suggestions.

3.6 Challenge: Asymmetric Data/Algorithm Literacy

Overview: Learners and teachers may have strong views, and provide valuable insights, about educational data and the ways that algorithms generate analytical reports. Typically, however, they do not understand how data is structured, or the inner workings of algorithms, which can disempower them when working with analytics experts.

3.6.1 Illustrative example

In this scenario, we want to develop a learning analytics tool to help student nurses to receive feedback from practice. From the multiple techniques and algorithms available, there are some limitations that only data/algorithm literate practitioners can see. This does not mean that we should limit students to saying what they expect or want from a feedback tool using their data, but also make some remarks on possible solutions. On the other hand, the students may benefit from understanding how their data is being used to provide better insights. Whose responsibility is to explain to them the inner workings of this tool? Should design sessions be structured the same way for non-data literate students? Should we explain the way data travels as a principle of transparency and privacy? (This example is adapted from Case study 1 Chapter 0)

If we consider learners merely as commentators on what expert designers propose, it may be possible to argue that they do not necessarily have to understand the inner workings of the algorithms and data representations. However, if they are invited to be true co-designers of the system, from the earliest stages, then what level of understanding do they need?

3.6.2 Research insights from other fields

The notion of this emerging challenge refers to the growing interest for business to make sure employees understand data in a meaningful way outside the statistics department (Schneier, 2015). Making data-informed decisions is now considered everyone's responsibility and for this, data literacy is now a required skill for many work and research areas. Even when data literacy is not a new concept, the application for this to non-technical areas is merging into our academic training.

When people are presented with data visualisations, the individual data literacies play an important role in what the observer understands out of this. The other part relies on how good the designer is to communicate insightful data results (Pangrazio & Selwyn, 2019). However, it is difficult to promote information literacy or data literacy without promoting statistical literacy. While their relative importance varies with one's perspective (Schield, 2004), in this case students may not need to become statistical experts but rather become data literate to apply data informed decisions.

Data literacy has become part of the "21st century skills" supported by many universities (Ridsdale et al., 2015) and pushed into curriculums outside engineering and mathematics programs. The issue with pushing this into everyone's curriculum is that in many cases teachers are also not well trained into using data as a normal practice. Educators need to gain data literacy skills to inform practice and be able to measure students progress (Mandinach & Gummer, 2013).

Some new approaches to information literacy have emerged that address how information is used in the different disciplinary contexts in which people learn and work (Maybee & Zilinski, 2015). In a perfect world, every citizen including learners and teachers are able to digest, interpret and use data literacy like any other basic literacy skill but this is not the case meaning that peoples opinion on data should be limited and contextualized if the intention is for designers to invite people to participate.

3.6.3 How this challenge emerges in learning analytics

In LA, data literacy skills play an important role when suggesting design changes to the core functioning of the tool. If stakeholders are intended to participate in the design process, practitioners require to derive actionable insights from limited opinions by the intended end-users. When learners are presented with visualisations product of a learning analytics algorithm, their personal experience with data objects will guide their contributions, this affects their ability to accurately interpret and critique presented analysis of data (Wolff, Moore, Zdrahal, Hlosta, & Kuzilek, 2016). If participants are not intended to become data experts to give meaningful feedback on the design, until what extent they should know about the inner workings of the algorithm? That's a critical question.

An example of measuring data literacy in learning analytics objects across students can be seen when using Open Learner Models. Using these methods, learners can identify partial data literacy needs when tracking personal data of their learning. Since this area is still work in progress, we still can identify that learners are able to develop their data literacy without receiving official training but rather playing around with what they need.

(Wasson, Hansen, & Netteland, 2016). This gives us a clue that the challenge is not about whether if we only invite highly data literate learners/teachers to participate but how to include people with different data literacy levels and get the most out of their contribution?

3.6.4 Potential ways to address this challenge

Conversations on a technical level will happen since the beginning of the process giving that analytics methods are a core component of learning analytics innovations. Co-design practitioners/researcher may benefit from introducing tools that help stakeholders learn the basics of analytics methods using common language and having experts in the topic participate. Retaking the example described in the beginning, a data expert or someone with enough knowledge in data practices can explain data policies and inner workings of analytics methods to nurse students. From there students can ask the data expert when in doubt and provide better insights once they learn the limitations of data analysis.

4 Methodology

Chapter overview

This chapter presents the methodology followed to produce evidence designed to inform the research questions. The methodology involves an iterative approach using Design Based Research (DBR), augmented by Design Thinking (DT). The highlights of the chapter can be summarised as follows:

1) DBR is the main methodology used to produce research contributions while producing design tools in the context of academia. In addition to the standard DBR process, iterations were complemented with Design Thinking for further analysis, since this provides helpful language to describe the details of each iteration.

2) There are three cases studies where the co-design studies will be implemented. The first case study aims to support nursing students and teachers to co-design a LA tool when providing automated feedback on simulation exercises. Second is a case study where students from a data science Masters program collaborate to produce an LA tool to help them track their progress when developing graduate attributes. The third case study involved teachers in co-designing the rules to operate an LA tool that automates the sending of personalised feedback messages.

3) The analysis techniques use qualitative data from transcripts, video and audio recordings, plus quantitative analysis and visualizations of collaboration between stakeholders. Thematic analysis is used to identify material related to each of the research questions, while annotated transcripts are presented as vignettes to illustrate critical incidents during the co-design sessions.

This chapter describes the methods used to address the research questions in this thesis. This chapter is structured as follows. In section 4.1, a thorough description of the iterative research methodology used in this thesis is provided. The section will justify the selection of Design-Based Research as an overarching methodology to address the RQs, and the ways in which it was adapted and enriched with principles from Design Thinking (DT). Section 4.2 describes the three authentic case studies that served to address the research questions and the ethical process followed to capture evidence from them. Finally, section 4.3 provides an account of the techniques used in the thesis. Techniques are divided into two groups: 1) co-design techniques applied during studies with stakeholders, and 2) analysis techniques used to distill insights from the sessions with stakeholders in order to extract qualitative evidence that illustrates how the co-design techniques support the LA design process.

4.1 Methodology: Design-Based Research and Design Thinking

4.1.1 The DBR approach

One of the particular challenges in LA design is to define what data and analytics are important for empowering learners and educators, and how the insights from these data can be communicated more effectively. As explained before in section 2.2, in general, the co-design and participatory design approaches focus on how interactions occur between stakeholders and how the design process can benefit from these interactions (Tone Bratteteig & Wagner, 2016). Applying an iterative design process can enable the designer to create a continuous feedback loop so that the development process can indeed solve an authentic need (Sharp et al., 2007). For example, prototypes, mock-ups and technology immersion techniques (e.g., software simulations) can be used to obtain early feedback from learners and give to them a feel of the functional and aesthetic aspects of the system being designed.

As a result, in this research project, a design-based research (DBR) approach was used to provide iterative, partial answers to the RQs (Anderson & Shattuck, 2012). A DBR approach to education and design allows the researcher to develop interventions and gradually test them through iterations. At the same time, it enables the generation of intellectual contributions which, in this thesis, address each of the RQs.

The DBR methodology proposes the concept of iterative analysis, design, development and implementation based on collaboration among researchers and practitioners in learning settings. Originally, DBR was conceived as an approach to address key issues in learning research, including the need to address theories of learning, to study learning in the real world and to derive research findings from formative evaluations (Reimann, 2010). The common implementation of DBR consists of 6 iterative phases in which designers: *focus* the problem, *understand* the problem, *define* goals, *conceive* the outline of a solution, *build* the solution, and *test* the solution (Easterday, Rees Lewis, & Gerber, 2014). These original 6 iterative phases are used to guide our research contributions and are subject to adaptations to fit into our context in co-design for LA.

In contrast to DBR in the learning sciences, this thesis does not seek to advance learning theory, but to generate evidence-based concepts and practices that advance our understanding of LA co-design – specifically, in response to the three Research Questions. The DBR methodology provides a disciplined process for gradually generating partial contributions to this knowledge and practice. The purple line in Figure 4-1 represents the DBR phases using co-design knowledge for interventions in each iteration and manage the partial contribution to our research objective (knowledge construction). The broken lines are partial actions required to generate each contribution during the process since writing our findings and documenting the process is established under the DBR standard methodology. The pink lines illustrate DBR iterations, but as described next, these iterations can be augmented through the use of Design Thinking (DT).

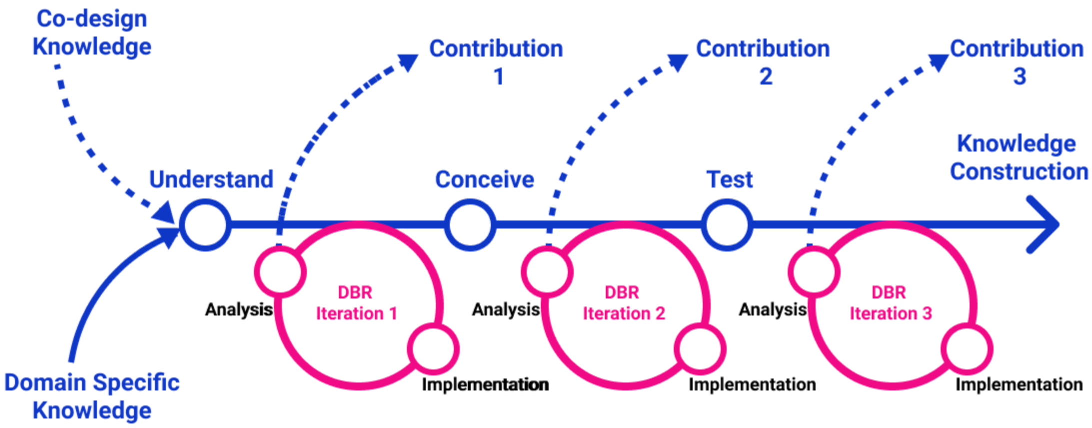

Figure 4-1: DBR as an iterative process for learning analytics design.

4.1.2 Design Thinking in DBR

Original specifications and adaptations of the DBR methodology often underspecify details like task distribution, roles and division of labour which are of interest for our research project (Reimann, 2010). In the methodological analysis performed by Reimann (2010) it is implied that for DBR to be used in co-design, practitioners must specify "*in detail the process of designing, including tasks, roles, artefacts, division of labour and* *quality criteria*”. This means that, while DBR provides guidelines and recommendations in conducting design-research, it is flexible enough to be adapted to domain-specific context like co-design. Examples of adaptations DBR can be seen in design frameworks such as goal-based scenarios (Schank, Fano, Bell, & Jona, 1994), anchored instruction (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990), and knowledge integration (Linn, Davis, & Bell, 2004)

This research has followed the DBR methodology to make sure design tasks, roles and artefacts used through the design process are specific enough for analysis during the iteration phase. Because in co-design for LA there is a lack of understanding between the roles, design tasks and artefacts as explained in section 2.3. To gain a better understanding of these elements, each iteration phase has been defined more in detail by incorporating Design Thinking (DT).

DT is a way of embedding the notion of iterative design into the design process. Coming up with ideas, building and testing in a short period of time is what DT brings to the table in comparison to other iterative processes such as Scrum, Kanban, Lean and Extreme Programming (Ellingsen, 2016). In terms of innovation through iterations based on tasks, roles, artefacts, division of labour, quality criteria, DT specifies three main sections (Koh, Chai, Wong, & Hong, 2015): *understanding, creating and delivering* and five different stages inside them: Empathy, Define, Ideate, Prototype and Test, which are defined as follows:

Understanding: The process starts with creating **empathy** and comprehend stakeholders’ context. This first part of the process can be exploratory and in some cases may set the tone of the project for the next stages (IDEO, 2016). Generating empathy in this stage allows identifying the problem to be solved, mostly using social research tools like a focus group, empathy maps and contextual studies.

Creating: In this section, practitioners aim to **define** goals/objectives for the project to solve the problems found in early stages. At this point, an agreement is desired among stakeholders and researchers. After this, people involved must **ideate** to synthesise the first proposals and potential solutions to fit design goals.

Delivering: This section involves translating concrete ideas into usable objects through **prototyping** techniques. Prototypes are mostly incremental and start with non-polished concepts prepared for the next task. After generating non-polished prototypes, the design flow continues towards **testing** proposals identifying issues and opportunities to improve. In iterative design, researchers gather as much data as possible and move into the next iteration this time having a better understanding of the problem.

The principles of design thinking working with the DBR methodology for co-design are introduced to specify design tasks, roles, artefacts and division of labour using the DT stages. Figure 4-2 shows how the stages explained before are connected and can be repeated as necessary before moving to our next stage where DBR is used to produce our contributions.

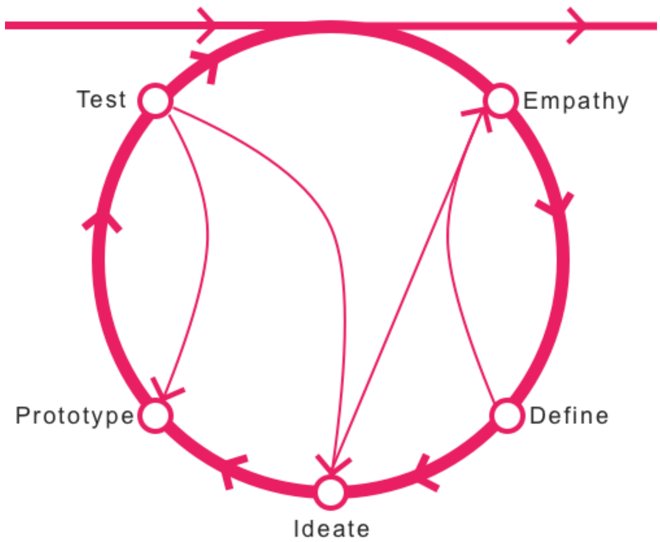

Figure 4-2: Design thinking stages used through the multiple iterations.

This DT augmentation of DBR iterations can also help in fitting diverse stakeholders in co-design by changing participants between iterations to analyse in detail the role of each participants and what tools are being used. This does not mean that actors must be in the same sessions at the same time but can be consulted as part of the feedback process.

4.2 Case studies

The following section summarises the contexts and includes the reference names used as identifiers of the three case studies in the following chapters (summarised at the end in Table 2). All the case studies were conducted in different faculties of the University of Technology Sydney, involving a variety of stakeholders, including different combinations of students, teachers, learning designers, developers, academic administrators and co-design practitioners. Fuller details of participants, researcher roles, data collection and analyses are provided at the start of the respective Case Study chapters.

4.2.1 Case study 1: Automated feedback for nursing students

This study was conducted at the Faculty of Health at the University of Technology Sydney. The study was part of a project aimed at building an automated learning analytics tool that can provide immediate feedback to nurses in the classroom while they engage in healthcare simulations.

During these simulations, learners need to enact practical skills through simulation-based sessions interacting with training equipment such as manikins and hospital-grade equipment. Some of these scenarios are quite immersive, involving reacting in a life-threatening situation to save a simulated patient. The regular classes are conducted in classrooms that are equipped with several hospital beds where patient manikins are placed. One section of the classroom is a regular classroom, but the other half simulates a hospital ward. Sessions with students involve multiple teams working at the same time and the main observed issue is that students don't receive enough feedback after practice. Thus, the project sought to use multimodal LA to obtain information from the physical activity in order to provide evidence that could trigger reflection. The main research question in this study is what kind of information should be collected and reflected back to learners and teachers, how this should be operationalised and presented back to learners.

Following a co-design approach, 19 Learners, 4 Teachers, 2 Learning Designers and 2 co-design practitioner/researcher. were invited to multiple sessions with the intention of understanding the current challenges faced during the sessions and design a learning analytics feedback tool to better support students. Participants in this project required to be part of the nurse program or be familiarised with the current learning design behind simulations.

4.2.2 Case study 2: Analytics for data science student blogging

This study was conducted as part of an authentic process to create a learning analytics tool for *Graduate Attribute* development with students from MDSI (Masters in Data Science and Innovation). The current tools used by students provided a limited but well-received help for new and senior students on the program. However, there was a need for new tools starting for the current learning analytics component of a blogging platform called *CIC Around* offered by the University of Technology Sydney.

CIC Around is a multi-site WP custom installation implemented for learners to write reflection pieces in a blogging style. Features included in CIC Around evolved through iterations to fit the needs of the program. The idea was for CIC Around to become a social platform for all MDSI students, regarding the units they were enrolled in and whether they were first or last year students. All MDSI students could have access to everyone's content. Blog posts usually were related to the tasks they had to do for different subjects therefore each blog site for each student was a part of their portfolio. At this point, graduate attributes were introduced as a way to measure skills development and track improvement through semesters using the blogpost as a reference.

In this case study, 15 Learners, 7 teachers, 5 Learning Designers, 2 Developers, 1 Co-design practitioner/researcher, 1 Course director and 2 Data experts were invited to design the new analytics component to support their graduate attributes through blogging.

4.2.3 Case study 3: Designing rules

This case, differently too Studies 1 and 2, did not involve the co-design of an LA innovation from scratch but instead co-designing for the appropriation of an LA tool already built. Ontask is a learning analytics project that "*aims to provide personalised and actionable student feedback*". However, the research and design team behind OnTaks are looking for improvements to facilitate stakeholders' interaction with the custom features and user interface.

OnTask feedback is sent through personalized emails to hundreds or even thousands of students, using an approach similar to "mail merge". For teachers and academics to deliver so many emails, they have to understand how to set up rules defining conditions in the student data which will trigger the inclusion of a feedback message in the email. A rule requires for teachers to select the intended audience for the email, pick a source of data available from the LMS, assign values and conditions to make sure te message is being sent to the right students.

This study involved diverse stakeholders including 1 Learning Designer, 3 Academic administrators, 2 Teachers and 1 Co-design practitioner/researcher. During this study, stakeholders interacted with the co-design techniques to set up new rules required for OnTask to function as a learning analytics tool.

The case studies were selected based on the diversity of the stakeholders involved, the availability of the participants to collaborate and the feasibility to implement our co-design methodology.

4.2.4 Ethical considerations

Personal information and data gathered from design sessions were covered under UTS ethics protocol found under ethics application "Adoption of Learning Analytics Artefacts and Participatory Design Students" ETH16-0958 and ETH16-0193. The ethics protocol follows recommendations delivered by the Graduate Research School (GRS) and the National Statement on Ethical Conduct in Human Research Information (NSECHRI).

All data was analysed following qualitative methods (survey design, questionnaires and content analysis) and qualitative techniques (case study, focus groups, verbal protocol and audio/video recording). Under these methods, transcriptions are the main object of analysis containing low-risk data. The main concern stated is the potential risk of disclosure that could cause discomfort or embarrassment to participants due to concern regarding of exposure of their data.

To minimise the potential risk of disclosure, audio and data collected were anonymised as a protocol for protecting participants identity. In relation to students' information, the nature of surveys and questionnaires was completely explained to participants highlighting that by no means the questionnaire/survey can be related to any measure of students' performance. Participants were not be asked to include their names into information sheets. Participants in each study could request their video or audio to be excluded from the repository at any moment during sessions.

4.3 Analysis

We used qualitative analysis methods for our case studies to answer questions about experience, meaning and perspective (Hammarberg, Kirkman, & de Lacey, 2016). The use of qualitative case studies is a well-established approach in research where multiple scenarios with similar settings are used to test the main hypothesis (Fielding, Lee, & Lee, 1998). The qualitative methods for analysis used in our thesis allowed us to look at the evidence collected through the case studies and apply certain rigour when supporting our research contributions.

Another reason to use qualitative methods as the medium for analysis is the possibility to investigate collaboration from the perspective of the main stakeholders. Information gathered through qualitative tools open the possibility to inquire participants through open questions and give them space to use their rational and preferred language as the medium of expression.

The first two case studies aim for participants to design new tools, this is considered as an **upstream** (from the top) case study enabling the test of the co-design techniques while developing an LA innovation. The third case study involves revisiting an ongoing project that has been deployed elsewhere, this makes the case study a **downstream** scenario and allowing us to understand what features from the original co-design techniques should be adapted (Fox, 2006).

The purpose of testing co-design techniques as upstream/downstream design is to design strategies for effective use where participants can negotiate how to improve an existing learning analytics tool (Downstream) or when participants are given the opportunity to design the tool from scratch (Upstream).

Each case study and iteration involved different analysis techniques to measure our contribution based on the research questions. Table 2 shows the co-design techniques and the analysis techniques used for each case study. The design direction column explains the design context of each case study, the tools for iteration column explains the techniques adapted and adopted as a list under each case study. Further description of the technique used for analysis can be found in the subsections below.

Table 2: Mapping iterations and tools across case studies.

Id	Case	Design direction	co-design techniques for iteration 1	Analysis technique it 1	Techniques for iteration 2	Analysis techniques for iteration 2	Co-design techniques for iteration 3	Analysis techniques for iteration 3
1	Automated feedback for nursing students	Upstream	**Adopt:** Superpowers, Card Sorting, Collaborative Sketches/ Prototype. Collaborative Personas. **Adapt:**, Learner/Data journey	Critical incidents, Survey design, Thematic analysis, Knowledge art framework.	**Adopt:** lo-fi Prototype. **Adapt:** Learner/ Data journey	Critical incidents, Survey design, Thematic analysis, Knowledge art framework.	**Adopt:** hifi Prototype, Questionnaire	Findings triangulation, Critical incidents, Survey design, Thematic analysis.
2	Graduate attributes, blogging and MDSI	Upstream	**Adopt:** Collaborative Sketch, Focus Group **Adapt:** Collaborative Personas, Learner/Data journey	Critical incidents, Survey design, Thematic analysis, Knowledge art framework.	**Adopt:** Focus group **Adapt:** LA DECK	Findings triangulation, Critical incidents, Survey design, Thematic analysis.		
3	Designing rules for automated feedback	Downstream	**Adopt:** Card Sorting **Adapt:** LA DECK	Critical incidents, survey design, Thematic analysis, knowledge art framework.				

The following section presents the multiple tools used to analyse evidence gathered from the case studies starting for a standard approach to transcript analysis, moving to identify critical incidents and finalizing with strategic coding scheme.

4.3.1 Thematic analysis

Running the multiple case studies under the same scope of measuring collaboration produced lots of useful data that required strategic marking and cleaning. We used a thematic analysis to identify evidence (transcripts, videos, photos, maps) and create strategic data sets for a qualitative analysis towards answering the research questions. Transcriptions removed stakeholders' pauses, stutters, and repetitions when speaking, since this was not of relevance for the kind of analysis required in this research.

Our coding strategy was used as a meta scheme that looks at extracting meta-content from the sessions rather than content that could be of interest for the design of the LA tool for each case. This means that the main nodes referring to the research questions are used across all the case studies following the (Boyatzis, 1998) approach to coding analysis for qualitative data.

Another practice implemented as part of the coding analysis is to assign emerging codes for each specific case based on our partial findings when running the design iterations, as described in Saldana's work *"The coding manual for qualitative researchers*" (Saldana, 2015). For this strategy, we looked for repetitive patterns like keywords, actions in the video and visual data that symbolically "assigns a summative, salient, essence-capturing, and/or evocative attribute" and use it as evidence.

The coding scheme shown in Figure 4-3 separates our general pre-set themes using the research questions and places individual nodes into the units for analysis. The main themes are:

Co-design techniques: These pre-set hemes are defined as the guide to code all data that provides evidence for the effectiveness of the co-design tools (RQ1). The nodes provided a meta-level using the following labels Tool effectiveness, Stakeholders interaction with the tools and Adopt/Adapt. The Adopt/Adapt codes are defined when looking for the following descriptions.

Adopt: Use techniques from current design practices proposed by other co-design researchers. Adopting a design technique requires following instructions and guidelines written by the original authors to ensure the concept is being followed as intended.

Adapt: Take the original concept for the tool/technique and change it to fit the context of co-design. Changes proposed for adapting includes adjustments in the aesthetics (how the tool looks like), the intended context for the technique to be used, variations on the steps followed and modifying the intended use.

Role of the co-design practitioner: This theme was used to label all data used to explain RQ2 in reference to the role of the co-design practitioner. The first sub-category defined three nodes marked as Researcher and Facilitator. This specific definition emerged to identify the responsibilities of the co-design practitioner. The other sub-category uses the dimensions of the KAF to situate actions under the labels Aesthetics, Ethics, Narrative, Sensemaking and Improvisation. These nodes were explained under (Section 0) in conjunction with the need for identifying actions (the last node).

Challenges in co-design units/nodes: This theme comes from our third research question related to current challenges and emerging practice when bringing co-design to LA. The nodes included in this theme are Data literacy, Power relationships, Surveillance, Learning Design, and Teaching-learning experience. Each one of these were explained in (Chapter 3) followed by their relationship with the co-design process.

Emergent themes are marked using an inductive approach from the pre-set themes (Boyatzis, 1998). This means that emergent themes will come from the analysis after identifying new phenomenon creating new categories under the existing pre-set. The thematic analysis allows for categories or themes to emerge from the data like the following: repeating ideas; new terms used by participants, metaphors and analogies; unexpected answers from stakeholders; and similarities and differences of participants' linguistic expression (Saldana, 2015).

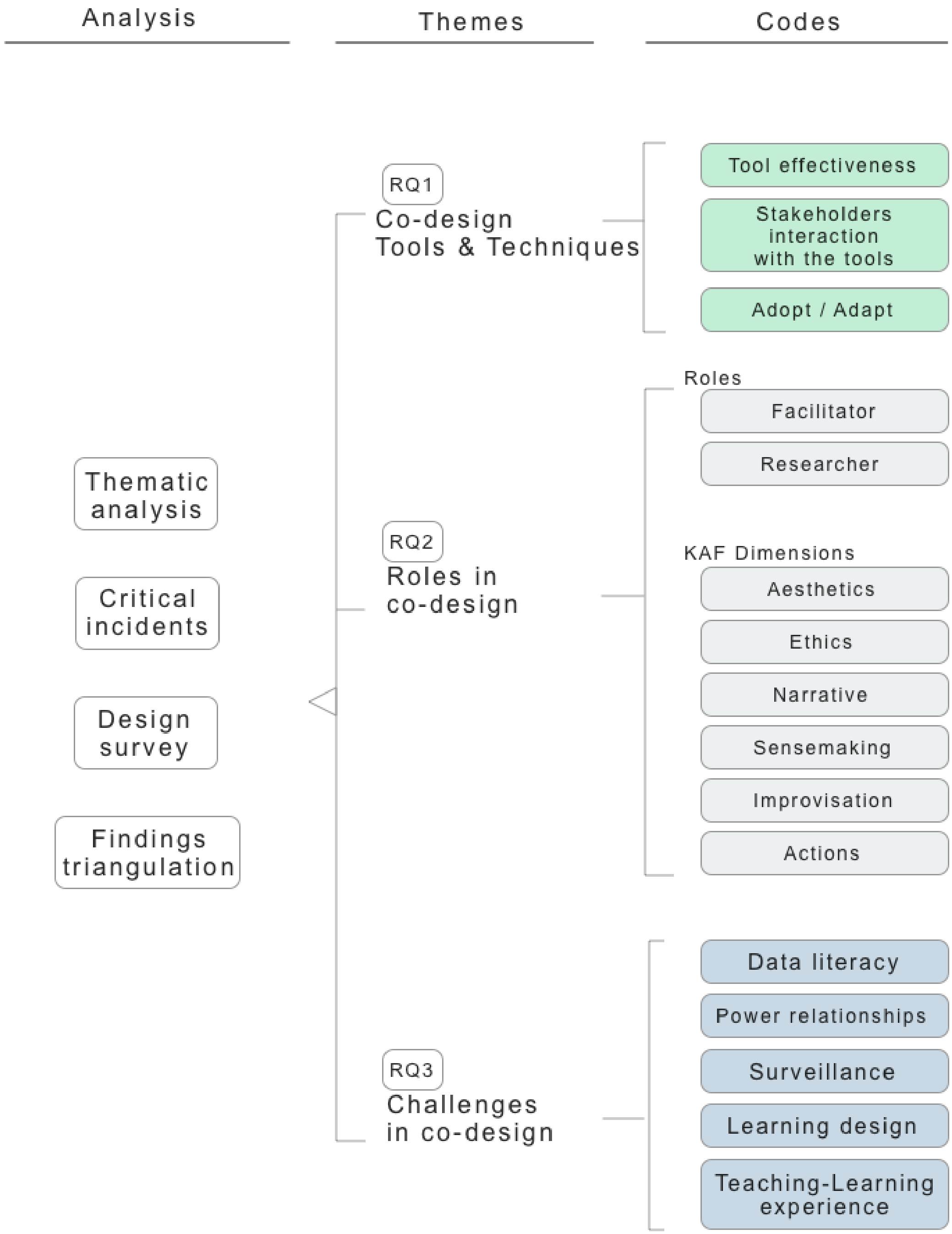

Figure 4-3: Using research questions to guide the coding scheme.

Further details on the application of each analysis method and technique are explained under each case study with small changes in practice to fit the available data. Every method described here allows the research team to look at specific parts of the co-design sessions and have a better look at the interactions between participants and their relationship with the learning analytics design process.

4.3.2 Critical incidents

Sessions with students, teachers, developers and other stakeholders produced lots of evidence that required a specific method to look for interesting design situations related to the co-design techniques in action. This evidence comes from the transcription of the conversations during the design sessions, the mapping of the video recording and the evidence found in the tool in use. All interactions between stakeholders, the co-design techniques and conversations during the co-design sessions were analysed using a methodological approach called critical incidents.

Critical incidents highlight events that “stand out” from a larger situation in some way. This qualitative method maps specific occurrence found during sessions including specific dialogues, the context where it happens and the actions executed (Angelides, 2001). The information identified through this technique was used to explain the problem faced by participants and generate possible ways to resolve the issue, all of this through our research lens as co-design researcher. As a guide to identifying those critical incidents we used a series of questions while analysing our evidence from the co-design sessions with stakeholders.:

- What was the participant saying?
- What was the participant doing?
- What action followed?
- How the facilitator/researcher intervened?
- How is this related to a collaborative issue?

The result of a critical incident being taken from the thematic analysis is an enriched vignette where the critical incident is described in detail. The vignettes include the transcript of the conversation where the critical incident took place, Identification of the role of the co-design practitioner and the participants' interactions with the co-design techniques using images from the working table.

4.3.3 Survey design

Gathering evidence at an individual level has been conducted through traditional survey design (Dixon-Woods, Agarwal, Jones, Young, & Sutton, 2005). Multiple surveys where delivered across the design iterations including questions related to each research question, the effectiveness of the design sessions and tools, and context-oriented feedback for each case study. The survey design was linked to each design session and delivered in a physical form for participants to answer in place.

The survey design allows participants to answer through multiple options, free form, ranked answers or binary contributions. Each survey was designed using questions listed in Table 3, which are organised in 4 main sections. The sections include questions about 1) students' current experience with their learning tools, 2) the value of their tools as learners, 3) the opportunity of using LA tools to support their learning practice, and 4) how learners envision their new tools to facilitate their learning process. Each section uses different styles of question, sometimes requiring mixing two styles such as open-ended questions, to stimulate conversation, and multiple choice, to limit answers to specific topics such as data, privacy, or tool features.

Table 3: Questions and examples used in the design of surveys.

Style	Purpose and examples	Used in case study
Open-question	Allows participants to answer in a free form using their own voice without forcing technical language. Examples: What are the current problems you face in current classes? How do you think a learning analytics tool will help you to improve your practice as a nurse student?	Case study 1 (Iteration 1-3) Case study 2 (Iteration 1-2) Case study 3
Multiple choices	Close answered question used to narrow options and open for technical language. Examples: Mostly used social platforms. Mark your preferred methods to communicate with other students and faculty members.	Case study 1 (Iteration 1-2) Case study 2 (Iteration 1-2)
Likert Scale	Used to scale answers at a standard level of agreement/disagreement (Albaum, 1997). Examples:	Case study 1 (Iteration 1-2) Case study 2 (Iteration 1-2)

	I find the current Learning analytics tools for collaboration effective. I think this tool will help me to improve my performance	
Ranked	Asks respondents to compare items to each other by placing them in order of preference. Examples: Please rate the following feedback sources in order of interest. Rank the priority when receiving automated feedback	Case study 1 (Iteration 1) Case study 2 (Iteration 1-2)
Binary	Options narrowed to two possible options simplified using a common language. Examples: Would you mind sharing your data with other students? Do you think this learning analytics tool can replace feedback given by teachers?	Case study 1 (Iteration 1-2) Case study 2 (Iteration 1-2)

4.3.4 Findings triangulation

After multiple iterations collecting and analysing evidence through our other techniques, we used a triangulation method to reconcile our findings and map our contributions. In this project, case studies provide evidence in different contexts and triangulation happens between observations, questionnaire response, participants comments, critical incidents, and peer-review analysis. This evidence was used as partial evidence towards our research contributions. For example, answers from the survey after the co-design sessions showed us stakeholders' perception of effectiveness in the co-design techniques. This was explored further by looking at the critical incidents and finding how the interaction with the tool shapes their perception. Triangulation refers to the use of multiple methods to compare and contrast the key findings across the sources/case studies for each evaluation objective (Carter, Bryant-Lukosius, DiCenso, Blythe, & Neville, 2014).

This method also allowed us to compare findings and insights from the multiple case studies using the research questions as the analytical lenses and finding evidence to support our contribution. As shown in the past section 4.3, findings triangulation was used at the end of each case study once we generated enough evidence to look for a correlation between cases and the co-design tool in use.

4.3.5 Knowledge art framework for role analysis

Conducting an analysis focused on the role of the co-design practitioner/researcher required an analysis tool that focuses on collaborative interactions between stakeholders, the facilitator and the surrounding context. An effective approach to analyse the role of a facilitator is the established framework known as Knowledge Art Framework (KAF) (Selvin & Buckingham Shum, 2014). The KAF recognises a "*constellation of people, tools, data, surroundings and other factors whenever sensemaking with visualisations is taking place*." This was used to map what happened during the session like people using the tools and interacting with the facilitator and other stakeholders. The map allowed us to navigate specific dimensions part of the framework and later build a glossary of actions for future practitioners (See Figure 4-4). The KAF describes the dimensions into three main sections: Primary elements, enablers and information/understanding of the dimension in use.

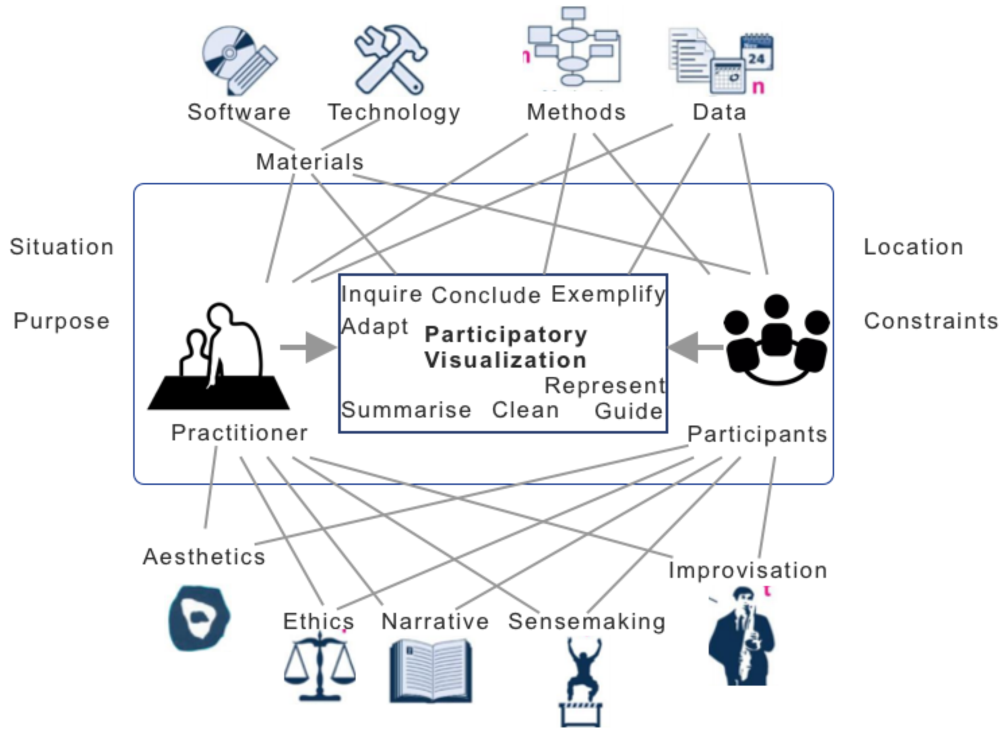

Figure 4-4: Knowledge art framework (Selvin & Buckingham Shum, 2014).

Primary elements are the focus of co-design sessions over any other dimension, this includes:

Co-design practitioner: Facilitates the construction of participatory visualisations in this case the co-design techniques placed used through the learning analytics design sessions. This actor takes the responsibility of providing what is requested by participants and assisting in generating new materials.

Participants: This concept includes all stakeholders involved during the design sessions being learners, teachers, developers, academic administrators, course directors, learning designers, researchers and data scientists.

Participatory visualisation: Medium used to clarify the main idea or component in design. Some examples include the use of multimodal components visual, textual or tactile. Material used for this includes: Sketches, post-its, issue maps, diagrams and free form drawings.

Interactions: These actions can be measured in four different levels including: Interaction between co-design practitioner and participants, interactions between co-design practitioner and participatory visualisation, interactions between participants and participatory visualizations, and interactions among participants. Some examples include modifying or creating new visualizations, starting a discussion among participants, keep the discussion on track and planning what to do.

After the main components, there are components defining the nature of the sessions where visualizations are being used. The surrounding components include the **constraints/context** and **boundaries** of the session. Boundaries include single or collaborative sessions. Constraints/context include the situation where the session is taking place, location, problem domain, time, budget and other resource limitations.

The second dimension involves enablers coming into action during the sessions, this includes:

Software: Participants using software to operate the participatory visualization. Another way to this in action is when practitioners guide the sessions supported by specific software.

Technology: Medium to operate visualisations during sessions such as projectors, laptop, virtual meeting rooms or non-technical objects such as flip charts, markers or whiteboards.

Methods: Formal methods used to filter participants and practitioner actions. In this case adaptation/adopting current methods from participatory fields merge with informal practice such as brainstorming and card sorting.

Data: Used through enablers as the source for generating content based on references, supporting literature, spreadsheets and log transcriptions from other sessions.

The third dimension includes information/understanding concepts to interpret actions enacted by the co-design practitioners.

> "When you act as a Knowledge Artist you give form to ideas [Aesthetics]; make choices about how to proceed [Ethics]; help establish meanings, motives, and causality [Narrative]; and respond when something breaks the expected flow of events [Sensemaking], often having to invent fresh and creative responses on the spot [Improvisation]." (Selvin & Buckingham Shum, 2014) pp. 9.

Aesthetics: Form and process to formalize ideas for participants to interact with. This concept applies to visual objects in detail when representations are mean to be used without guidance and less strict when informal sketching happens during co-design sessions.

Ethics: Refers to the practitioner awareness of various individual and collective needs, interest, goals, and sensibilities. This dimension places responsibility on how co-design practitioner should proceed based on current conflict and decisions being made on the spot.

Narrative: Help practitioners into connect moments, ideas, and statements over time. This also includes the sense of causality and consequences when connecting pieces into something functional for everyone.

Sensemaking: Presents the rational when encounter with unexpected moments supported by uncertainty and information overload. Visualizations may help to build a rational when the story won't match information received.

Improvisation: Ability to bring alternatives when pre-planned methods, tools or processes seem to fail during the design process. Acting outside the script requires creativity and some knowledge on working techniques to drift away from the problem.

The original map of the KAF recognised the dimensions of traditional collaborative sessions. However, we needed a way to conclude what action can be followed by co-design practitioners to address RQ2. For this research project, we added an additional layer describing the possible actions to enact these dimensions and map them into design results. The actions come from an analysis of current co-design projects in the field where we identified common actions. *Analyse*, *Plan* and *Inquire* are actions that can be found in collaborative projects with learners described in publications from Pam Woolner (2007) and Luckin et al. (2013). The *Decide* action is suggested by Culmsee and Awati (2013) as required to make the co-design process flow. *Improvise*, *Adapt*, *Display* and *Exemplify* were taken from work by Selvin and Buckingham Shum (2014). These are control actions useful to keep the conversation going and keeping the collaborative visualisation in shape. The actions described in the following section maps the intended dimensions to the actions suggested for our research project. The KAF was used to code and analyse transcriptions/video recordings from the co-design sessions with stakeholders.

One example of using the KAF framework as a reference to analyse the role of the co-design practitioner is when annotating critical incidents using the design vignettes. In these cases, the actions found in the video and transcript analysis are annotated using one of the framework dimensions to identify what the practitioner did in response to participating interactions. A conversation using the *Exemplify* action would look like when interacting with learners "*I'm trying to make sense of what data could be tracked.* Learner". In response to this the practitioner must act as a facilitator and proceed to *exemplify* which is part of the [Sensemaking] process "*Maybe social media, browser activity, actions on the LMS.* Facilitator".

Table 4: Enhancing the Knowledge Art Framework with design actions.

KAF Dimension	Key actions	Definition
Sensemaking	*Analyse*	The process of inspecting, cleansing, transforming and modelling data with the goal of discovering useful information, informing conclusion and supporting decision-making.
Narrative	*Plan*	Building a scheme/method beforehand to enact actions in design, prepare materials for collaboration and foresee complications when scheduling sessions.
Narrative/Ethics	*Decide*	The process of making choices by identifying an action to follow, gathering information, and assessing alternative resolutions. The decision

		process in co-design looks for a balanced, impartial and comprehensive way.
Improvisation/ Narrative	*Adapt*	Change the source material to fit the intended context in design, complement the current tools in use and comply with the design constraint.
Sensemaking	*Inquire*	Posing questions, problems or scenarios for stakeholders to reflect and formalize an answer to the design task.
Aesthetics	*Clean*	Arrange, organize and delete components in visualizations for the purpose of generating an uncluttered representation. This also applies to data by detecting and correcting (or removing) corrupt or inaccurate records from the data set collected.
Aesthetics	*Display*	Make visible design components to stakeholders using a range of interactive media, printed materials or data visualizations.
Improvisation/ Narrative	*Adopt*	Select and use the source material, tools or design objects without adding any modifications.
Sensemaking	*Exemplify*	Illustrate possible scenarios using stakeholders' context, vocabulary and known materials to help them formalized an argument to the design tasks.

5 Case Study 1: Automated feedback for Nursing students

Chapter overview

In this case study, nursing students were the main partners participating in multiple sessions guided by a co-design practitioner/researcher. The main reason for implementing this case with nursing students is the current interest from the Health faculty in implementing learning analytics-based tools to improve the current feedback given to students.

The structure of the chapter presents the DBR iterations including what techniques can be used, how challenges emerge when working with stakeholders in design, and the role of the co-design practitioner. The highlights of the chapter present evidence towards answering the research questions:

1) *Focus group, card sorting, collaborative persona* and *sketching* were effective techniques that help nursing students, teachers and researchers to work in collaboration towards developing an LA tool.

2) There is a need for new tools that work in the context of learning analytics co-design. The adaptation of the familiar user journey mapping technique into a *Learner/Data Journey* mapping technique enabled nursing students to describe the context of the problem, informing researchers and teachers on potential LA tool requirements.

3) The co-design practitioner/researcher played an important role when guiding nursing students and teachers acting as a facilitator. Besides working as a facilitator, the co-design practitioner in LA also performed research actions to support both the design process, and his own research, including documenting, analysing and providing information back to stakeholders.

4) Challenges emerged as expected from the rationale presented in chapter 3. The co-design practitioner was able to facilitate the use of different techniques, by performing specific actions to surface *surveillance/privacy* concerns and potential solutions. This case study also provides examples of the need to review the *learning design*, nursing

students' *undeveloped data literacies,* and students making suggestions from an inexperienced perspective on *learning/teaching theory* that an educator disagreed with. *Power relationships* emerged in the context of the influence held by academics over LA researcher access to students, and less than expected as conflict between learners and teachers in face-to-face sessions.

5.1 Context and Stakeholders

An authentic study was conducted to instantiate the co-design Learner/Data Journeys and use them to distil insights and make design decisions with educators and learning designers. This study was conducted at the Faculty of Health in the University of Technology Sydney. The study was part of a project aimed at building an automated learning analytics tool that can provide immediate feedback to nurses in the classroom while they engage in healthcare simulations (Echeverria, Martinez-Maldonado, Power, Hayes, & Shum, 2018; Echeverria, Martinez-Maldonado, & Shum, 2019). During these simulations, learners need to enact practical skills through simulation-based sessions interacting with training equipment such as manikins and hospital-grade equipment. Some of these scenarios are quite immersive, involving reacting in a life-threatening situation to save a simulated patient. The regular classes are conducted in classrooms that are equipped with several hospital beds where patient manikins are placed. One section of the classroom is a regular classroom, but the other half simulates a hospital ward.

The following Figure 5-1 shows the map of the three research questions that will be tracked in this chapter as the first case study. Findings and contributions will be later discussed using the map to make sure all questions are being solved linking evidence shown in the multiple iterations.

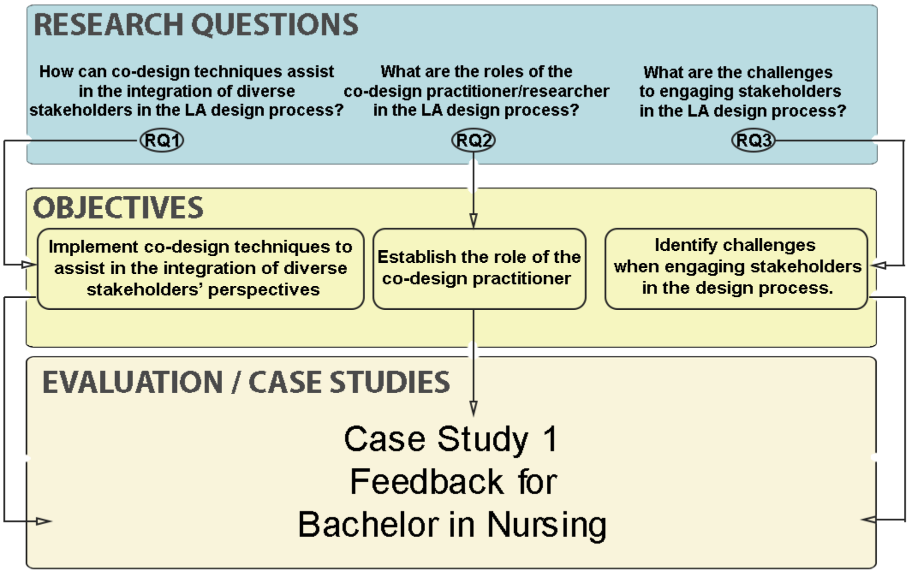

Figure 5-1: Map of the questions and objectives followed in this chapter.

Following a co-design approach, participants were invited to multiple sessions with the intention of understanding the current challenges faced during the sessions and design a learning analytics feedback tool to better support students. Participants in this project required to be part of the nursing program or be familiarised with the current learning design behind simulations. As seen in Table 5 the distribution and roles of stakeholders ranges between students, teachers, learning designers and designers to collaborate through tools and techniques proposed.

Table 5: Stakeholders participating in case study 1

Role	Description	Participants	Groups
Learners (L)	Currently enrolled in the bachelor in nursing program with experience in simulation -based classes.	19	7
Teachers (T)	Including teachers in any simulation classes part of the nursing training program.	4	4
Designers (D)	Responsible for developing the automated feedback tool and relevant prototypes.	1	1

For each iteration, the researcher (i.e. the thesis author) performed the role of the co-design practitioner/facilitator to guide each co-design session. As a researcher, he was also able to gather data on the co-design process, by being in face-to-face interaction with stakeholders. As the researcher he was the main person responsible for analysing the data extracted from the sessions. Another researcher participated along the three iterations, and acted as a secondary facilitator to manage the design materials and relations with stakeholders.

The learning design used in this faculty's simulation-based classes is typically structured into three main parts, with changes based on the particular teacher's learning objectives:

Introduction/demonstration: in which teachers explain the theory behind the practice and provide instructions for learners to follow.

Practice/simulation: which requires learners to distribute the relevant roles to play and practise using the equipment available including mannequins; and

Debrief/reflection: in which learners commonly receive some feedback on their performance and reflect on how their team did.

The following sections describe how the co-design of the feedback tool evolved through three iterations. The first iteration focused on exploring learners' and teachers' needs, the second iteration focused on delivering a first prototype of the automated feedback tool represented as an interactive timeline, and the last iteration focused on improving the design of the LA tool. For each iteration, techniques were implemented and tested with the purpose of measuring the usefulness of co-design-based practices, specifically, adopting four well-established tools and adapting two existing ones to create new tools, as detailed in section 5.3.

5.2 Study Design

5.2.1 Case 1: Iteration 1

5.2.1.1 Study and analysis

The first iteration was intended to generate understanding and identify the main issues students or teacher face in simulation-based classes, in order to start shaping the intended learning analytics tools to support students. Using the iterative co-design process, explained in section 4.1, iterations were intended to be short and focused on continuous improvement over time until the first version of the learning analytics tool fulfills the requirements. Participants involved in this first iteration are described in the following table.

Table 6: Stakeholders participating in Iteration 1.

Role	Description	Participants	Groups
Learners (L)	Currently enrolled in 2-5 semester in the bachelor's in nursing program	14	5
Teachers (T)	Including mentors/teachers in any simulation-based classes.	2	2
Designers (D)	Responsible of developing the automated feedback tool and relevant prototypes.	1	1
Co-design Practitioner (CP)	Responsible of organizing, guiding, facilitate and orchestrate design sessions through co-design.	1	1

For this iteration, different techniques were adopted/adapted to open the design process for stakeholders' collaboration and gathered data related to the research questions. As described in section 4.1.1, DBR iterations are used as the methodology to gather data for research while enabling the design process to continue. Each iteration is structured using Design Thinking stages as a way to break down the tasks proposed to participants. This first iteration comprised three main stages (as shown in Figure 5-2):

Stage 1 Understand simulations: For the first stage, students and teachers were invited to explain their current issues with simulations in terms of curriculum, material used in practice, interactions with the teacher and the quality of feedback. Also, a designer in chrge of implementing the LA tool was invited to observe and interact with sktaholders during the sessions. To gather these data, four techniques were adopted, namely focus group, card sorting, fabulation and adapted a persona profile based technique named collaborative persona. Part of this stage was to come up with as many ideas as possible to move forward to a first design.

Stage 2 Create possible solutions: After generating understanding about the issues to solve, the process moved towards selecting features that the LA tool must have to fulfill stakeholders' expectations and solve the problem with getting automated feedback. At this point, the co-design practitioner/researcher identified the main features to include in a first prototype and allow students to participate through sketching and the learner/data journey technique. After generating possible solutions stakeholders identified that an automated feedback tool was needed to support the nursing simulations.

Stage 3 Create a feedback tool prototype: The goal of this stage was to deliver the first lo-fi prototype to participants using data analysed from sketches and feedback in earlier stages. This first low-fi prototype only shows high-level features for participants to test and shape before moving into development.

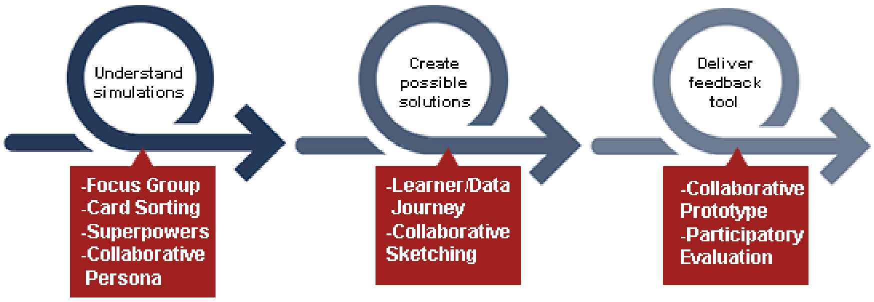

Figure 5-2: Stages and techniques used in Iteration 1 with stakeholders from nursing school.

The following sections explain each tool in detail and their purpose in the learning analytics context for case study 1.

5.2.2 Case 1: Iteration 2

5.2.2.1 Study and analysis

In this iteration, the co-design pracititoner and designer in charge of implementing the LA tool used data found in the previews section to deliver a working version of the prototype. Stages are structured in the same way as iteration 1 using different versions of the co-design techniques as seing in Figure 5-3.

Stage 1 Understand simulations and opportunities: The team retakes the research task of finding specifics parts of the problem to focus on. Interviews were adopted to fit the co-design settings of the sessions and the digital version of the learner/data journeys was introduced to stakeholders.

Stage 2 Update the possible solutions: The second stage aimed to update the paper prototype produced in in teration 1 adopting fast prototyping techniques.

Stage3 Deliver timeline feedback tool: The third stage requires an evaluation of the timeline prototype with teachers and students as a way to ensure usefullness and usability. The three stages are runned by the same co-design practitioner with similar time settings per session over a 3 month period.

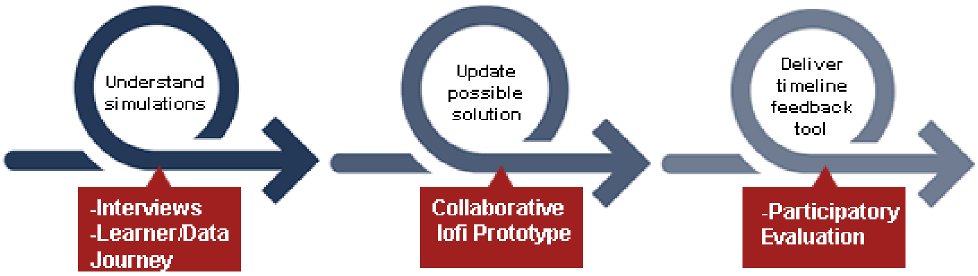

Figure 5-3: Stages and tools used for Iteration 2 with from nursing school.

Participants were invited to be part of this part of the project from the same list of volunteers used in the past iteration to ensure continuity and consistency. Table 7 describes participants and groups involved in each stage.

Table 7: Stakeholders participating in Iteration 2.

Role	Description	Participants	Groups
Learners (L)	Currently enrolled in 2-5 semester in the bachelors in a nursing program and those who participated in iteration 1.	5	5
Teachers (T)	Including mentors/teachers in any simulation-based classes and those who participated in iteration 1.	2	2
Learning designers (LD)	Responsible for giving structure to the pedagogic content and strategies followed during classes.	1	1
Designers (D)	Responsible for developing the automated feedback tool and relevant prototypes.	1	1
Co-design Practitioner (CP)	Responsible for organizing, guiding, facilitate and orchestrate design sessions through co-design.	1	1

Tools and method used in this iteration are a continuation of the past iteration this time feeding back information to participants using the learner/data journey. The extended description of each tool is explained in the following section.

5.2.3 Case 1: Iteration 3

5.2.3.1 Study and analysis

The last iteration part of the case study focuses on delivering partial updates to the original prototype. At this point in the project, the initial co-design practitioner prepares to depart from the team and leaves the design/development leader to complete the project. Stages followed in this iteration are shorter than the past ones, however, the prototype keeps evolving until a first functional design is delivered (as seen in Figure 5-4). Stages followed in this iteration includes:

Stage 1 Update the Hi-fi prototype: Generate a hi-fi prototype for learners and teachers adding the main functionalities for the system to work. Real information from simulation groups should be used to evaluate usefulness and usability issues before coding additional sensors.

Stage 2 Evaluate the prototype: Organize a testing session with learners using a general protocol based on usability testing and task scenarios.

These two sages are the foundation for the following iterations by constantly updating the prototype with functional pieces of code, also the effectiveness of the tool is constantly measured to ensure the initial problem is being solved.

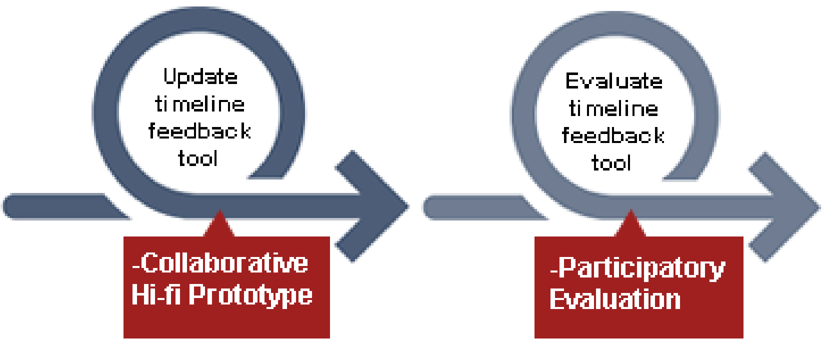

Figure 5-4: Stages and tools used for Iteration 3 with stakeholders from nursing school.

Stakeholders involved in this iteration are described in Table 8. The main difference with this group is the distribution of participants. Students mostly students that were familiar with the project and also were capable of re-enacting what they do in class.

Table 8: Stakeholders participating in iteration 3.

Role	Description	Participants	Groups
Learners (L)	Currently enrolled in 2-5 semester in the bachelor's in nursing program and those who participated in iteration 1.	6	3
Teachers (T)	Including mentors/teachers in any simulation-based classes and those who participated in iteration 1.	1	1
Designers (D)	Responsible of developing the automated feedback tool and relevant prototypes.	1	1
Co-design Practitioner (CP)	Responsible of organizing, guiding, facilitate and orchestrate design sessions through co-design.	1	1

The following sections explains how the hi-fi prototype has been designed, the analysis on the role of the co-design practitioner and closing remarks about this first case study.

5.3 Co-design techniques

This section details which co-design techniques were adopted or adapted from existing co-design practice, the purpose of the techniques and their application through the case study. Table 9 maps the techniques adopted and adapted for each iteration with the analysis techniques used to measure their effectiveness. The selection of this co-design techniques is based on their use in similar fields and their flexibility to be adopted into the LA co-design process. Each tool is being described in the following sections including description of the tool and their purpose in learning analytics design.

Table 9: Mapping iterations and techniques for case study 1

Iteration	Co-design techniques for iteration 1	Analysis technique it 1
1	**Adopt:** Superpowers, Card Sorting, Collaborative Sketches/ Prototype. Collaborative Personas, Focus Group. **Adapt:**, Learner/Data journey	Critical incidents, Survey design, Thematic analysis, Knowledge art framework.

2	**Adopt:** Lo-fi Prototype. **Adapt:** Learner/ Data journey	Critical incidents, Survey design, Thematic analysis, Knowledge art framework.
3	**Adopt:** Hi-fi Prototype, Questionnaire	Findings triangulation, Critical incidents, Survey design, Thematic analysis.

5.3.1 Adopted: Focus Groups

Purpose in designing learning analytics: The main strength in using focus group sessions as a co-design technique is their effectiveness for collecting ideas that can be used for improvement and for identifying popular opinions among learners. They are also much more flexible than surveys or scales because they allow for questions, clarifications and follow-up questions to probe vague or unexpected responses (Krueger & Casey, 2014). In cases where more people are involved besides learners and instructors, it is necessary to ensure that the questions do represent their interests.

Description: This technique can provide great insights into learners' opinions towards specific topics. The potential of focus group sessions is the ability to get a collective view on the problem and concerns. In addition to this, it is possible to get more in-depth information conducting individual interviews. Conducting interviews should be implemented if resources and time are available without compromising the project (Wilson, 1997). Focus groups offer researchers and designers the possibility to provide an open space for discussion, being this a very useful first step when establishing initial collaboration between different stakeholders.

The main goal of conducting a focus group is to provide a channel for learners to communicate using open-ended questions and avoiding, where possible, short answers. The session should start with a clear set of instructions and a quick explanation about the topic to be discussed. In learning analytics, it can be helpful to provide an explanation of what learning analytics is, why is it relevant for the session, what is the intention behind gathering these data and to address any concerns actors may have about the process. After this, it is recommended to allow some time for unanticipated questions.

This technique is intended to be for qualitative purposes, so numbers and percentages are not appropriate and should not be included in the final report. The report should be descriptive and present the meaning of the data as opposed to a simple overview (Mellon, 2014). Three classic approaches to analyse focus group sessions include:

Classical content analysis: This method includes assigning codes to particular sections of the script. Each code allows the researcher to identify whether each participant refers to something of particular interest and assess whether each group is giving feedback on certain code (D. Morgan, 1998).

Keywords-in-context: This method helps to identify the context of specific words or sentences. The importance in context for words in this approach is based on what's behind user intentions when using them (Fielding et al., 1998).

Discourse analysis: This analysis requires choosing segments from the conversation and looking for cultural associations on their use. In more explicit analysis, it is possible to look for rhetorical moves and accountability (Jørgensen & Phillips, 2002).

In the end, a report can be written to include the final interpretation of group statements. This interpretation should be built following a descriptive process, providing meaning to the data and personal interpretation based on the facilitator's expertise. Involving specialists from different areas in education can be helpful when interpreting comments especially to avoid biases influencing the interpretation (Onwuegbuzie, Dickinson, Leech, & Zoran, 2009).

The focus groups were analysed using a traditional thematic analysis of the transcriptions. As detailed in Section 4.3.1, the coding scheme was informed by our interest in the use of co-design techniques, the Knowledge Art framework for coding the roles of the co-design practitioner (Section 4.3.5), and annotation of emerging challenges informed by the analysis of Chapter 3.

5.3.2 Adopted: Card sorting

Purpose in designing learning analytics: In LA design sessions, card sorting can help stakeholders to clarify the components through problem exploration and allow them to express ideas through an actionable design object. Some examples include separating categories into learning-related and technical related concepts; or sharing an understanding of analytics methods and data practices across stakeholders.

Description: Card sorting is a technique used to design or evaluate concepts by grouping components into understandable working units. The concept of doing this in participation is to allow participants to explore concepts without guidance and allow them to write down on cards and share them or group them. This method has been used in multiple design areas where discussion and problem exploration is part of the main interest, this is mostly due to the easiness to implement, the openness for discussion and the flexibility to shape the outcome at any time (Bevan, 2003).

Card sorting sessions are commonly divided into three different moments required to produce usable outcomes for the practitioner:

Write the ideas: participants are required to write ideas into small pieces of paper by not thinking into limitations or labels. Free thinking surrounded by context allows people to synthesise complex ideas into usable phrases or keywords. During this phase, the practitioner must explain that even when collaboration is expected, individual thinking is the most valuable thing and every contribution is valuable. In most practices, participants are invited to place their ideas into the main board or on the table for everyone to see it.

Group and label: Once participants place their ideas on the table, it is required to group them into emerging categories based on the similarities. Labels for each group can be chosen by either the facilitator or the participants in the context of the design task.

Decide/vote: Once the groups are defined and participants agree enough ideas were collected, ideas can be rated in order to make collective main interests visible. In this phase, it is required for participants to rank their interest by placing a vote into one category from the set of groups. Since voting brings the idea that there must be a winner/loser, the practitioner must state decisions by voting will be used at some point to give priority into what actions should be followed by the co-design practitioner (Spencer & Warfel, 2004).

5.3.3 Adopted: Fabulation Superpowers

Purpose in designing learning analytics design: The concept of learning analytics is mostly unknown for many academic stakeholders and for these researchers may find a problem when asking direct questions about technical issues. The concept of *Superpowers* (Holstein et al., 2017) is being used in this case study as a way to help participants imagine special abilities that can be used to solve their current problems. The results invite researchers to make a link between the expectations and feasibility based on the current technology available. An example of this might be participants wishing for ‘omniscience’, able to see and remember everything students do. The challenge for the LA team is to translate this into a possible solution.

Description: The concept of fabulation in design is taken from what in literature refers as relating invented stories often involving fantasy (Howlett & Mukherjee, 2018). When using fabulation in design, participants are expected to relate histories where a fictional product or ability is not set to real boundaries including technical or social to solve their current issues. Fabulation for stakeholders in design invites participants to use imagination using examples without limiting their language.

Common examples of this concept being used in design include designers asking participants to imagine the perfect tool for them to solve all their problems, open questions such as "What would you do if you are granted limitless privileges?", "What would you do if you have an infinite amount of resources?" or placing hypothetical scenarios around the problem for participants to elaborate.

This version of fabulation as a method in co-design is inspired by one of the recommended techniques used by the Stanford design school (School, 2016). This variation is adapted to our context meaning that not only participants state their wishes but also imagine the context in where their ideas could be used.

5.3.4 Adopted: Collaborative Persona

Purpose in learning analytics design: The challenge for the co-design practitioner and designers is to design an automated feedback tool to provide learners with useful insights into their practice. Using learning analytics tools, it is possible to track different sorts of activity around the classroom but the co-design practitioner and the research team must understand how learners define their main attributes. In this initial part of the study, it is important to understand how learners can help create better representations of themselves and identify what other problems may be addressed through a data-intensive approach.

Description*:* Persona profiling is a technique used to model and summarise critical information about people who may be involved in the learning ecosystem. The persona may provide some input to receive some output from, or affect the function of the artefact being designed. In educational contexts, this technique can be called learner persona profiling, if the intended goal is to characterise learner profiles. Thus, a learner persona is a hypothetical learner who is representative of a number of potential learners, educators, etc. The purpose is to generalise and cover a significant portion of the potential users or people who may play an active role in the successful deployment of the learning analytics tool. This can facilitate the design process by bounding the scope to a limited, manageable set of personas, rather than a vague population.

An initial template was crafted by the lead designer based on what teachers and researchers established as main interests (Figure 5-5). This template includes fields starting with what values are endorsing as nurses in training, learners' goals, and open topics that may not be expressed in other ways as students.

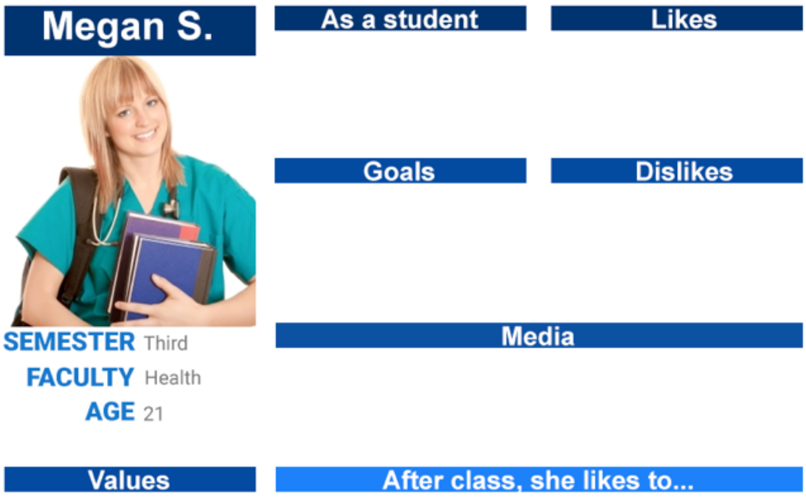

Figure 5-5: Template provided as an initial representation object.

5.3.5 Adopted: Collaborative sketching and prototyping

Purpose in designing learning analytics: For educational purposes sketching and prototyping can be used to converge research findings done in collaboration with stakeholders. Reflection and interpretation are the main objectives when building together the first prototype helping all learners involved in understanding what are they looking for in visual representations (Luckin et al., 2013).

Definition: The prototype stage after ideation described in DT is where ideas acquire a visual representation before being implemented. Prototyping in collaboration brings an opportunity for co-designers to engage beyond the ideation process. Prototyping may be useful to enable participants to communicate in a non-traditional way. This approach can invite learners to communicate their needs and expectations (Gaver, Dunne, & Pacenti, 1999). Sketches can be low-fidelity only to illustrate concepts and unpolished ideas without worrying about user interface details or technical limitations. Also, it is possible to demonstrate user interaction by implementing techniques like Wizard of Oz

(Hanington & Martin, 2012) where simulation is being done without an actual product working.

Sketch-in is an alternative group activity in which learners use sketching to resolve design problems together. This activity can be done in quick sessions using basic drawing materials like post-its, paper sheets and whiteboards. The LA practitioner and stakeholders can try and test data visualisations, colour schemes, interaction styles and give definition to features that fit into the learners envisioned use and stakeholders intention for the LA tool.

5.3.6 Adopted: Interviews

The approach used for interviews in this part is based on common practices in user research (Carter et al., 2014; Foundation, 2018). Interviews are useful research objects when understanding personal views on the subject and aggregating ethnographic data to the design process. Other benefits of implementing interviews for research are:

- Low cost and flexibility to improvise.
- Users are familiar with the process.
- Compatible with keyword analysis and transcription analysis.

The interview design for this iteration involves 1 on 1 interview guided by a questionnaire. The co-design practitioner looks for more elaborated questions related to feedback. The difference between these interviews and the focus group sessions is that questions are framed to feedback related topics such as how critical events should be presented, the details on the desired feedback and the usefulness of the data presented.

Adopting interviews for co-design purposes comes with some drawbacks that require changes. These drawbacks include:

- The nature of participants to have memory issues when recalling what they did. This issue makes participants recreate the history of what happens by filling the missing parts with their own version of history.
- Technical inclined questions are hard to answer given that participants are not expert designers. Questions should be framed in terms of personal opinions and not making them decide what benefits everyone.

- Participants tend to give insights on what they are supposed to do instead of on what is being done. In some cases, the practice matches with the description but even when conducting contextual studies some differences in practice can be spotted.

5.3.7 Adopted: Collaborative Hi-fi dynamic prototype

Description: Prototypes as collaborative design objects allow stakeholders to see in detail how the product would look like, the context where it can be used and spot design short-comings through evaluation (Pernice, 2016). Hi-fi prototypes are still considered work in progress, this means that back-end code can be incomplete and mostly focused on the user interface component.

The difference between our first lo-fi and a hi-fi prototype depends on the amount of detail spent on the following features:

Interactions: Students and teachers should be able to click on menus/link and get a response based on those actions.

Visuals: The user interface should be in a closed state to what the live product would look like. The timeline interface includes colours, icons, layout and distribution of graphics in detail ready for teachers and students to test and comment on them.

Content: The content must be a reliable representation of what students and teachers would read, see and interpret. Information used as dummy should include labels, data and descriptions.

Once the content, visuals and the interactive component are designed, the hi-fi prototype is ready for evaluation.

5.3.8 Adapted: Pen+Paper Learner/Data Journey[1]

In education, there are only a few examples in which user journey mapping has been used as a representation tool and as a shareable object to facilitate communication between the design team, academics and developers. IDEO (2016)proposed a design thinking toolkit for educators in which journey mapping was suggested as an effective tool for identifying critical pain points that learners may commonly face while engaging in learning activities,

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[1] Peer-review version published in: Carlos G. Prieto-Alvarez, et al. (2018). Mapping Learner/Data Journeys: Evolution of a Visual Co-Design Tool. OzCHI'18. Melbourne, Australia, ACM: 205-215.

However, no attempt was made to involve learners as collaborators, making this a map aimed at supporting the designers or teachers as designers.

Other examples in education include user journeys being adapted to support learners to reflect on time and money required for their academic projects (Ortbal, Frazzette, & Mehta, 2016), or as templates to track the cost-benefit trade-offs of the different courses that can be part of their degree (Montero, 2016). Journey mapping has also been used for marketing purposes for academic institutions to improve the processes for learners to select units of study and pay their tuitions (HEM, 2014)

Most of the examples listed above have reported cases in which journey mapping was used by the design team to better understand learners' activities. In most cases, the final journey maps were entirely crafted by the facilitator without involving learners. A notable exception of this is reported by Montero (2016) who proposed a template for learners to generate their own journeys in terms of their curriculum pathways. The other cases mostly relied on questionnaires and interviews as the main resources to collect evidence to build the journey maps.

In this context, the traditional journey maps were adapted to fit the learning analytics components regarding nursing practice. First, it is required to specify a process for co-designing journey maps with learners to identify the opportunities of interaction that learners could have with future intelligent feedback systems that exploit digital traces of learners' activity. Second, a summary of findings from the collection of leaner/data journeys is produced to support the integration of sketched maps into an interactive synthesis map, designed to enable stakeholders to explore and discuss the insights that the design team has discerned from the consultation.

The aim of this process is to generate understanding about places, timing and actions associated with learners' experience in order to formulate potential data-intensive educational analytics solutions.

Figure 5-6 depicts the proposed three-phase process for crafting Learner/Data Journey maps and using them as communication tools to involve other stakeholders in the co-design of a data-intensive educational tool. The three phases in this process are the following:

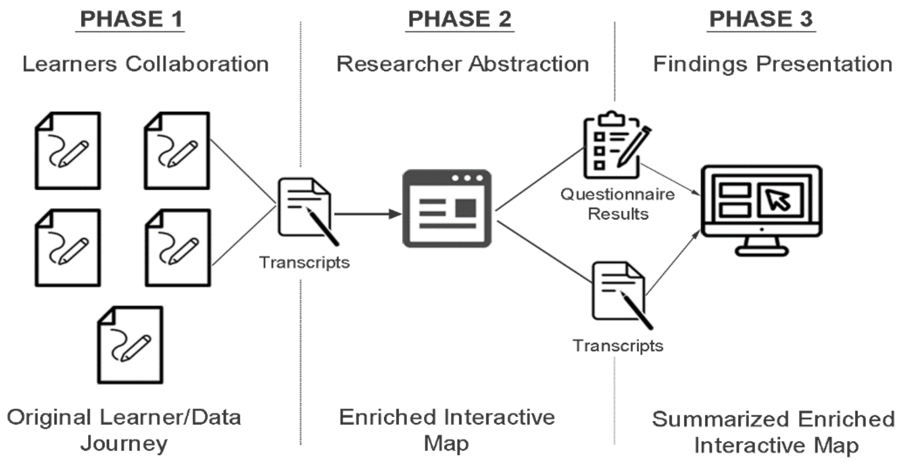


Figure 5-6: Design learning data journey process.

i) **Co-designing Learner/Data Journeys with learners**. This phase involves scaffolding groups of learners to collaboratively co-create a Learner/Data Journey based on their own experience using a template and other associated tools.

ii) **Synthesising Learner/Data Journey insights**. This phase consists in distilling key insights from these journey maps.

iii) **Communicating insights and converging to make design decisions.** This involves providing the means for multiple stakeholders (educators, researchers, and learners themselves) to integrate and synthesise insights to suggest design requirements.

5.3.8.1 Phase 1: Crafting Learner/Data Journeys

This first phase is divergent. The aim of this phase is for learners to engage in explaining their own learning experience in the form of a Learner/Data Journey. This can be a piece of paper where learners can draw. It can also involve a scaffolded process to ensure that relevant information is being captured for designers or other stakeholders can make sense of it. The scaffolded map construction should ideally be delivered in face to face co-design sessions. In these sessions, learners can start by responding to simple questions about their usual activities and actions performed during their classes. Being a collaborative task, participants can discuss the different ways in which students perform their activities and how data could help them reflect on such activities. Learners can be asked to represent their paths explicitly by using distinct colour markers, sometimes disagreeing with other participants but always giving enough context for researchers to understand in post-hoc analysis sessions.

For a Learner/Data Journey to be useful, details of data interactions, learning scenarios and descriptions should be highlighted by learners, providing enough details on what each path represents. This should be scaffolded by using a template (see case study for an example in the next section) to delimit the area for marking and critical learning spaces that are meaningful according to the educational context.

The resulting Learner/Data Journey objects can be seen as descriptive snapshots of what happens during a class or learning session. This phase is divergent because the maps should portray how learning experiences vary across situations and for different learners. Each learner can bring a different perspective not only because each one is different, but also because each may face different teacher, teachers or learning situations. This is particularly the case of higher education. However, although it may be helpful to collect as many journeys as possible, researchers should consider adopting a careful recruitment strategy, prioritising diversification over quantity, to reach saturation and reach a consensus of the most critical issues that may arise. At the very least, more than one collaborative session with three or more learners should be run to get different perspectives. The snapshots are produced by editing the template presented below.

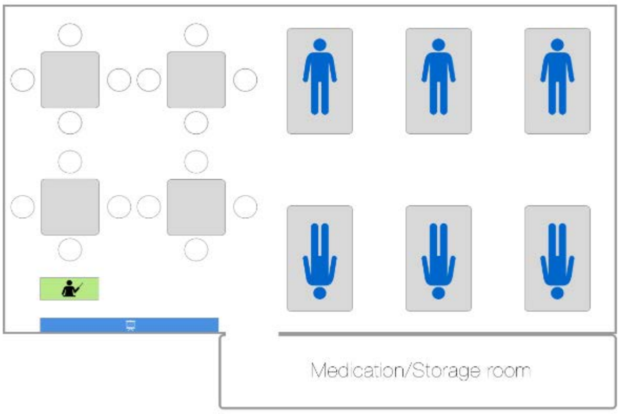


Figure 5-7: Representation of the classroom used for nursing practice/simulations.

Since not everything can be mapped into the Learner/Data Journey, conversations during the activity can be recorded for further analysis. Recorded conversations between participants and the facilitator can be used to enrich the final journey map with valuable information to reconstruct what learners said while building the map.

5.3.8.2 Phase 2: Synthesising Learner/Data Journey Insights

Conducting multiple sessions with learners can produce different Learner/Data Journeys and a significant volume of information. Feeding findings back from these journeys to other stakeholders requires for facilitators (commonly designers or researchers) to summarise the key information in such a way that the context remains presented. The role of the facilitator should thus be to develop one or more representations that summarise learners' input without decontextualizing the information and communicate critical insights. It is suggested that this phase is critical in any participatory endeavour.

A framework that can be used to craft effective representations of people knowledge is that of Knowledge Art (See section 4.3.5). This framework had been proposed to help facilitators to guide participants in creating representations of issues or ideas, such as collaborative diagrams, especially in the context of Participatory Design. In short, this paradigm highlights that facilitators also have a voice in the participatory process. Similar to participants themselves (e.g. learners in our case), the experiences of the facilitators and interactions between facilitators and participants, can strongly influence the creative ways in which the representations of participants' knowledge can be crafted.

The synthesis of the Learner/Data Journey may thus involve the generation of a coherent narrative, and consideration of other elements such as aesthetics, ethics, and sensemaking. This adaptation of the co-design technique focus on the narrative that is added to the different isolated Learner/Data Journey maps to provide them with coherence to be presented to other stakeholders and to distil critical insights from them. This process should not only consider the original maps crafted by learners but also the video recordings, and transcripts to understand how these were crafted (see Figure 5-6 describing the transition between Phase 1 and 2).

5.3.8.3 Phase 3: Communicating and Converging to Make Design Decisions

This phase is focused on convergence. The synthesised journey maps can be further enriched by integrating other sources of stakeholder input that could assist interpretation (i.e. any contribution not recorded in the original journey maps). Using coding schemes and affinity diagrams may help the facilitator to link transcriptions with the main interest of stakeholders in Phase 2. For example, in this case study, A KJ method was used to build affinity diagrams by 1) identifying key individual challenges that students may face during their learning experiences, and 2) establishing possible relationships between them. Since participants come from diverse backgrounds, they may find interest in the different abstraction levels provided. The following section explains how this can be operationalized to fir the nursing case study.

Phase 1: Crafting Learner/Data Journeys

Figure 5-8 shows a journey template that was provided to learners, representing the learning space (in this case, a simulated ward with manikin patients in beds). Each group used the template provided and drew the trajectories they commonly follow during the class. Thus, this represents the sequence of the tasks or idle time, in the physical space. They were asked to use stickers to represent feelings, locations where they want to receive feedback, critical actions they perform in the spaces, and what data they would like to have captured.

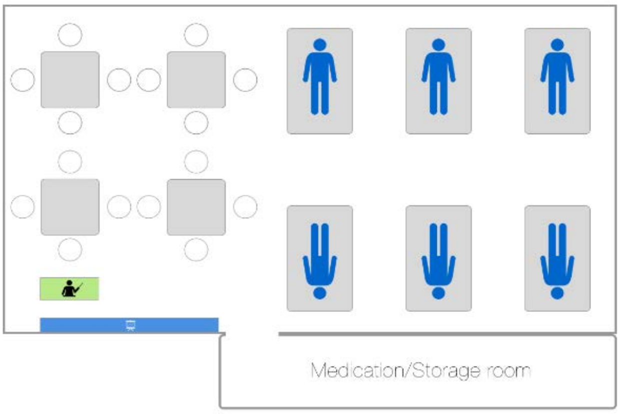
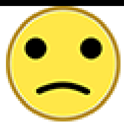
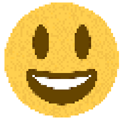
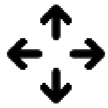
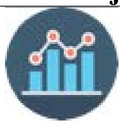


Figure 5-8: Journey template representing the physical space in simulation classrooms.

The purpose of giving pre-defined stickers, in this case, was to help learners with the complicated task of drawing actions or defining specific medical equipment. It also provided a standard method for further analysis since the same emoticon has the same (or similar) meaning across sessions. Learners were free to use their own annotations for actions, feelings or aspects not represented in the set of predefined stickers. Table 10 summarises what kind of iconic representations they were asked to use to represent their learning experience.

Table 10: Stickers to annotate the journey that were used by nursing students part of the study.

Category	Stickers	Meaning
Emoticons	 **Sad**  **Happy**  **Doubtful**  **Frustrated**	Feelings at particular points of the learning process, e.g. happy, neutral, frustrated, doubtful.
Data Collection	 **Audio**  **Video**  **Positioning**  **Proximity/movement**  **Manikin vital signs**	Interest in data being logged, including audio/video recording, location, movement and interaction with learning content

Critical Event	 **Cardiovascular resuscitation**  **Defibrillate**  **Administer drug**  **Check vital signs**  **Administer injection**	Major events that should be noticed by everyone including learning activities, actions performed, and equipment being used.
Analytics	 **Look at a dashboard**	Interest in an analytics tool providing automated feedback during the process.

Stickers can be placed at the end of specific paths to identify important events. Figure 5-9 presents an example of a journey map filled by a group of learners. As seen in the figure, multiple roads can be traced over the same map and have different experiences. Some of the learners, in this case, identified the action of sitting on the table at the beginning of the class as a positive experience while others struggled to fit into one group. Notations are placed on the map, but the particular details are being explained in the conversation with the facilitator.

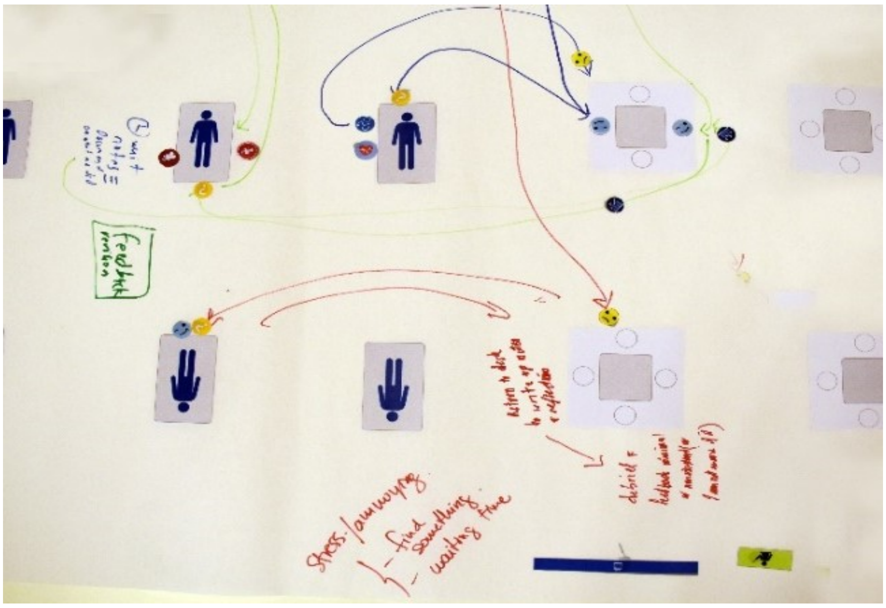


Figure 5-9: Example of paper-based Learner/Data Journey

5.3.9 Adapted: Digital Learner/Data Journey

After producing multiple paper-based journey maps, it is proposed to produce a synthetise version using a digital version containing findings summarised through an interactive tool. Analysing and synthesizing data produced from the first Learner/Data Journeys requires a set of specific themes to look at. These themes included: practice, feedback, analytics and challenges. In this phase, the facilitator mapped important statements in the transcriptions with the drawing representations. By following this process, each comment can be linked to specific stages. This allows adding context to the comments mentioned by learners on what commonly happens during a simulation.

The facilitator can look for recurrent themes and comments mentioned repeatedly. From these, some quotes can be extracted and included in the summarised log to be used for the interactive map construction (see next phase). Comments that are not associated with any of the main themes area left in the general transcription log. Since not all learners express the same feeling about the learning stages, the facilitator can provide an "Experience Spectrum" measure line. This object is used to define the overall experience after looking at the emotion icons on the map. Mapping learners' experiences in a linear scale allow the facilitator to track mood changes between stages and link those to the possible reasons following the transcripts.

5.3.9.1 Interactive map exploration

In this part of the study, the co-design practitioner produced an interactive tool using the summarised information from the previous stage and for participants to evaluate it. Producing and evaluating this tool required a different set of participants in addition to learners who participated in the first study. The recruitment included two teachers (aged 40 and 50 years) with experience in simulation-based classes and in organising the course structure; two designers (aged 28 and 34 years) who have been involved in designing the process of the automated feedback tool, one learning designer (aged 39 years) in charge of updating and structuring the current course content and two learners (aged 18 and 26 years) who participated in the first study.

Journey maps may seem limited if the information is not captured and linked with the source material. To address this, it is required to design a summarised, enriched version that merges what the facilitator collected from the sessions including video, audio, questionnaires and other media where learners provided some input. Mapping these resources with the Learner/Data Journeys was aimed at providing teachers, designers and other stakeholders a channel for exploration. In this case, the facilitator used a prototyping tool to produce a web-based application ready for distribution among participants (see Figure 5-10).

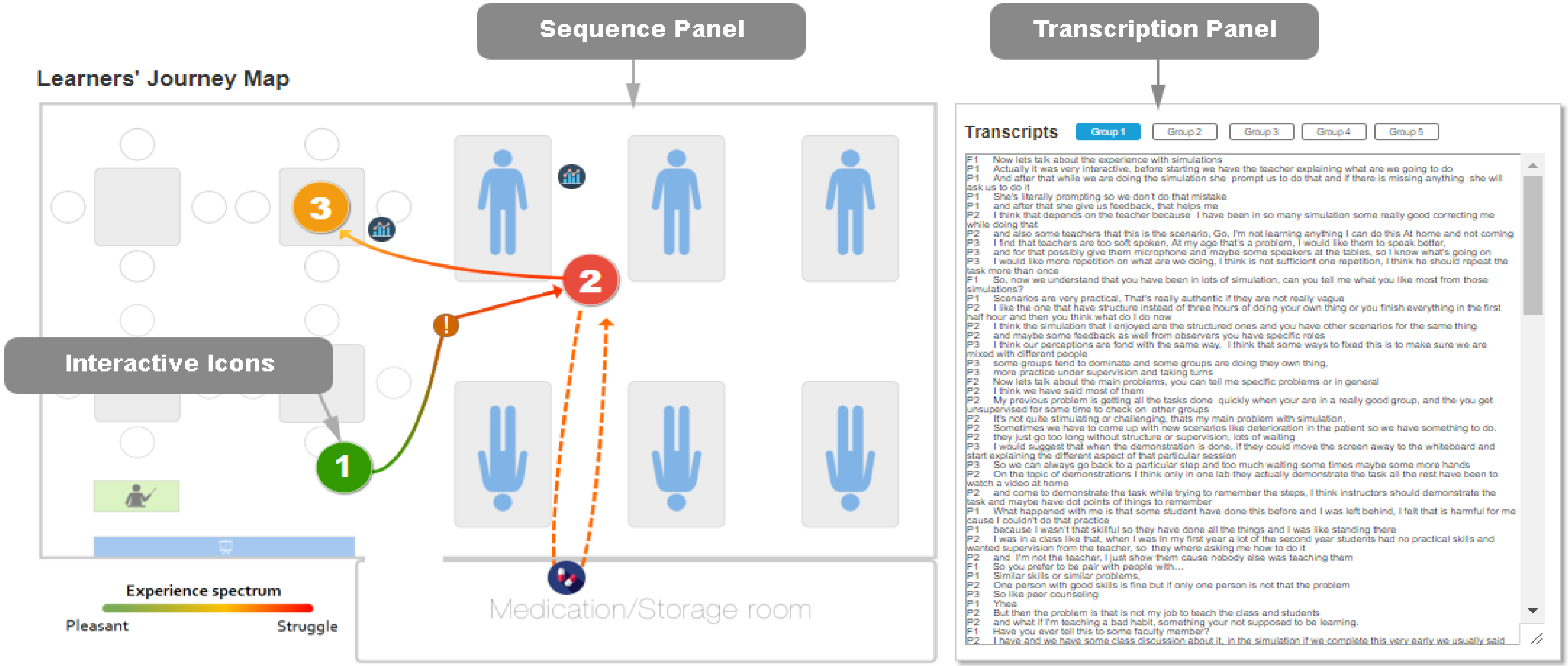


Figure 5-10: Learner/data journey digital tool.

The interactive tool links transcriptions to stages described by learners, teachers, researchers and designers. Participants can explore in detail actions described by clicking on each icon. The novelty of using this format is that exploration is being guided by what are designers interested in instead of what the facilitator wants participants to see.

The interactive version provides two panels; the first panel shows the sequence of actions summarising learner's paths. The second panel shows the transcriptions related to those particular sections, if required, participants can explore the content per group or per line using the top menu.

Transcriptions are shown in a side panel and react to users pointing at interesting events (Figure 5-11). Participants do not require to read the full text since the tool takes them to where the quote is being taken for further context. Stickers become icons and are placed in the positions of the journey map in which learners positioned them during the Learner/Data Journey design. The detailed cards show the most relevant quotes and the overall feeling about that stage using the "Experience spectrum" line.

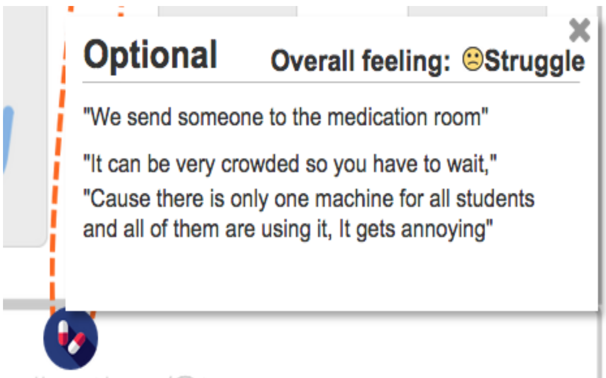


Figure 5-11: Interactive icons for transcriptions' context.

5.3.9.2 Adopted: Collaborative lo-Fi prototype

The lo-fi prototype is an extension of what sketching brings as a design tool. The objective of adopting lo-fi prototypes is to produce a visual representation of the product in a short period of time. At this point in the iteration, there are many ideas that can be tested by producing paper-based visualizations and take them through user evaluation (Pernice, 2016).

Lo-fi prototypes can be implemented depending on the level of detail presented. Interactive prototypes can mimic actions using animations or predefined movements without actual coding. Statics prototypes are not suitable for that level of interaction but can be implemented through action methods including:

Wizard of Oz: The designer follows user actions and manually triggers visualizations. The preparation for this involves a person who is familiar with the design and a set of pre-defined scenarios that participants may encounter

Paper-prototype: All designs and interfaces are created on paper. During a testing session with participants, the designer shows the interfaces based on what the user is pointing on paper.

The difference between Hi-fi prototypes and Lo-fi prototypes depends on the amount of detail and functions designed. Lo-fi prototypes allow the practitioner to generate multiple ideas in the same time period. Also, Lo-fi prototypes expose the idea that the current version is a work in progress making participants more open to provide critical feedback. In this scenario, A lo-fi prototype is being produced to close the idea that a timeline-based interface is the most suitable form for users to explore critical events.

The following section describes 1) emerging challenges when working in a second iteration mixing learners and teachers, 2) results from implementing the interactive learner/data journey and a lo-fi prototype, and 3) the role of the co-design practitioner

5.4 Analysis

Data used as evidence come from transcription analysis, triangulation of evidence and mostly qualitative analysis of design sessions described in section4.3. The thematic analysis was done following interest in the usefulness of adopting/adapting co-design techniques (RQ1), the use of knowledge art framework to define the role of the co-design practitioner (RQ2), and emerging challenges in co-design for LA (RQ3).

Analysis of critical incidents was used to understand how stakeholders interacted with the co-design techniques, the challenge that they were facing and the role of the co-design practitioner. Following this protocol, stakeholders' actions were annotated using the video recordings and transcriptions to create snapshots of their actions. This is required to understand how nursing students responded to other stakeholders' commentary, the way tools support their conversations and track any results related to emerging challenges.

Additional information was analysed from surveys delivered after sessions using open questions, Likert scales and ranking options for stakeholders to give a personal opinion on the effectiveness of the techniques, issues from nursing practice and interest in the learning analytics features.

The protocol followed for the evaluation of the learner/data journey tool consisted of a think-aloud approach through 4 activities for all participants with the following steps:

1) The facilitator explains how the first Learner/Data Journeys were built,
2) Participants explore the Learner/Data Journeys produced while trying to re-construct the actions,
3) Participants explore the interactive journey map and compare with the initial Learner/Data Journeys and
4) Participants answer a questionnaire evaluation the clarity and usefulness of the Interactive map.

All the sessions were video and transcribed for analysis using a coding scheme and the KJ (bottom-up) method to generate affinity diagrams on emergent topics. The primary topics used to categorise information were data collection, learning activities, perceptions on getting feedback, and the perceived usefulness of the Learner/Data Journey map. This information was used to generate the summarised interactive map for teachers, learners, researchers and designers to explore the findings and move onto generating the first design.

Next, evaluation sessions were held, exploring stakeholders' ability to understand, explore and reflect on the data collected using the original 1) Learner/Data Journeys (paper) and 2) the interactive Learner/Data Journey.

5.5 Results

5.5.1 Effectiveness of co-design techniques for learning analytics design

Results shown in this section are a contribution towards *RQ1: How can co-design techniques assist in the integration of diverse stakeholders' perspectives?* Figure 5-12 shows a map (extracted from Figure 1-1) how this part of the case study fits in relation to the relevant research question, objective, and contribution.

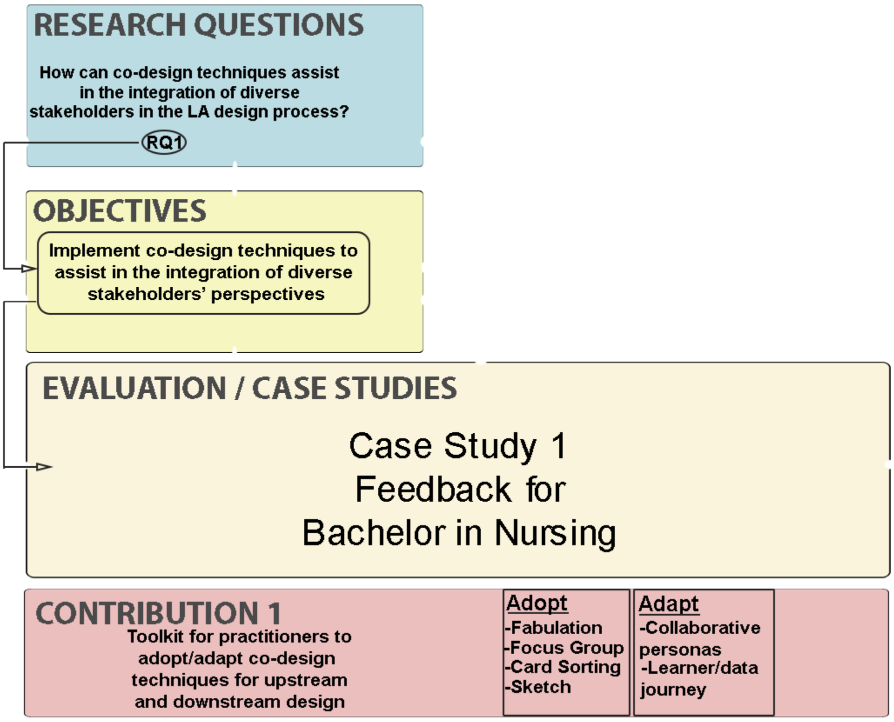


Figure 5-12: Map of contribution 1 in relation to RQ1 Co-design techniques.

5.5.1.1 Card sorting as a self-expressive tool in design

Card sorting, in this case, allowed the research team to conduct a guided session with teachers to explain and classify their current issues with simulation classes. From both sessions, teachers generated cards based on their activities, problems and examples of superpowers useful to help them overcome these issues.

Figure 5-13 shows the raw format where teachers can provide an answer to our first questions using post-its and a paper-based board. The granularity of ideas resulted to be too open for the design team to focus on one issue at a time. For this purpose, voting shaped as a green dot was included to rank those ideas that were clear enough and in the interest of teachers to focus on.

Figure 5-13: Using fabulation (Superpowers) through card sorting collaboration. Teacher 1(Left) Comparison with Teacher 2 (Right)

For the design theme, this visualisation using boards to summarise data helped to better understand the language used by teachers, the technical parts of each problem; and some expectations towards implementing a learning analytics tool. Using the resulting board for researchers to conduct further analysis is an indicator of the co-design objects self-representation. Teachers voice represented as post-its are carried throughout stage two and tree and available for everyone to revisit in case any further explanation is required. Limitations spotted in using card sorting are explained in Table 11.

Table 11: Limitations found when implementing card sorting as a co-design method.

Limitation	Description
Time	Sessions required to be designed for short questions fitting the 45 minutes available with teachers.
Granularity	In detail, questions were avoided to keep the conversation on point towards feedback.
Self-expression	After some time, revisiting the boards became difficult without the audio transcriptions since keywords were used to fit in the post-its.

Once data was gathered from both sessions with teachers, information was separated this into two boards using Trello and identify the similarities and emerging themes. As seen in Figure 5-14, similarity and small differences exist but it is possible to agree at least three main issues.1) Class size is an issue that detriments the quality and time available to provide feedback to students. 2) Equipment malfunction or limited programmed responses. These findings are relevant to inform teachers and academics about their practice but at the moment, the co-design practitioner and the designer decided to focus on delivering feedback after practice a the main objective and then proceed to look for solutions to the other issues

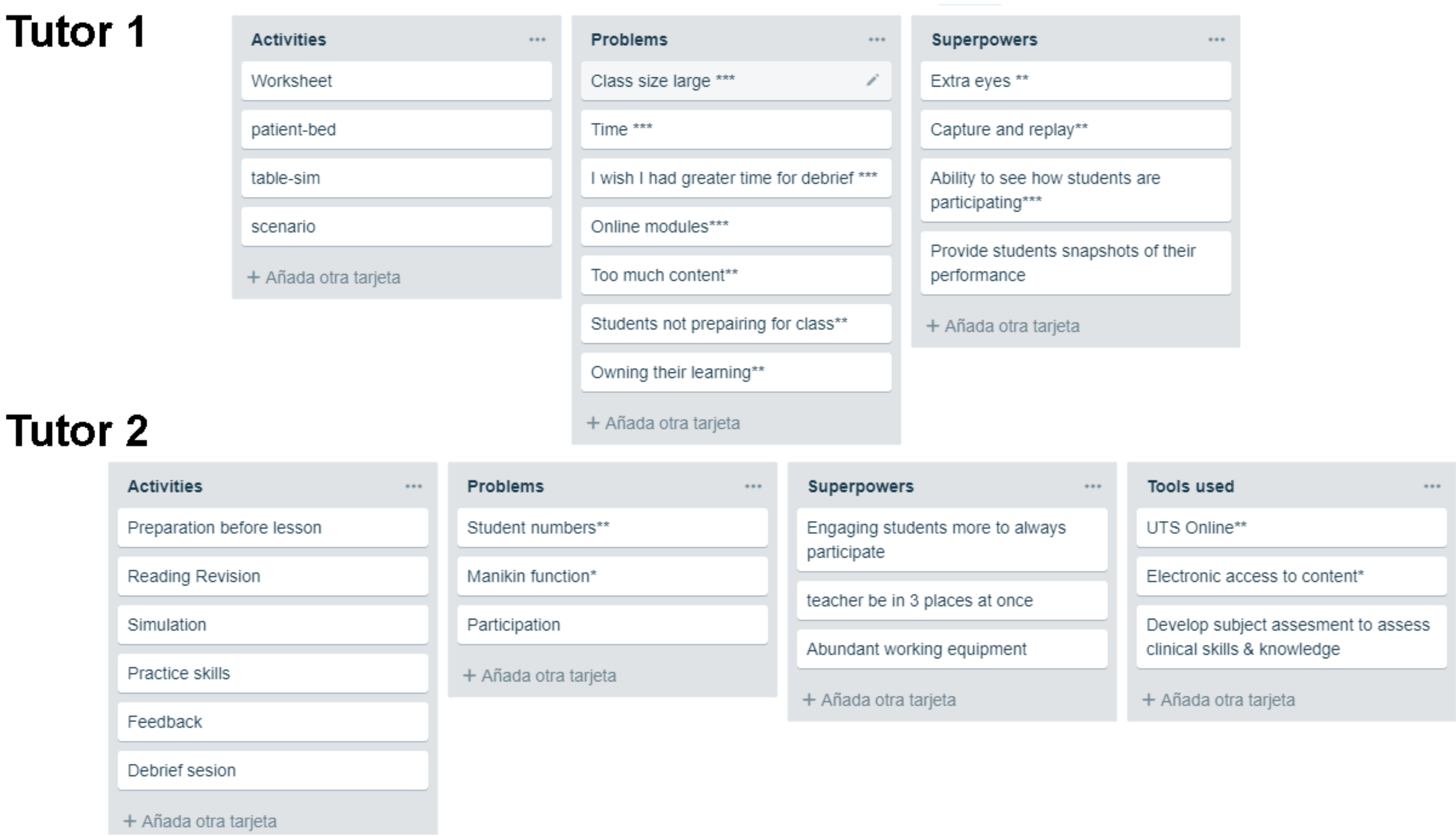


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Figure 5-14: Using Trello to group cards into categories for stakeholders understanding.Effectiveness of collaborative persona

After conducting the sessions, the co-design practitioner gathered and compared the different profiles built by participants. Field and notes were added to our initial template (based on learners' feedback and observations. The new fields added were on specific goals for the simulations, the different uses of social media and the reason behind wanting to become a nurse.

Table 12 describes observations gathered from the conversations during the activity and new fields requested based on learners' feedback.

Table 12: Observations and new fields requested by learners per session.

Group	Observations	New fields
1	Personal and global values are hard to express in one single field. Media sources used by learners differ based on technical expertise.	Personal goals and academic goals. Social media and LMS preferences.
2	After class activities can be used to express leisure and additional hobbies.	A field for open comments on personal traits.
3	Values generate discussion since this term is not used by teachers or any resource provided by the faculty.	Concerns.
4	Academic goals are different from personal goals.	Academic goals.
5	A different template for seniors and new students.	Current challenges.

Some recommendations were suggested by learners to improve the technique based on comments collected from stakeholders. The first one is to complement the persona profiles with comments provided by learners and show this to the design team. Some components on the template are mere suggestion than designer may not be followed but now they become aware in case additional information back up the suggestion.

Building collaborative representations by using a Persona template helps researchers and designers to open the design process to learners. The resulting objects can be used in the future to generate usage scenarios where learning analytics innovations can be deployed. Also, these objects become a resource for designers and other stakeholders to comprehend user intentions without going into technicalities. For the following sessions, some other techniques from PD and co-design areas will be tested to gather additional information and support collaboration through the whole design process of LA tools.

5.5.1.2 *Low-fidelity prototype sketching*

Following our iterative process, a first lo-fi prototype was produced using results from our first two stages (Understating/Ideation) from DT. For this part of the process, the designer's perspective and sketches from students were used to generate a storyboard putting together expected features. Figure 5-15 shows one of the storyboards where the designer narrates how the expected learning analytics tool should be implemented at the end of each practice as a form of immediate feedback. The user interface design contains feedback data through an interactive timeline for students to navigate.

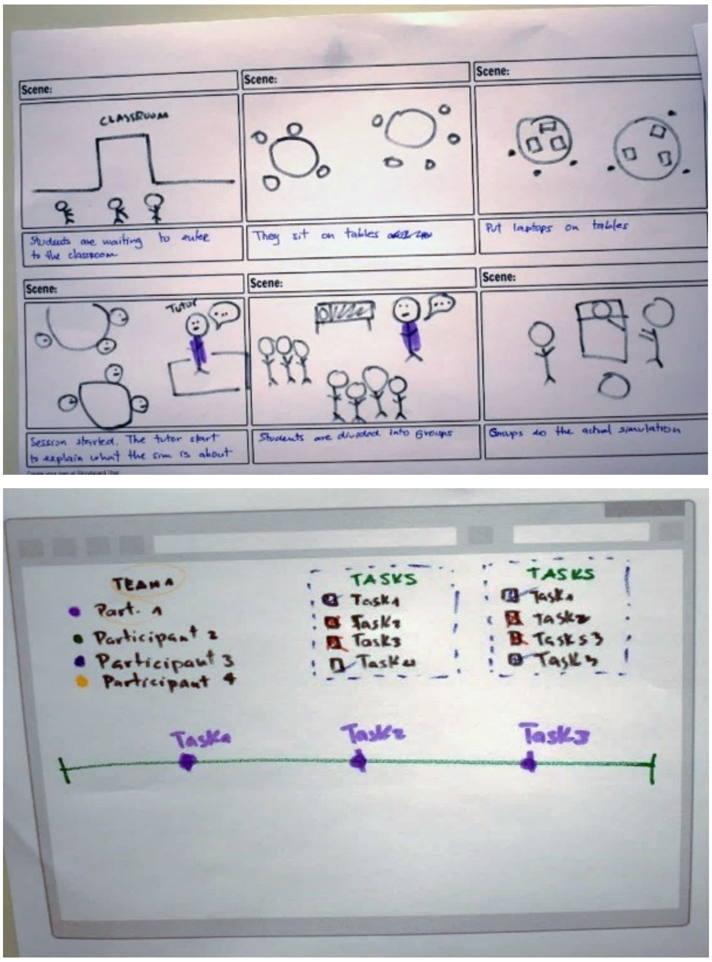


Figure 5-15: Storyboard (Left) and sketching example (Right).

This unpolished work helped us to define and produce a more detailed representation using an interactive prototype for the design team to explore. In Figure 5-16 features are distributed in multiple interfaces where students can explore their feedback provided by the analytics tool.

This first interactive version summarises what students visualized in their sketch and card sorting activity as a desired learning analytics tool for feedback. The main components to show includes:

Critical incidents through a timeline: Exploring any incident encountered along with the simulation class. Sections can be navigated in the function of time and severity according to teachers' criteria.

Critical incident through video: replaying parts of the simulation practice through video clips and navigating critical incident such as mistakes/delays.

Critical incidents through audio: replaying specifics parts of conversations between team members and the instructor.

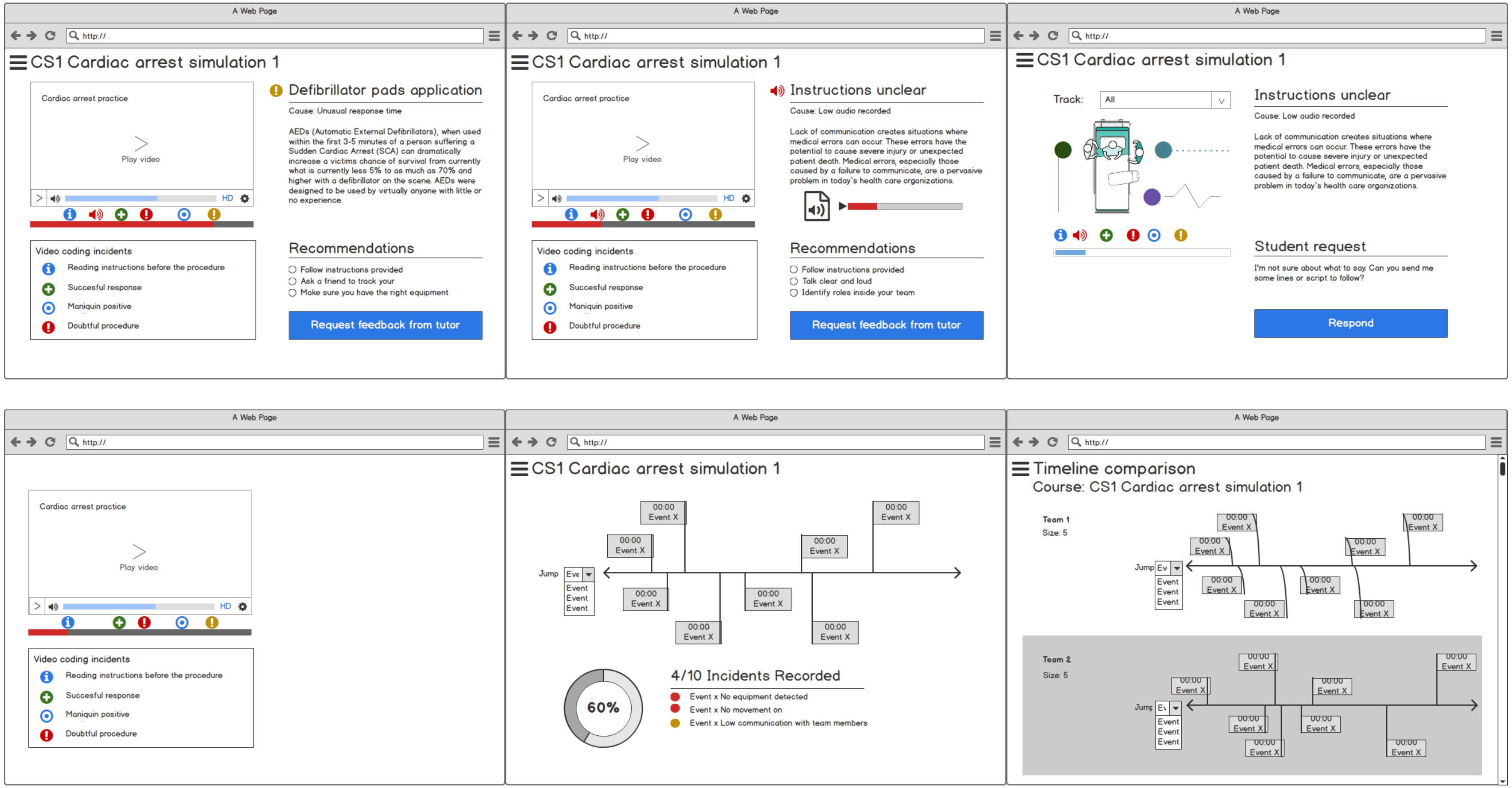


Figure 5-16: First prototype for the feedback tool exploring video, audio and the interactive timeline.

5.5.1.3 Evaluating the (Paper) Learner/Data Journeys

Feedback gathered from the firs phase of stakeholders unsing the Learner/Data Journey resulted in contrasting views about how useful it is to revisit these representations. Table 13 shows insights after each code analysis from stakeholders' comments:

Table 13: Perceived advantages/disadvantages of paper-based Learner/Data Journeys.

Strengths	Weaknesses
Opportunity to have a voice (Learner 1)	Detailed descriptions are missing (Learner 2, Teacher 1)
Identify pain points (Teacher 2)	Hard to identify sequence (Learner 2, Teacher 2)
Visualise opportunities to deliver a first design (Learning designer, Designer)	Requires prior knowledge about simulations (Learning designer, Designer)

As pointed out by teachers and the designer responsible of implementing the feedback tool, the Learner/Data Journeys helped to better understand what happens in simulations, it also allowed learners to have a voice as a form of contextual enquiry. However, showing journeys to other stakeholders outside the nursing program would require further explanations. Participants described the journey maps as "incomplete" since learners used markers to draw their paths and oral explanations for the details. For example, a learner said, *"I know this is the direction because I was there" (L2)*. This means that contextual information represented in the maps needs to be decoded in order for people who are not familiar with the context to gain an understanding of the activity. This was described by a second learner as follows: *"Other learners may have a problem understanding the icons" (L3).* Even the designer of the learning analytics tool reiteratively asked for the description of the icons. For example, she asked the following question during one of the sessions after being explained the characteristics of the map representations: *"Do you have some description on these icons?" (T1).*

Figure 5-17 shows the resulting paper maps for each group. In these representations is possible to track the multiple paths taken by students and some critical points attached to places.

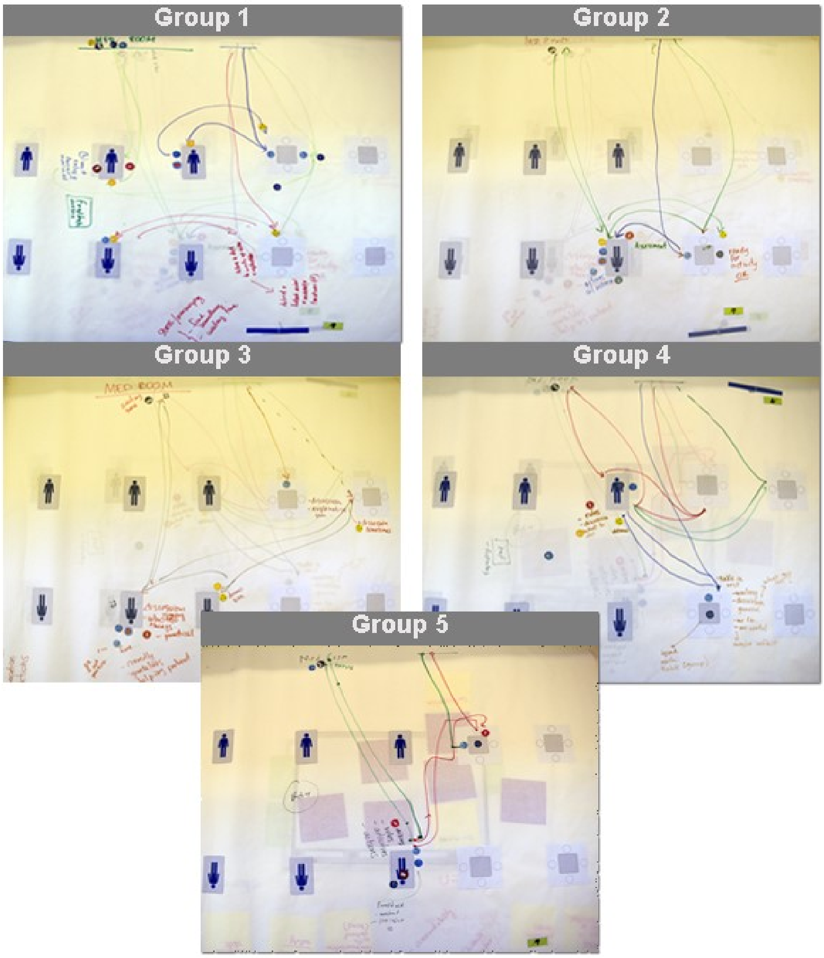


Figure 5-17: Paper-based journeys produced in each co-design sessions.

Learners found other journey maps difficult to understand besides their own, in most cases using their own experiences to make sense of the actions represented in others' maps. Requiring contextual knowledge about the simulations to understand the current maps may have an impact on how new participants are invited to collaborate. This was illustrated by the confusion of one of the learners in the following statement: *"I remember doing this, but I don't remember what this means (points at emoticons)" (L1)*. One of the learning designers that have been in some classroom sessions also stated the following: *"Because I was there I can remember things but for someone else, they won't understand." (L2).*

A critical incident to stand out from the evaluation stage was when Teacher 1 tried to re-construct what struggles students are having by looking at the icons used in the map. The teacher tried to tell the story by pointing at specifics point through the map and failing to match what students said in detail (Figure 5-18)

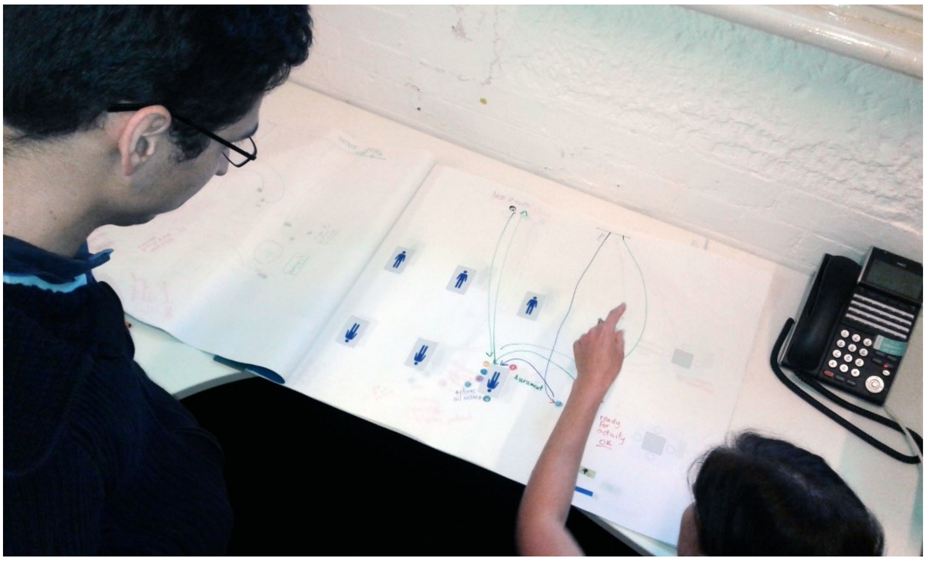


Figure 5-18: Teacher reconstructing actions following the visualization.

5.5.1.4 *Effectiveness of digital learner/data journey and comparison with the paper-based.*

Results are separated in 3 main categories starting with the insights from generating the original Learner/Data Journeys in the first study, then the contrast between the original Learner/Data Journeys produced and the interactive journey map, and finally a series of observations based on the application of this three-phase approach.

Feedback collected from the first phase suggests that the Learner/Data Journeys were used by the learners without further changes during the co-design sessions. Introducing this new tool into the co-design session did not require additional effort in terms of an extensive learning curve or considerable training time. In terms of perceived usefulness, there are three spotted benefits in using Learner/Data Journeys: it facilitated open communication, it provoked instant self-reflection and it helped learners to generate understanding of the possibilities of using analytics to support their own learning.

In terms of the role that the Learner/Data Journeys played to facilitate open communication, some learners expressed a positive feeling in being able to communicate their problems to a faculty member. One of the learners stated this as follows: *"We never have a chance to talk about these issues besides the short questionnaire at the end of the* *semester" (L3).* This illustrates the potential value of providing a mechanism for learners to have an active voice and a representational language to communicate their learning experiences.

In terms of instant self-reflection, some learners were able to reflect on their current experiences, including common mistakes and pain points that they may share with other learners. One learner expressed this as follows: *"Now I know I'm not the only one having problems with that class, maybe is the teacher" (L4).*

Lastly, in terms of the possible role for the Learner/Data Journeys to help learners gain some understanding of the analytics that can be used to support their learning, some learners expressed being able to better understand how data can be collected and used to create a data-intensive educational tool. One of the learners started to think about the 'correct' uses of data as follows: *"I guess is fine if you only use information from the session".* A second learner suggested a way in which the surveillance mechanism could be fine if used for the right purposes and under certain limitations as follows: *"I don't mind if you use my information as long as you don't share my name".*

5.5.1.4.1 Evaluating the Summarised Interactive Learner/Data Journey

Table 14 presents some of the feedback gathered from the interactive Learner/Data Journey evaluation using two categories: strengths and weakness, based on participants comments.

By exploring the interactive map, teachers expressed interest in how learners rated the overall experience per stage. While representation based on the most used icons in each event were used, the fact that participants could corroborate that not all learners struggled in the same place made them reconsider if they are having the same issues. For example, one of the learners explained this as follows: *"I would think that stage 3 was somehow pleasant, I feel kind of relief after the simulation part" (L2)*. One of the learners also expressed the following: *"It's interesting how other learners feel the same" (L1).*

Table 14: Perceived strengths/weaknesses of the interactive Learner/Data Journey

Strengths	Weaknesses
Able to find similarities between comments (L1, L2)	Difficult to visualise contrast between personal views and other learners' comments (L1, T1)
Able to track the context of the quote being used (T1)	Unable to explore the contrast between overall feeling ratings (T2, L1, L2)
Able to revisit the conversation where data is being collected (LD, CD)	

5.5.1.4.2 Differences in the use of digital learner/data journey

Other interesting results is the difference in use from both learners and teachers. Figure 5-19 shows the clickstream heatmap of how teachers (in green) and learners (in red) interacted with the tool. Teachers were more interested in seeing the summarised findings through the icons and stages. Learners found interesting the ability to navigate through the transcriptions. In some cases, learners started to look for their own quotes to corroborate if there were not being misinterpreted.

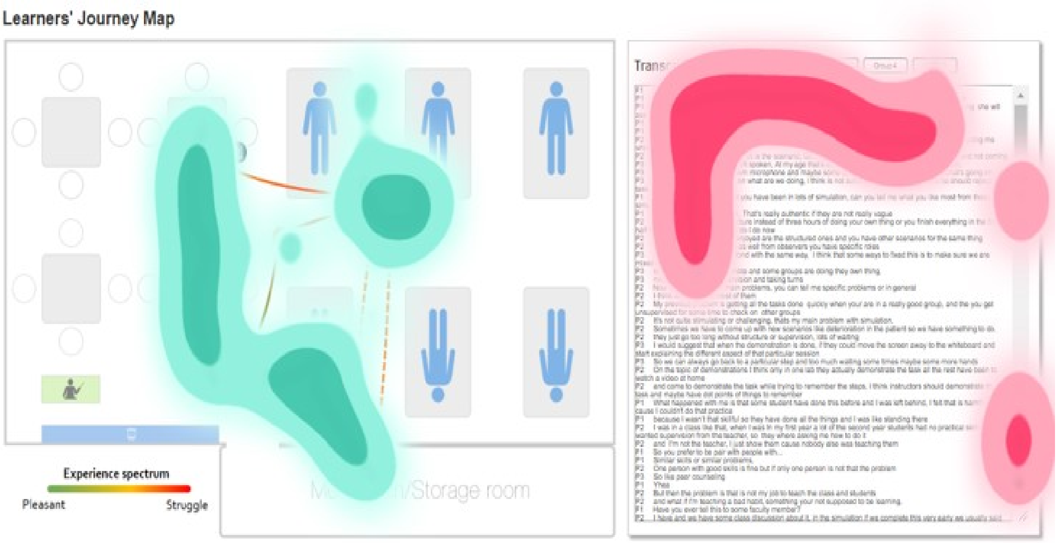


Figure 5-19: (Green) teachers (red) learners click stream heat map.

Learners also stated that they were are aware that simulations are practical scenarios in a controlled environment. Even when the instructions are the same as the ones used by professional nurses, stress and situational pressure when dealing with a real patient is hard to be re-enacted. This was described by one of the learners as follows: *"It's hard to feel stressed since the mannequin is not that real" (L1).* Teachers also realised that learners commonly do not see the simulation scenarios as real enough, making them reflect in future efforts to improve the current practices. This was expressed by one of the teachers as follows: *"This is rather interesting because the level of stress impacts their ability to do all the other stuff" (T1)*

In terms of surveillance and data sharing, most learners would not openly share information through social media but are keen to give personal data in favour of getting help. This was expressed by one learner as follows: *"I won't mind sharing my data if that means we are having some feedback" (L1).* Additionally, another learner specified what kind of data they would not like to share, such as those representing errors or potentially embarrassing situations.

Another item to add on this topic is the fact that participants never thought about data privacy and surveillance before being asked through these co-design sessions. Building the maps helped learners to reflect what other sources of data can be used by researchers to build the first design.

Inviting learners to participate in the design of their own surveillance tools not only prompted learners to think about possible design features for a feedback tool, but also to ask a question about how algorithms behind the analytics are using their data. Coordinating some strategy to enhance learners' data literacy to a certain level may help the design team to make the process more transparent for everyone. In sum, the Learner/Data Journeys provided an alternative to the usual document "Terms and conditions" that most participants admitted are too hard to understand or too long for them to read.

Implementing Learner/Data Journeys as collaborative objects still requires adjustments to fulfil practitioners' expectations. Further exploration in different scenarios is required to provide corroboration in other aspects including participants data literacy, knowledge background and experience with technology design. A scaffolded process based on three phases makes the implementation of Learner/Data Journeys understandable for facilitators and new designers without having to generate additional objects. The level of analysis and abstraction conducted in the second phase is linked to how familiarized is the facilitator with the research subject. However, in some cases, this will result in biased assumptions on what themes are important and what information should be shown in the interactive journey map.

Learner/Data Journeys have the potential to become into boundary objects for bigger design teams. This characteristic should be tested in future research studies including people from other fields outside the health faculty. Sharing this design object in other settings may enhance the Learner/Data Journeys as found in the results.

While Learner/Data Journeys are well received by participants, there are some additional constraints in relation to the effort and time for facilitators to build and connect all the information through the different phases. These constraints may impact the adoption of this tool by other designers. A potential way to enrich the Learner/Data Journey of a specific educational context can be to integrate a journey map crafted from observations that could be used to scaffold communication with learners.

At a bigger glance, Learner/Data Journeys can be seen as the first step into a whole design process, for example, the information presented by this tool may be useful when identifying the main requirements during the exploration phase of an iteration. Insights from the journeys can potentially be used by designers to identify low-level specifications, such as hardware requirements and infrastructure, and also higher order learning aspects that can lead to the re-design of pedagogical materials such as the curriculum, learning task instructions and expected learning outcomes.

5.5.1.5 Generating a Hi-fi paper timeline prototype

Information gathered through the early stages helped the designer to produce a first paper visualization for participants to evaluate. In this visualization shown in Figure 5-20, critical events are marked in the function of time during simulations. Information provided as feedback in this design represents what teachers and learners found most interesting to see in past iterations. Patient stats and readings are marked at the top distinguished with icons, participants are presented through their own timeline and physical position readings are described like a percentage.

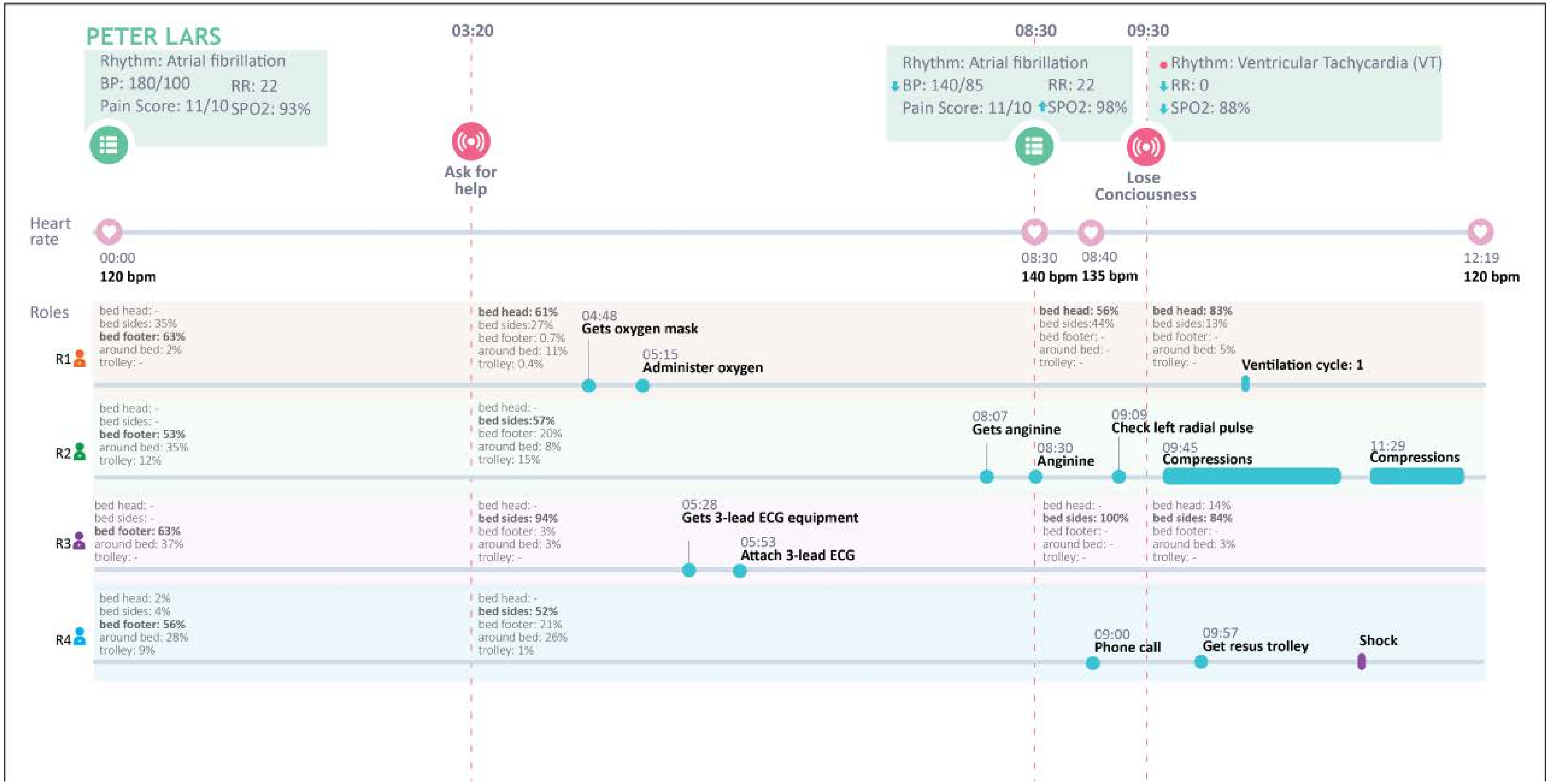


Figure 5-20: Paper-based timeline prototype

After the initial two iteration, the hi-fi prototype not only worked as the next step in design for iterative completion. The underlying benefit spotted when showing the prototype during this stage is the opportunity to see teams in action and the interaction that followed with the tool.

At this point, learners are very familiar with the project objective and feedback on their part became focused on improving data being shown on the screen. The fact that participants became familiar with the project over time also helped to reduce the amount of time spent in explaining activities, otherwise, the facilitator would have to explain in detail how data is being collected, sensors and the scope of the project.

Figure 5-21 shows the latest state of the timeline prototype. In this version, information collected from past simulations is displayed as interactive components for teachers and students to explore. The different options available includes those feedback elements that participants ranked and described in the early stages when problem exploration was conducted. Time response, actions, arousal state and location are implemented as hidden options to reduce information overload and increase the tool usability.

Interactive actions in this prototype allow students to click on specific actions to display teachers' recommendations on their practice (Figure 5-22). The veracity and trustfulness in those recommendations are linked to three main things: the teacher-learner relationship and the learners' familiarity with the tool, and the learners' familiarity with the nurse practice.

Another change included in this version is the new space for location mapping through heatmaps (Figure 5-23). Location was described as a mere percentage in past versions, the need for clear visualization of these data emerged from the multiple evaluations along with the three main iterations.

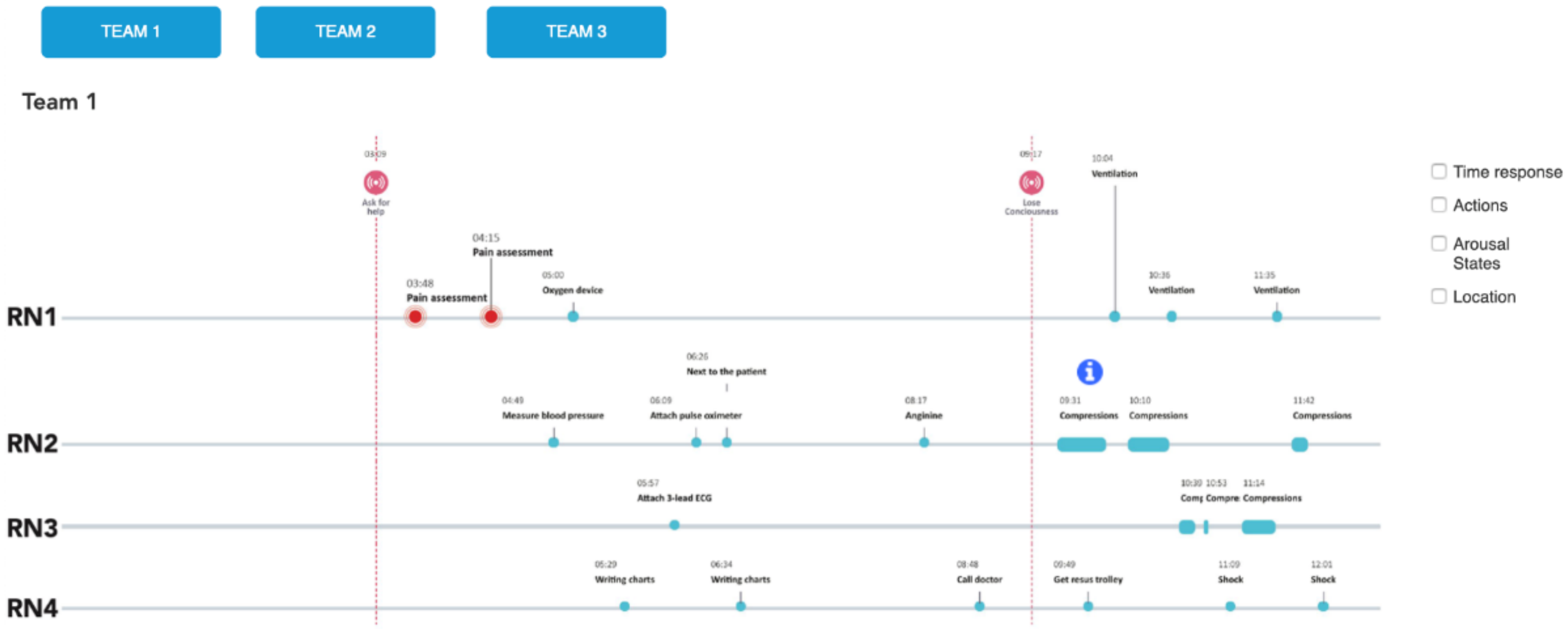


Figure 5-21: Implementation of the hi-fi prototype including 3 teams and the highlight menu.

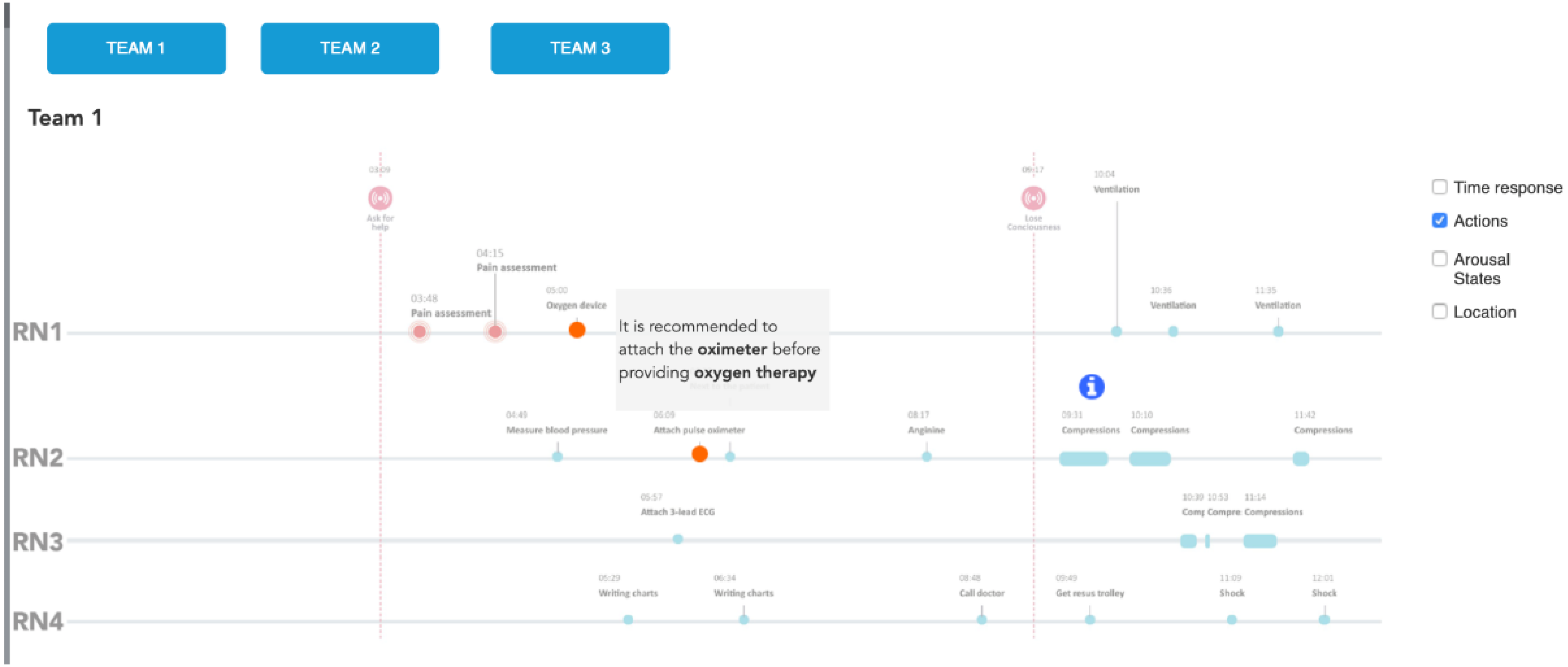


Figure 5-22: Timeline prototype with special highlights for actions

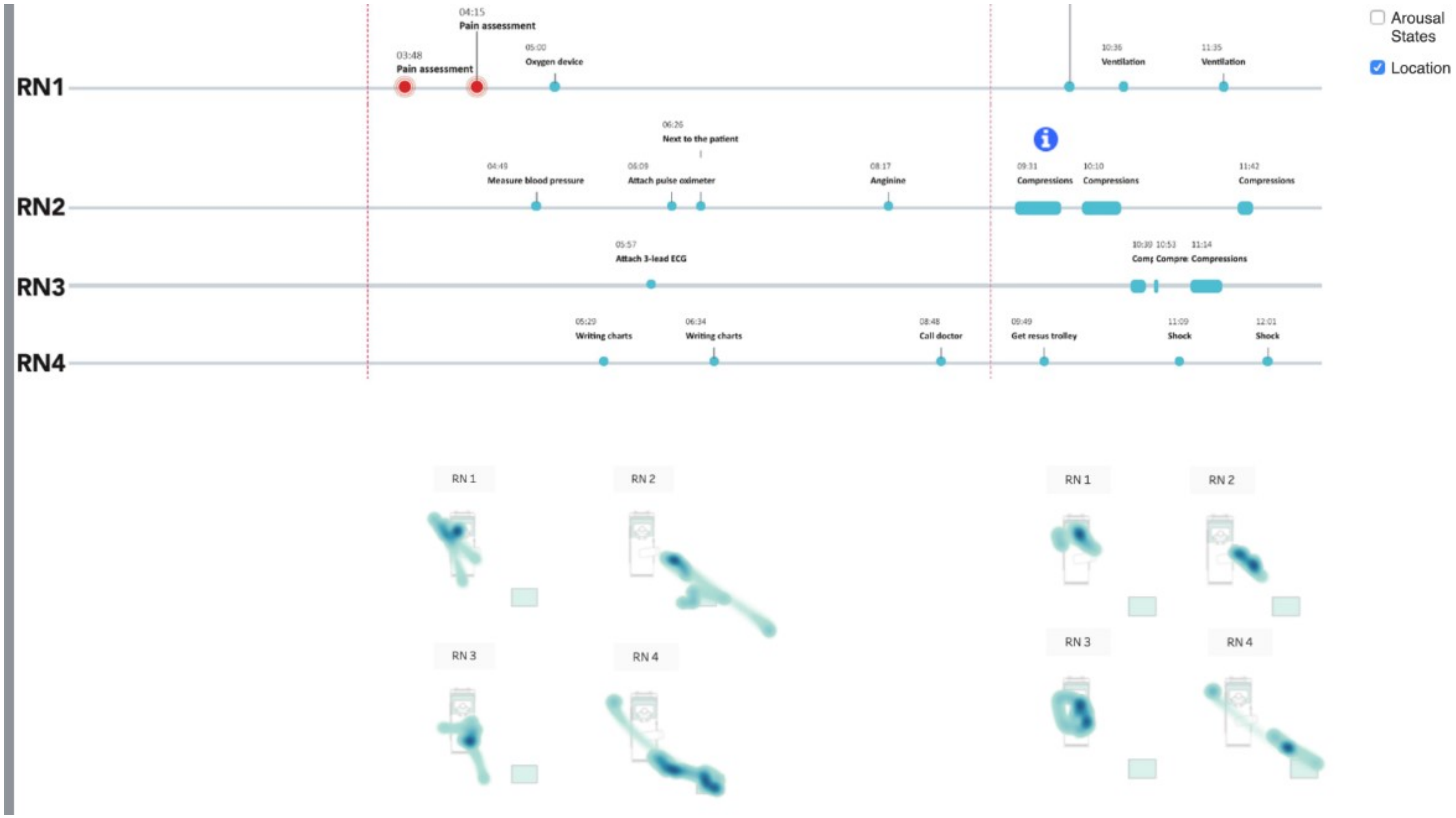


Figure 5-23: Timeline prototype showing position through a heatmap.

5.5.1.6 Evolution of the automated feedback tool through co-design

The effectiveness of using co-design techniques to develop the automated feedback tool interface can be noted when analysing the multiple prototypes delivered along with the three iterations. Figure 5-24 shows the evolution of the interface components from the paper-based sketchings to the high fidelity representation.

The main features suggested by stakeholders, in the beginning, evolved from simple lines drawn by learners and teachers to detailed objects in the following iterations. The co-design practitioner and the design team used information gathered from interacting with stakeholders with the co-design techniques (Collaborative personas, Learner/data journey, Focus group & Collaborative sketch) to include all suggestions requested.

The incremental approach to interface design allowed the co-design practitioner and the design team to test the components with stakeholders before spending time into solving the technical details to make it work. This proved to be very helpful for the co-design process since some features requested by learners in the beginning became irrelevant once stakeholders started to interact with the tool.

One example can be seen in the paper-based prototype produced in iteration 1 where the timeline was proposed as the main interface object to explore details requested by learners and teachers. In iteration 2, the design team added interactive details like critical incidents, mistakes and mannequin details as a summary of what was discussed during the co-design sessions. Iteration 3 became a natural evolution of the timeline by adding a comparison between team members and accurate representations using real data from one of the sessions with students.

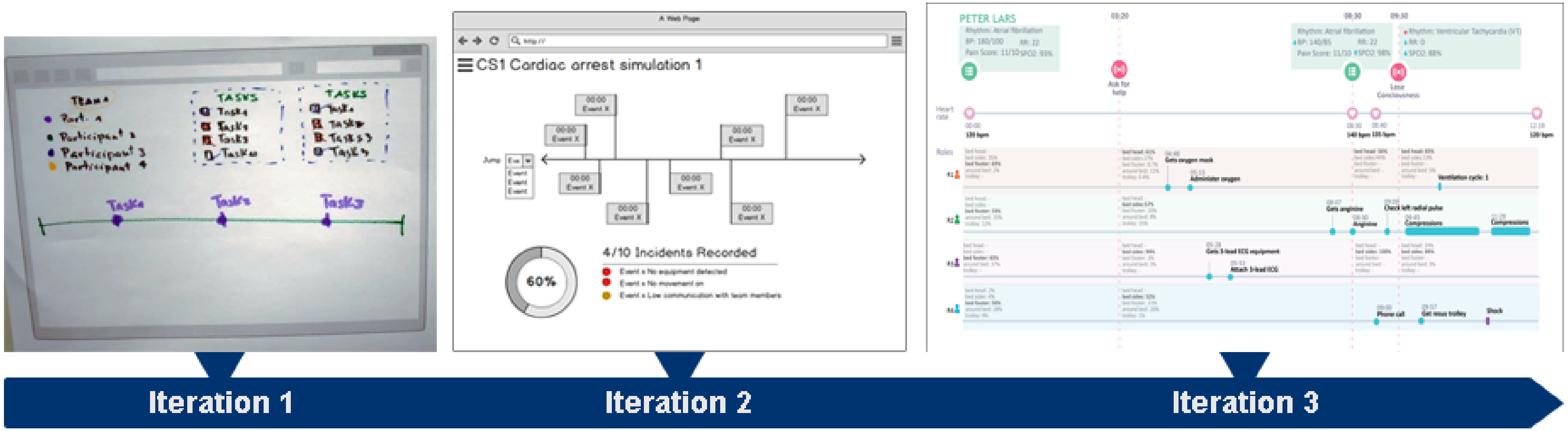


Figure 5-24: Evolution of the automatic feedback tool from iteration one to three.

5.5.2 Challenges when working with co-design for learning analytics

This section opens with an example of how power relationships between team members shaped the co-design process, and then presents a series of vignettes to illustrate critical incidents where other challenges emerged. Each vignette includes a summary of the challenge emerging from stakeholders' collaboration, the context where the incident happened, an explanation of what the co-design practitioner acted and the role of the co-design technique during the session. The following section presents a selection of the most relevant critical indent for each challenge. Further examples can be seen in the *Appendices* section.

Results shown in this section are a contribution towards RQ3 What are the challenges when engaging stakeholders in the design process. Figure 5-25 shows a map of our research question and objective used to guide our contribution towards understanding emerging challenges in co-design practice for LA.

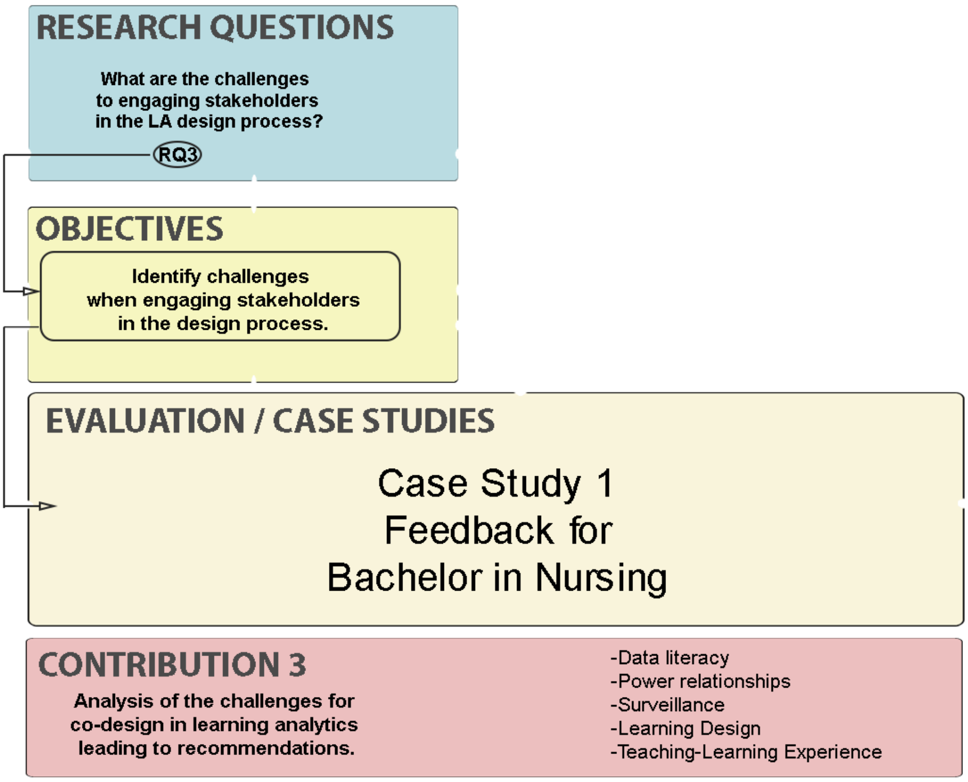


Figure 5-25: Map of contribution 3 in relation to RQ3 Emerging challenges in Co-design for LA.

5.5.2.1 Power relationships

An interview with the PhD research student developing the LA system provided new insights into the dynamics of power relationships between the student and the subject matter expert who was an academic in another faculty, which are likely to be typical in LA co-design research in a university setting. The research student was asked to reflect on any instances where stakeholders had used their position to influence the co-design process. As shown in the transcript (Table 15), the nursing course director was able to use her influence to recruit students to participate in the project, and facilitate access to nursing facilities for the LA researcher. According to the LA researcher, without this help, it would have been impossible to run the studies on time.

Table 15: Transcript of the conversation between the co-design facilitator and the LA researcher in case study 1.

Line	Transcript
1	**Facilitator**: Do you think stakeholders' position and ability to influence the design process had an impact in your project?
2	**Practitioner/Researcher**: So, because of [Course Director] came in… students were more engaged into the… Into this research. Then we could have access to students. And [Course Director] said, yay, it will be good, to all the students. It will be good if you had some time like next week to do some interviews with [Practitioner/Researcher]and [Supervisor], because blah, blah, blah. It was because of [Course Director] comments to students that we could get students. They also suggested to add question that were not part of my research questionnaire.
3	**Practitioner/Researcher**: I was completely lost actually. I think that I won't be, I wouldn't be able to finish my PhD at this point. But because of [Course director] help and engagement with the research, I think that sort of we could get, I mean, sort of accomplish my goals of my PhD. But I remember, I mentioned this to [Supervisor], saying that that's the problem when your research is not tied to a subject. Or you don't have that engagement directly with teachers.

Thus, while the original reason the course director was engaged was as a key stakeholder bringing clinical and pedagogical expertise, and as an anticipated end-user of the LA tool, her ability to influence the design process, while never discussed in official conversations, turned out to be critical when the researcher was struggling to convince students to participate. In terms of making co-design happen, this was a positive exercise of power.

In another interesting example, the PhD researcher described how the course director of the nursing program began to suggest changes to the empirical studies to reflect their interests. This is not a surprising development in a university context, but required some careful negotiation. The PhD researcher could not implement all the proposed changes in the available timeframe, which would have disrupted her thesis schedule, and research interests. The resolution was to implement some of them, as a 'trade' that recognized the course director's help.

We now present a series of vignettes from the design sessions to illustrate the other challenges identified in Chapter 3.

5.5.2.2 Surveillance and privacy SP1 – Example 1

Case study 1: Automated Feedback tool for nurse students

Co-design tool: Focus group

Design Cycle: Iteration 1 Session 1

Critical Incident: Students differences in concerns over repercussions when exposing data about mistakes.

This case illustrates an incident where participants held contrasting views about sharing personal data. The arguments between participants differ when it comes to comparing the benefits against the disadvantages. This was found in session 1 during the first collaborative design session focused on designing an automated feedback tool for nursing students.

The session invited 3 nursing learners (ST1-3) to a co-design activity using the focus group technique (Section 5.3.1). The objective of this section is to understand learners' perspectives on sharing personal data with other stakeholders and the limits of privacy. In the end, activities done following this protocol helps to understand how stakeholders use the code-sing tools and what challenges can emerge from this practice.

The section below includes a vignette explaining the actions initiated by the co-design practitioner, the partial transcript that emerged during this conversation, and the interactions with the focus group.

Vignette 1: focus group with students

The conversation starts with the facilitator asking participants about the concept of sharing their data with other students (Line 1). Student ST3 (Line2) responds expressing concerns about allowing other people to see her mistakes. Student ST2 reflects on this argument and admits that is something that they never considered (Line 3). ST3 affirms that their data is considered quite personal (Line 4). ST2 then proceeds to try to convince her by pointing out that information should be shared to be useful (Line 5).

Table 16: Vignette 1 including the practitioner actions, the transcription with students' perspectives on sharing their data and the interactions with the focus group

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***			
[Narrative] ***Inquire***	*1*	**Facilitator**: What do you think about sharing this data with other students?	*Script for Focus group*
	2	**ST3**: I think it's good as long as it's not used against us so we're not ranked badly or something like that because that's…	
	3	**ST2**: I never thought of that.	
	4	**ST3**: It's quite personal information.	
	5	**ST2**: Information should be shared. If information is retained, it's pointless.	

Vignette Commentary

The challenge

The challenge of privacy and surveillance emerged when ST2 and ST3 had conflicting views on the benefits of sharing their data. The information in question mentioned in this session is mostly their results after engaging with the simulation, however, ST3 considers that mistakes made during the practice is personal information

(Line 2&4). This reflects students' concerns that data is a representation of their persona, hence it should present their best results.

On the other hand, ST3 is aware of the benefits of having someone's perspective to point out their mistakes. In Line 5, ST2 tried to convince ST3 by giving the argument that information should be shared, otherwise it is pointless. The argument given by ST3 reflects the narrative that the design team is trying to convey for the feedback tool. Students partially agree without the facilitator having to intervene. Later on the session, ST1 and ST2 approved the argument about taking the "risk" and see data as an abstract representation of their actions.

The role of the practitioner

The co-design practitioner acted as the facilitator for this session. The main responsibility of the facilitator, in this case, is to keep the conversation flowing but at the same time setting the constraints around sharing data with other people. The best way to lead through this path was by starting the conversation with an open question (*Inquire* action) regarding their data. The way this question was structured (Line 1) prompts participants into sharing their personal opinion and creating a trusted space without judgment.

Effectiveness of the co-design tool (Learner/data journey)

The focus group structure allowed the facilitator to guide the conversation through strategic questions. In line 1 the facilitator follows a script with the topics of interest, in this case, privacy and the possible questions to stimulate the conversation. The arrangement is shown in line 2 granted the flexibility to shift the conversation from a plain interview with the facilitator to peer discussion between students. This proved to be useful since students achieved agreement through discussion themselves, before moving to the next activity.

5.5.2.3 Teaching and learning expertise TL1 – Example 1

Case study 1: Automated Feedback tool for nurse students

Co-design tool: Learner/Data journey.

Design Cycle: Iteration 1 session 1 & iteration 1 session 5

Critical Incident: There is a tension between students' preference and teachers' pedagogy expertise in terms of automated feedback provision.

This example illustrates an instance of the challenge of designing by taking into account students' preferences and teachers' expertise. Some tension between these two was found when contrasting two sessions (session 1 & session 5) which were part of the first iteration of the case study focused on designing an automated feedback tool for nursing students.

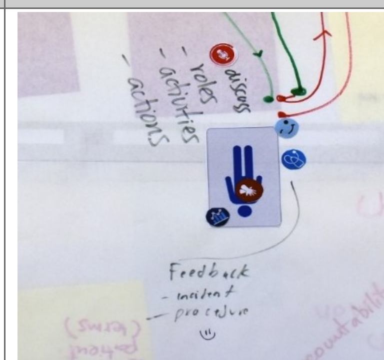
Session 1 included 3 students using the Learner/Data Journey tool (Section 5.3.8) to represent potential places and moments in which feedback could be more useful for them to reflect on their simulation. Session 5 required a teacher to visually inspect a number of resulting Learner/Data Journey maps and provide commentary on students' preferences.

Critical moments that highlight the challenge mentioned above are presented below as vignettes, including the actions performed by the co-design practitioner (playing a facilitator role), the partial transcript of the dialogues that emerged during the sessions, and the interactions with the co-design tool.

Vignette 1: Learner/data journey with students

This vignette starts when the facilitator asked students about their preference in terms of where and when they would like to receive automated feedback about their performance in their simulation (see Table 17, line 1). Two students immediately agreed that they would like to receive feedback at the simulation space, near the patient manikin (lines 2-3). Immediately after, one student clarified why getting feedback and remediation is better during the simulation instead of waiting until it is over (line 4). Students used the learning-data journey tool to represent their preference visually (line 5), which the facilitator completed based on his notes (line 6).

Table 17: Vignette 1 Students representing their preferences in terms of receiving automated feedback using the Learner/Data Journey tool

Practitioner		Transcription	Co-design Tool
[KAF] ***Action***		[Session 1: learners]	
[Narrative]***Inquire***	1	**Facilitator:** We can provide you feedback, too; your patterns, conversations, something. Would you prefer to be… Would you return to your table, or close to the mannequin?	
	2	**ST3:** The mannequin.	
	3	**ST2:** Yes	
	4	**ST2:** I think I'd prefer to get feedback and remediation when a problem [arises] rather than towards the end when the whole thing has become more blurred.	
	5	**ST2** (Action-*The student (ST2) placed an 'analytics sticker' by the bedside on the Learner/Data Journey map)*. The figure at the right shows the resulting image produced in iteration 1 session 1.	
[Narrative] ***Summarise***	6	**Facilitator:** (Action- *wrote and annotated the Learner/Data Journey map seen as bullet points in the resulting image*).	

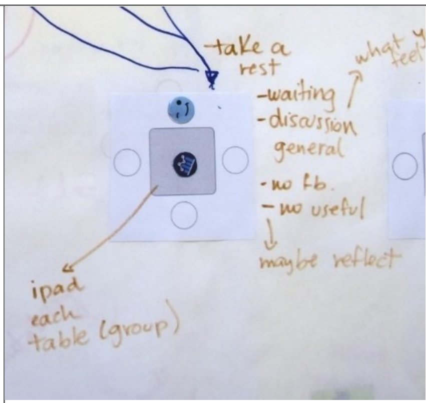
[Aesthetics] ***Clean***			

Vignette 2: co-design session with a teacher

In this vignette (Table 18) part of session 5, the conversation starts when the facilitator asked the teacher (TE) to elaborate on what is the best place to deliver feedback to students (line 1). The teacher responded that information should be delivered during the debrief at the end of the session (line 2). After this, the teacher elaborates on why students' suggestion can be more detrimental than beneficial if the feedback is delivered during their practice explaining that providing too much information can be distracting (line 3). The vignette finishes with the teacher using one of the maps produced by some students to illustrate her position. This visualisation showed students receiving feedback at the working tables away from the manikin location (line 4).

Table 18: Vignette 2 Nursing teacher using the Learner/Data Journey tool to critique students' commentaries.

Practitioner		Transcription	Co-design Tool
[Sensemaking] ***Inquire***	1	**Facilitator:** Where do you think is the best place to deliver this feedback to students?	
	2	**TE:** I think it'd be really useful in the debrief. I don't think it's going to be good during the sim, because I think they'll get distracted by it, they'll be looking at what they're doing. I think if any student says, I want that, in the middle of a sim, I think it's going to be detrimental; it's going to…	
	3	**TE:** Because there's too much information there for them to be able to chunk it down to what they're looking for and continue with the sim. So if you're thinking about putting that in here, I think that could be not as useful.	

	4	**TE**: points at the map where students from group 1 marked the tables as the expected place for feedback delivery.	

Vignette Commentary

The challenge

Learners suggestion to get feedback in real-time while doing simulations comes from their firsthand experience with the current learning environment. According to the learners, adding feedback during the sessions will make them reflect in the moment and change their practice. However, the teacher suggests that feedback won't be useful as learners propose since too much information can be hard to digest in real-time. The teacher speaking from a learning expert role understands that learners should have more time to reflect on their feedback and this should be done at the end of their practice sessions. It is a challenge for the co-design practitioner to get both perspectives of the same problem and decide based stakeholders' expertise.

The role of the practitioner

The practitioner acted as a facilitator and made sure to ask the same question to both parties to get a full perspective of the problem. The *inquire* action from the facilitator helped to make decisions whose recommendation would be used to deliver the automated feedback tool.

Effectiveness of the co-design tool (focus group+ collaborative sketch)

The learner/data journey helped the co-design practitioner to capture information from learner's commentary. Learners used the stickers and markers provided to make sure everyone understood where feedback would be expected. The same results helped the co-design practitioner to transfer the conversation to a session with the teacher and get a close evaluation from the learning expert perspective.

5.5.2.4 Learning Design LD4 – Example 4

Case study: Automated Feedback tool for nurse students

Co-design tool/technique: Learner/Data journey

Design Cycle: Iteration 1 Session 2 & 5

Critical Incident: Students suggest changes for the debrief section against the current learning design suggested by the main teacher.

The following example shows an incident where students commentary on getting personalized leads to requests on changing the current learning design proposed by the nursing school. This example was found in session 2 and 5 part of the first design iteration with nursing students.

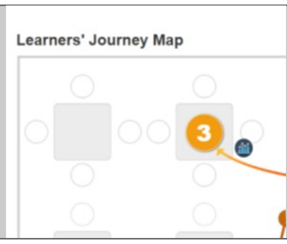
Session 2 and 5 invited 3 students and 2 teachers to discuss possible scenarios where the automotive feedback tool could be useful to inform nursing practice. While engaging whit the design activity using the Learner/Data journey, participants showed more interest in having personal feedback from the teacher than getting a learning analytics tool for this leading to request to change the current time allocated for this interaction.

The following vignettes illustrate the interaction between these two groups and the subject of discussion regarding the learning design.

Vignette 1: Learner/Data journey with students

In the following transcript, the facilitator asks students to comment on how helpful the learning analytics tool would be in relationships with understanding their actions (Line 1). After this, ST1 summarizes what other participants think about implementing an automated feedback tool to support the debrief section (Line 3). Their position reflects their desire for having personalized debrief by having individual time with the teacher. In line 4 we can see how ST2 remarks how having direct feedback from the teachers would be better than implementing a tool.

Table 19: Vignette 1 Students commenting on the need for personal feedback rather than implementing a learning analytics tool for this.

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***		[Session 2]	
[Sensemaking] ***Inquire***	1	**Facilitator**: Do you think this tool would help you to better understand your actions during simulations?	
	2	**ST:** (Action – *Students points at the tables using the Learner/Data Journey map)*	
	3	**ST1**: I think it would be better if we have a proper debrief, If we are lucky enough to have it, and the teacher personally explains what I'm doing wrong.	
	4	**ST2**: It would be better if the teacher could come to your table and give feedback to each student.	

Vignette 2: Learner/Data journey with a teacher

The following part shows the teacher part of group 5 interacting and commenting on learners' comments regarding their request for more time. In line 1, the facilitator introduces the topic by posting a question while the teacher explores the learner/data journey interface. In line 3, the TE explains that doing implementing what students request goes against the current learning design since "you can't have the teacher to yourselves". The TE continues to explain how running multiple sessions limits the teacher's availability even when student' request seems to be reasonable.

Table 20: Vignette 2 Teacher interacting with the Learner/Data journey tool to provide commentary on changing the learning design to fit time for personal feedback.

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***		[Session 5]	
[Sensemaking] ***Inquire***	1	**Facilitator:** What do you think about student request on personal feedback?	
	2	**TE:** (Action – *Teacher clicks on the Learner/Data Journey map to see what students think personal feedback)*	
	3	**TE**: You can't have the teacher to yourselves. Well, there was one group there. They're talking about their Third-Year classes.	
	4	**TE**: For instance, the Third-Year classes will have five scenarios running simultaneously in class, and you've got one teacher, and she goes between them. Now, it's a form of simulation, but it's not a simulation per se. So it then becomes about: how do you define what is simulation, what does that mean to you as a teacher and what does that mean to the student? And those two things can be polar opposites, because I don't think as an academic group that that is shared clearly with the students early enough so that there's this defining point between…	

Vignette Commentary

The challenge

The challenge of working with a stablished learning design makes students request hard to implement according to the teacher's comments. Students' argument supports their need for better debrief after simulations, but implementation goes against teachers' capabilities. The teacher in charge of designing simulations agrees that having the teacher for themselves could help, however, these actions are not possible since that requires restructuring all simulations. The teacher position on this topic suggests that students and teachers have a different understanding of what should be part of the learning design in simulations. This is different than having limited teaching a and learning experience since students' request is indeed a possible solution to the lack of personal feedback.

The role of the practitioner

The co-design practitioner plays the role as a facilitator posting relevant questions to keep the conversation going and ensure participants provide relevant information towards the design of the tool. The *Inquire action* makes the practitioner engage with the design objective and support the sensemaking process when understanding participant positions and expectations towards the design features.

Effectiveness of the co-design tool (Learner/Data journey)

The Learner/Data journey tool helped the practitioner to guide conversations around expected features to improve personalized feedback. In the first session explained in vignette 1, the students used the Learner/Data journey to place their comment in the context of the simulation structure. During the following session explained in vignette 2, the teacher used the Learner/Data journey digital interface to read students' comments in context and better understand students' position before commenting on the subject. The results shown through this critical incident suggest that the Learner/Data journey facilitated communication between participants and made the design task easier to navigate by breaking the task into a small section using the map as a point of reference.

5.5.2.5 Data and algorithm literacy DL1 – Example 1

Case study: Automated Feedback tool for nurse students

Co-design tool/technique: Focus Group

Design Cycle: Iteration 1 Session 4

Critical Incident: Students inexperience with data leads to a misunderstanding of how information is being analysed.

The following incident illustrates how the data and algorithm literacy has an impact on how students understand tracking their data for academic purposes. The incident was found in session 4 when the practitioner asked details on their positions towards using continues track of their actions.

Session 4 invited 3 students to discuss possible features for an automotive feedback tool using their data. At this moment, students started to question how data is being collected and the concept of privacy inside the university.

The following vignette shows the transcript from this conversation, interaction with the facilitator and the use of the focus group as a co-design instrument for conversations.

Vignette 1: focus group with students

The conversation starts with the ST1 describing how they think data analysis works when it comes to using their data (line 1). The facilitator continues to inquire them about tracking their action during the simulation (line 2). ST2 responds that data collection is not a common subject to think about as a nursing student and opens another question to other participants on what kind of data is being collected (line 3). In line 4, ST1 tries to respond that UTS track their data when using their services including log in information but still is unclear to them the details of this process. The transcript finishes by students suggesting that maybe UTS is tracking more data than they may feel comfortable with (line 5-7).

Table 21: Vignette 1 Learners discussing their position towards being tracked and the lack of clarity from the university in term of data policies.

Practitioner	Line	Transcription	Co-design Tool
[KAF] *Action*		[Session 4]	
	1	**ST1**: It is just having an algorithm and that is say, this, this, tick, tick, tick, this feedback and then this, this, this, this feedback.	
[Sensemaking] ***Inquire***	2	**Facilitator**: Do you find it sensible to be tracked during the simulations?	*Script for Focus group*
	3	**ST2**: I didn't even realize they collected data. How did they collect data from us?	
	4	**ST1**: So if I... All I do is UTS online. So they're collecting data from me when I do that? When I log into my course? How do they...? What data are they collecting?	
	5	**ST2**: Oh, so your teachers know you've done stuff.	
	6	**ST1**: You have done stuff.	
	7	**ST2:** Oh my God, I do everything...	

Vignette Commentary

The challenge

The challenge illustrated here shows that the lack of data literacy makes students unaware of how data is being tracked and the inner workings of the algorithm. This makes students unable to comment on details of how they expect the tool to provide an analysis using their data. In line1 is clear that the student understands that the tool must use an algorithm for this, but when describing their idea of the algorithm in action, they use unspecified words like "this" to avoid technical language. The general comment for the practitioner is that students are not aware of the current policies regarding tracking their data when in the classroom and using the digital spaces. This places an obstacle for the practitioner when asking to further elaborate on their privacy preferences leaving this task for the data scientist or the research team to decide.

The role of the practitioner

The practitioner worked as a facilitator to introduce the concept of data privacy to participants. The *inquire action* was intended to make students discuss their preferences in terms of data surveillance in the classroom. Giving the answer from students, the practitioner decided to not continue with the topic and mark this section as a subject for other sessions with data experts.

Effectiveness of the co-design tool (Learner/Data journey)

The focus group worked as space for participants to give an answer without the pressure of being right or wrong. Even when answers were not as detailed as expected, the open comments from students helped to better understand their position towards surveillance using nontechnical language.

5.5.3 The role of the co-design practitioner

Results shown in this section are a contribution towards RQ2What are the roles of the co-design practitioner in LA. Figure 5-26 shows a map of our research question and objective used to guide our contribution towards generate understanding on the multiple roles of the co-design practitioner leading to guidelines.

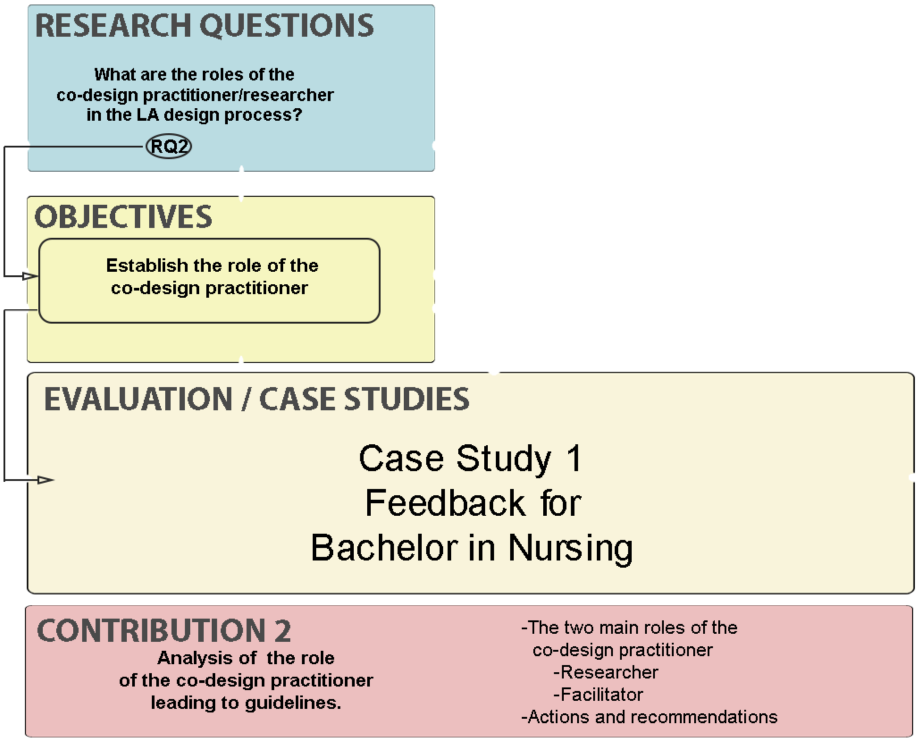


Figure 5-26: Map of contribution 2 in relation to RQ2 Emerging challenges in Co-design for LA.

5.5.3.1 Co-design practitioner as a facilitator in face-to-face sessions

When preparing for the learner/data journey activity, the co-design practitioner required to make sure to explain the objective and the rules to follow during the sessions.

In this case, participants take charge of what do and use the visual resources available for them like stickers and colour markers.

Given the novelty of this activity, the co-design practitioner had to generate a template using the nurse simulation context, this helps in making sure the visualization mimics the aesthetics of the physical space where simulations unfold. Another reason to provide a visual object like this is for participants to be able to establish their own narrative of what is happening, also, it places the sensemaking process in the hand of learners with the minimum practitioner intervention to minimize a biased conversation.

During this part of the session, the practitioner plays the role of an active observant and making sure participants follow the instructions. In some cases, as in group 3 (Figure 5-27), the practitioner makes use of emoticons as visual objects to help participants explain their rationale behind their answers. This is an example where an in deep conversation requires a visual object to fit a big narrative such as the whole experience in simulations classes.

Figure 5-27: Practitioner helping participants using visual representations as examples.

5.5.3.1.1 Representing other stakeholder as a facilitator.

During session 3 and 4 a critical event included the practitioner as a consultant for other people perspectives when talking about complex subjects like data privacy. In this case, shown in Figure 5-28, participants where interested in what other students from previous sessions answered about data privacy and showing their data to other people. The co-design practitioner responds with the best intention of giving an answer that fairly represents other people opinions. This sort of incidents can be referred to as the ethics component on what the co-design practitioners should consider. The co-design practitioner must look to benefit first learners and teachers before looking for the research team/academics interests.

Answers provided by students are completely based on what other people find acceptable since learners undeveloped data literacies play an important role in understanding data privacy. Learners trust in some degree that the practitioner is an unbiased entity that would seek for a mutual benefit by using their answer for something considered good.

Figure 5-28: Participants asking about answers given by other students on privacy.

In the end, learners trusted the co-design practitioner with information that they were not able to discuss with the academic administrator and teachers. This involves controversial topics like unprepared teachers, lack of channels to communicate learners concerns and unclear actions form the faculty to fix their issues with not getting feedback.

5.5.3.1.2 Translating findings back to other researchers and the designer.

Information gathered through multiple design sessions is stored and analysed in detail, the objective of this process is to look for relevant traits useful for the design team when stating what is the problem and how a learning analytics tool could help. The role of the co-design practitioner between stages is to summarise this information and present it back to other stakeholders involved in the project.

The co-design practitioner prepares a visualisation to help the designer navigate raw data and focus on planning the first prototype design. An example of this can be seen in Figure 5-29 with a compilation of charts ranking what learners consider most important when it comes to receiving feedback. The role of the practitioner includes a research specific part capable of presenting research findings while retaining learners voice on strategic summaries.

In this summary, it was found that some answers given by teachers match what students find useful. On the other hand, those features like Quantitative CPR information and level of stress differ to some degree with what teachers think could be useful for learners to know. The reason for this became somehow not critical to explore since agreement on at least three other features was achieved, this is considered enough work for designers to implement and the decisions were to corroborate this in future iterations with more teachers.

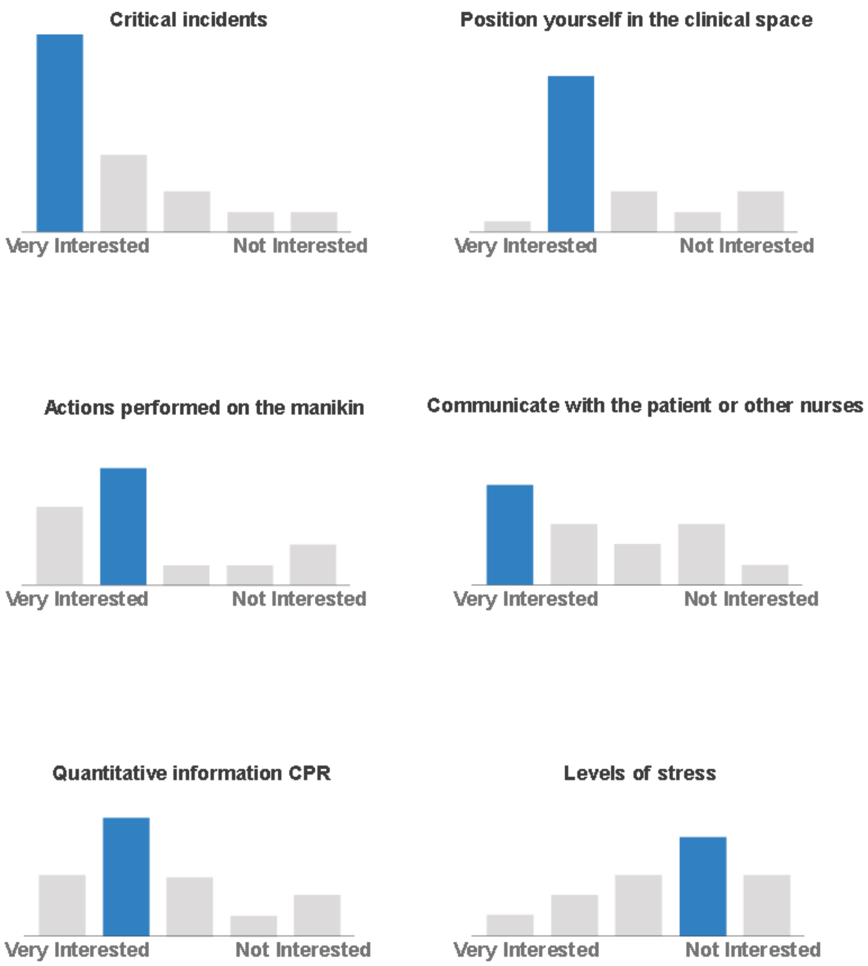


Figure 5-29: Visualisation used to summarise what learners consider of interest for feedback.

Besides using the chart summary in Figure 5-29, other findings became subject of interest in relation with the current feedback that is being received and the general sentiment towards current practices in the classroom. The reason for providing a Likert scale object is to explore the positive/negative spectrum without pushing a feeling of judgment on teachers work Figure 5-30, Figure 5-31 and Figure 5-32 were produced by the co-design practitioner to feed information back to designers. This helped the designer to understand the users general feeling towards the learning design, learning practice and sense of having a voice.

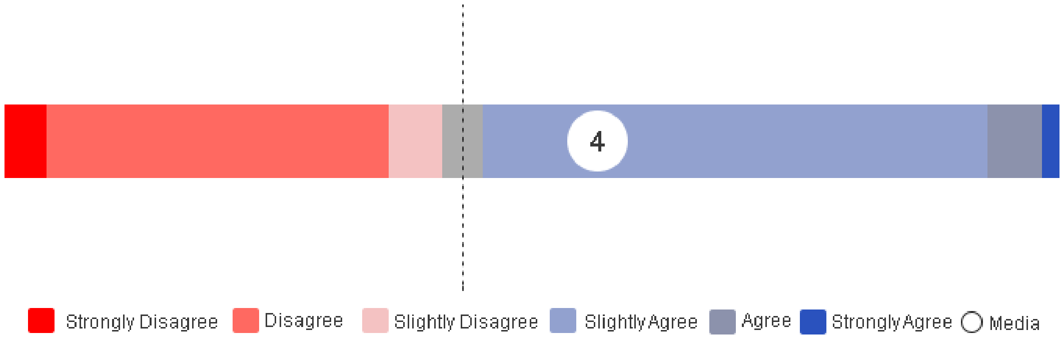


Figure 5-30: Results for the statement "I have been offered support based on the most relevant, up-to-date and accurate information the teacher could have about me"

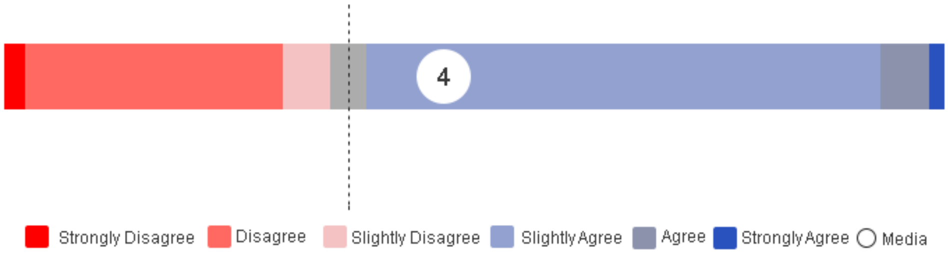


Figure 5-31: Results for the statement "I think the current feedback provided by teachers to be useful and complete"

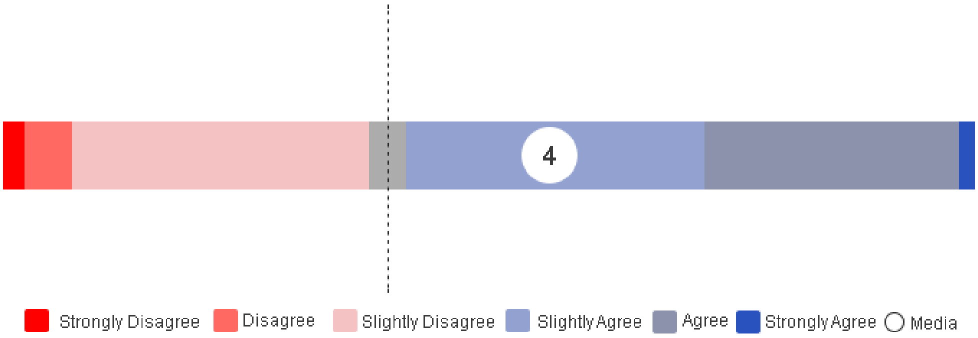


Figure 5-32: Results for the statement "I think my opinion is being heard when it comes to new changes to the simulation classes"

Outside the design and development team, part of the co-design philosophy is to keep stakeholders informed on the current finding relevant to them. The co-design practitioner produced a tree map chart explained in Figure 5-33 to summarise findings in questionnaires/surveys, transcriptions from groups sessions and transcriptions from individual sessions with teachers. The tree maps are separated into three main topics, those comments related to feedback/analytics marked in blue, comments related to team dynamics are marked in orange and comments related to the learning design/content are marked in green. The inner labels inside each category are named after emerging themes and keyword during the analysis.

This same visualisation was presented to all stakeholders while asking them to say if this information matches what they expected. Interesting answers include the agreement on what other people think is the same problem like the lack of persona feedback marked with "No personal feedback", and the need for being notified when doing a mistake "Mistakes detection" expressed by some learners *"I knew I wasn't the only one not getting time with the teacher"* (L2).

For some stakeholders, this visualization started a side conversation on the issues of having too many students or the relationship between the learning design content and the availability to provide personal feedback. In particular, teachers found the objects marked as "No clear instructions" and "Technique demonstrations" as surprising since learner where the primary source of information for these topics *"this things should be in the workbook" (T1) "Some teachers run their classes in different ways" (T2).*

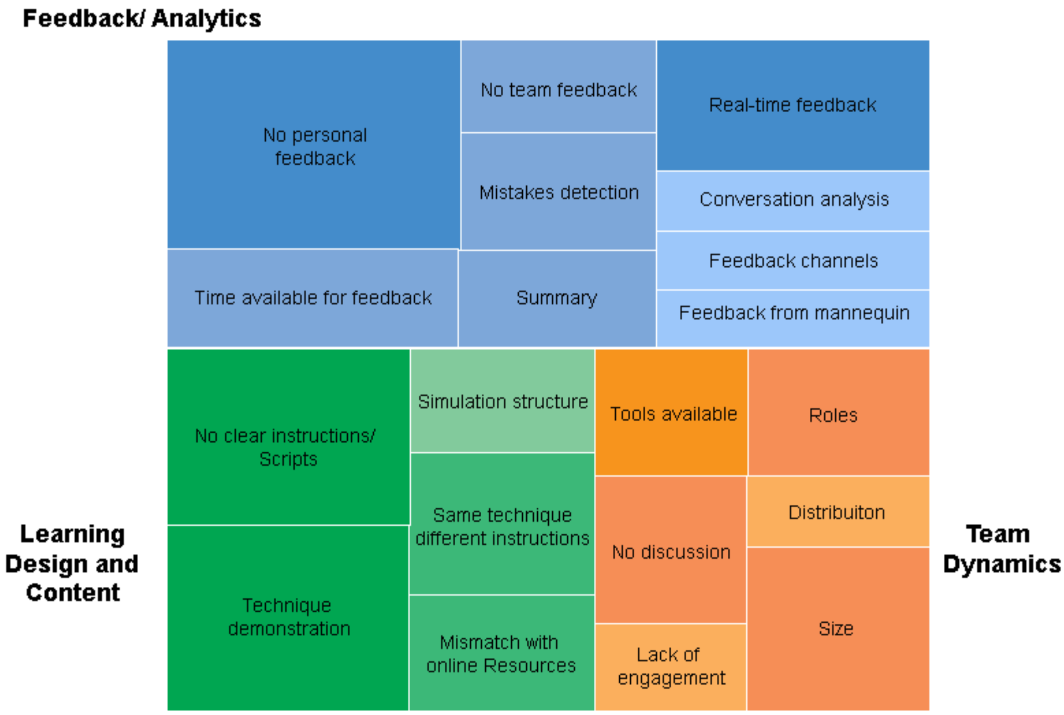


Figure 5-33: Tree map chart summarising transcription analysis for stakeholders.

By the end of this analysis, important questions in relation to stakeholders' expectations become the responsibility of the co-design practitioner. As a researcher, the co-design practitioner provided an object called a definition table (Figure 5-34) to summarize the similarities in interest from both groups (teachers and students) under the focus point area. The focus point area is intended to inform designers what should be the main issues to solve and the constraint behind them when implementing a learning analytics object.

Prioritising objectives in co-design means that someone must rank what is important to implement in the first version and what features are sent to the backlog of thing to do. The difference between a feature in the focus point area and the general topics is that focus point objects are mentioned in most conversations with teachers including their ideas on how to solve it. Objects in the general topics area such as "training teachers" are only mentioned by teachers and in some degree does not compel to the design team to solve. Objects found in the exploration area are topics mentioned by only one type of stakeholder but in some degree can be solved by the same tool.

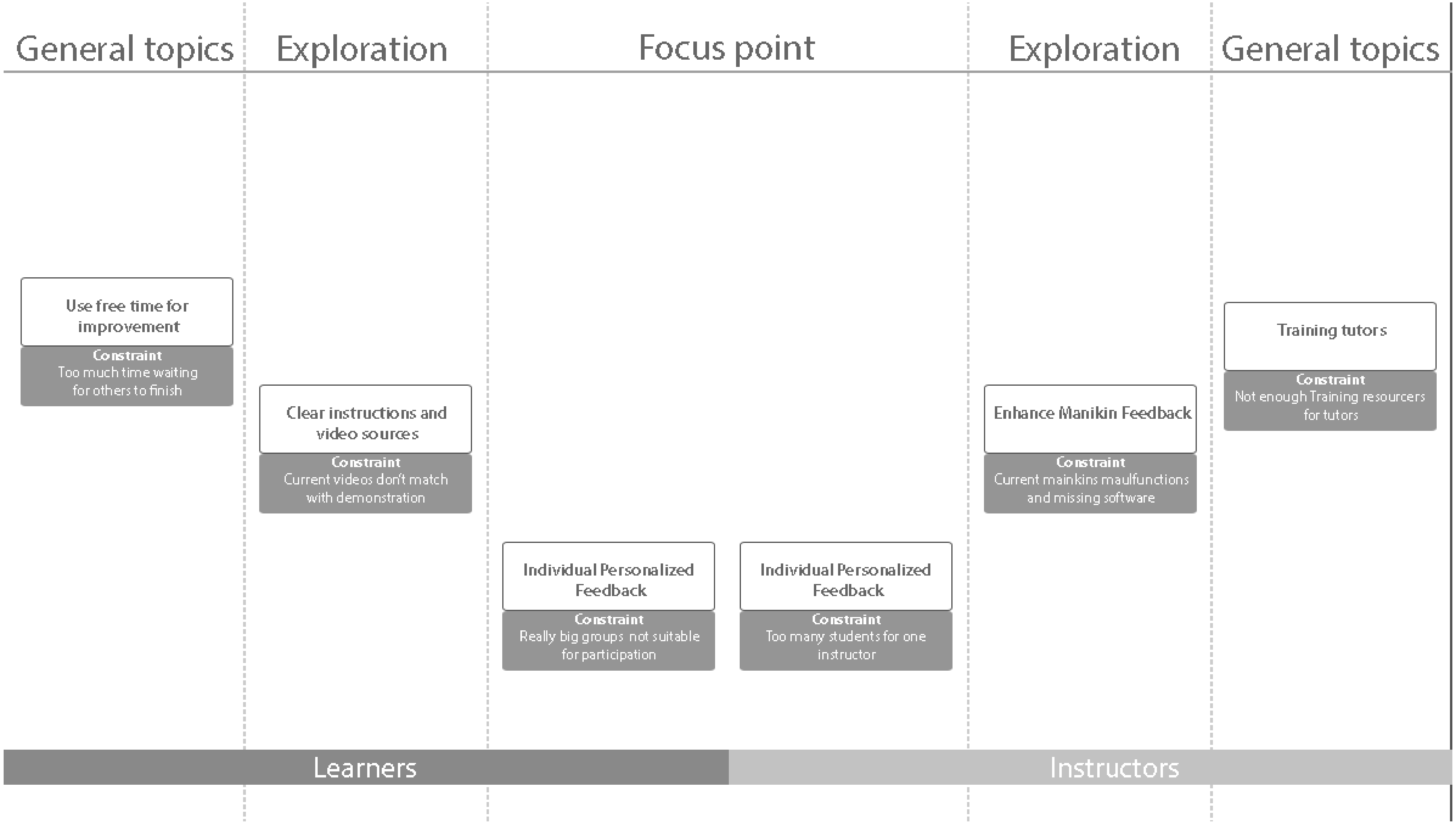


Figure 5-34: Co-design definition table.

5.5.3.1.1 Summarising findings through a visualisation

Designing the interactive learner/data journey introduced intermediate steps to what building visualization requires when the initial design evolves through data evidence. The practitioner designed the participatory visualization from multiple sessions, this places the responsibility of preserving the narrative and sensemaking from past sessions visible for everyone without missing context. Changing the technology medium from paper to a computer allowed the practitioner to overcome the main constraint of information overload using dynamic visualisations, however, this diminished the flexibility to improvise since participants relied on making hand notes to the map.

5.5.3.1.2 Co-design practitioner as a researcher for data triangulation

Data produced during the first iteration became too big for participants to navigate during sessions. The role of the co-design practitioner, in this case, is to take all sources of data an make a useful analysis for stakeholders to read and comprehend. During the synthesis process some critical events involving teachers required for triangulation of data between course material and results from the past iteration.

One example of this is when one of the teachers (who is also a learning designer in that program) became interested in corroborating what the learner/data tool shows and what is written on the students' guide. The tool shows comments where learners struggle to receive feedback at the end of the class. The teacher wanted to see if they are following what is written on the guide just to corroborate what should be happening and make notes on what can be improved in the course design (Figure 5-35). *"they seem to struggle in this part (points at map), the comments blame the lack of debrief, but the guide includes a mandatory section for this" (T2)*.

The practitioner engaged in explaining that after further analysis the problem seems to be on how teachers put this into practice, this also contradicts what the teacher thought was an issue with the current learning structure. Finding further answers to what is shown as issues through the tool requires navigating back and forth to the data sources. Even when using the same tool, participants showed interest in revisiting different things and the practitioner became responsible to answer to those questions.

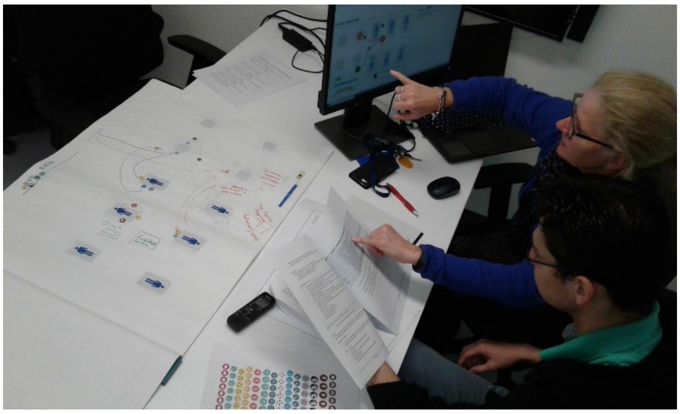


Figure 5-35: Helping a teacher to corroborate data shown in the digital tool.

5.5.3.1.3 *Co-design practitioner as a facilitator*

The practitioner plays a secondary role beyond producing visualizations to inform stakeholders. The design process keeps evolving and the practitioner oversees activities beyond design such as evaluation and management. A critical event shown in Figure 5-36 involves the co-design practitioner as a facilitator for prototype evaluation.

The protocol follows the usability test principle stating that it is recommended for the facilitator to not be the designer to avoid bias in answers. The designer delivered the prototype as a paper visualisation and the facilitator engaged with users through a think-aloud protocol. Results on the process are informed to the designer and the design process is delegated for the following iteration.

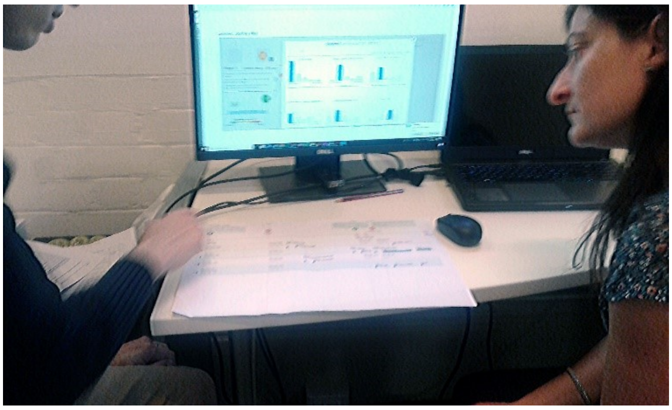


Figure 5-36: Co-design practitioner facilitating the evaluation of the first prototype.

5.5.3.1.4 *Co-design practitioner as an active consultant for designers.*

During the design of the low-fi prototype, the co-design practitioner worked as a consultant for designers to ensure information is not being taken out of context. In this case, the co-design practitioner did not engage directly with creating the feedback visualization but helped to point out user needs along the way using his criteria.

The notion of the co-design practitioner working as a proxy for participants representation became again an important role, this points to the ethical dimensions of being true to what users found beneficial and balance with what is feasible to implement.

At some point, the designer took some liberties in how to implement features in the function of the timeline object. An example of this is students requesting a visualization of their position. The expected object by students is to have a heatmap image in relation to the bed as shown to them in the first iteration. During discussions between the co-design practitioner and the designer, the agreement became that position must be represented in some way and the easiest way to implement is to add percentages. The practitioner is there to ensure a tracking position is added as requested by students and the designer is there to generate the aesthetics of the visualization.

5.5.3.1.5 Actions and emerging guidelines for co-design practitioners.

In addition to the actions noted in section 5.5.2 when describing challenges emerging from the co-design sessions, we used the knowledge art framework to identify all the actions conducted by the co-design practitioner when using the co-design techniques and interacting with stakeholders.

Table 22 shows the relevance of the Knowledge Art Framework dimensions to identify the actions in the context of collaboration between the practitioner and participants. The results column provides examples of how the actions helped the co-design process when the practitioner included these actions.

Table 22: Co-design practitioner actions emerging from interactions with stakeholders.

Framework Dimension	Action	Result
Aesthetics	**Adapt** generic templates to participants context	Personalized templates of current tools helped participants to provide feedback in their context
Ethics	**Represent** nurse students interests when their attendance to design sessions is limited.	The co-design practitioner works as a proxy for students interests when decisions on what features should be included and what data is considered private for them.
Sensemaking and improvisation	**Adapt** elements from other tools when current objects are limited by their original design and participants find hard to verbalize their thoughts.	The co-design practitioner requires to improvise by bringing examples and elements found in other tools to make sure the conversation keeps flowing.
Narrative	**Guide** conversations with stakeholders to make sure research interest are being discussed across multiple sessions.	The co-design practitioner required to shape activities along three iterations to make sure that feedback stays as the main topic. This action often required for the practitioner to guide conversations, keep participants on track to finish activities and shape questionnaires to make it relevant to researchers' interests.
Improvisation	**Improvise** when participants find difficult to use available tools. This also refers to design tools flexible enough to support participants' improvisation.	Participants found difficult to use some of the tools available when designing their journeys. Improvising by using pen and paper became the only way for them to keep the process going.
Software & Technology	**Manipulate** technology features to facilitate things for participants. Picking the right software & technology medium for	The co-design practitioner decides when to shift from paper-based tools to software applications. Initial design sessions

	generating/showing visualizations brings benefits and constraints unique to their application.	required a flexible medium such as pen and paper, but later iterations required digital tools to fit information.

5.6 Conclusions from case study 1: co-designing automated team feedback for nursing students

Findings from running co-design sessions with nursing students can be summarised following our three research questions. The following list includes insights about the adoption/adaptation co-design techniques into LA design:

- Adopting co-design techniques like focus group, card sorting and fabulation allowed nursing students to discuss their issues with the learning environment, opportunities to implement an LA solution and get information useful for teachers to improve their practice. These techniques have a better impact when used in the first stages of the design process since the co-design practitioner requires to run a contextual study in collaboration with students and teachers.
- Adopting collaborative sketch and collaborative personas allowed nursing students to have a hands-on approach to the design process without requiring expertise in LA technical topics like analytics methods and developer tools. Nursing students were able to build an interface mockup during the first iteration that informed designers of learners' expectations towards their feedback tool.
- Adapting traditional user journeys into Learner/Data Journeys allowed everyone to understand the context of the problem, pain points that could be addressed by the automated feedback tool and similarities between actions followed by students in class. . The paper-based journey is useful to collect information using common items like markers and stickers. The digital version is useful to communicate findings back to stakeholders to promote reflection.

A summary of our findings in response to the second research question concerning the role of the co-design practitioner are as follows:

- The co-design practitioner/researcher oversees setting up of the co-design process, inviting relevant stakeholders to design sessions and keeping the process on track via LA prototypes.
- There are two roles that the co-design practitioner must perform in co-design for LA: facilitator and researcher.

- The co-design practitioner performing as a researcher involves methodological tasks like analysing data produced during the sessions, making sure that the research objectives are being discussed and using existing knowledge in the field of nursing practice and analytics to support stakeholders informed decisions.
- The co-design practitioner performing as a facilitator involves actions like guiding participants during the sessions, representing other stakeholders when they cannot attend meetings, keeping the collaborative space organized, and adopting/adapting relevant techniques based on the nursing context and diversity of stakeholders.

Insights about challenges emerging when interacting with stakeholders (RQ3) can be summarised as follows:

- While nursing students clearly have to understand patient data privacy issues, surveillance and privacy about their own learning data were not topics that they were able to discuss in detail. Nursing students undeveloped data literacy impacted their ability to discuss privacy concerns, analytics methods and other learning analytics technical components.
- The nursing students were interested to change the design of simulations based on their experience of some of its limitations. Their suggestions about changes to curriculum and instruction are understandable, since they felt they had few other opportunities to have someone listen to these views.
- Leaners' undeveloped learning/teaching expertise led to some proposals that conflicted with what the teacher saw as good pedagogy.
- Power relationships were most apparent between team members, as the PhD student developing the LA system had to negotiate with the nursing academic around access to students and facilities, and the design of the empirical studies.
- DBR provided a good structure to test the co-design sessions while collecting data in relation to our research objectives. The flexibility of DBR made the adoption/adaptation process easier to maintain between sessions. However, it was necessary to structure stages (using design thinking) inside each iteration

to track the moment and place where the tool was effective, the context where it was being used and the possible ways to improve it.

6 Case Study 2: Analytics for data science student blogging

Chapter overview

This chapter describes a second case study where diverse stakeholders, part of the UTS Masters in Data Science and Innovation (MDSI) participated in a co-design project. The students and educators work on designing a learning analytics tool in a blogging platform, where students already perform tasks designed to build their "graduate attributes" (transferable competencies). The chapter starts by setting the context and describing participants' profiles, before iterating through the design process.

Each iteration provided insights into how co-design techniques can be adopted to support data science students, what challenges emerge when working with data scientists, teachers and learners; and what is the role played by the co-design practitioner when interacting with diverse stakeholders considered literate in data intensive tools like LA.

The highlights of the chapter can be summarised as follows:

1) *Focus groups, collaborative persona, collaborative sketch* and *learner journeys* helped to initiate collaboration between data science students, academics, researchers and teachers.

2) There is an opportunity for card-based design approaches to engage stakeholders in LA. The *LA-DECK* is an adaptation of card-based techniques for structuring co-design sessions between participants with diverse knowledge backgrounds. The cards provided a common language for participants to communicate their ideas and expectations required for effective LA tool design.

3) The co-design practitioner provided guidance along the co-design process by selecting which co-design techniques fit the context, which stakeholders to invite to co-design sessions, and making decisions to help advance the design process.

4) Challenges emerged as expected (from Chapter 3), particularly around *surveillance/privacy*. The practitioner sought to select the best co-design technique to help surface and resolve these concerns, making changes between sessions, and negotiating stakeholders' requirements. The results and examples in this chapter illustrate how data science students were able to negotiate their privacy concerns in detail and provide insights on the analytics methods.

This study involves 3 main iterations where learners, teachers, researchers and other stakeholders interacted using a range of adopted/adapted generative tools. The new tools introduce in this study is an adapted concept of design cards described in section 6.3.5 under the name LA-DECK, also, it includes a revised implementation of adopted tools previously used in 0 such as focus groups, collaborative persona profile, sketching and learner journeys. The final section presents a series of findings contributing to a better understanding of the research questions, but in the distinctive context of data science education where the participants are highly data literate, namely, 1) the challenges of co-design for learning analytics, 2) the effectiveness of the proposed co-design techniques, and 3) the role of the co-design practitioner.

6.1 Context and Stakeholders

This study was conducted as part of a project to create a learning analytics tool for *Graduate Attribute* development (explained below). The current tools used by students provided a limited but well-received help for new and senior students on the program. However, there was a need for new tools starting for the current learning analytics component of a blogging platform called *CIC Around* offered by the University of Technology Sydney. Teachers used this platform to help students improve graduate attributes, transferable, professional skills including complex system thinking, creative sensemaking, problem-solving skills, communication and ethical leadership (detailed in Table 23).

Table 23: Graduate attributes addressed in the data science Masters program.

Graduate Attribute	Description
1- Complex systems thinking	1.1 Identify and represent the components and processes within complex systems and organise them within frameworks of relationships 1.2 Explore and test models and generalisations for describing the behaviour of complex systems and selecting data sources, taking into account the needs and values of different contexts and stakeholders 1.3 Analyse the value of different models and generalisations, about the behaviour of particular complex systems, for making predictions and informing data discovery investigations
2- Creative, analytical and rigorous sense making	2.1 Engage with and critique contemporary trends and theoretical frameworks in data science for relevance in their own practice 2.2 Be proficient in exploring, analysing, manipulating, interpreting and visualising data using data science techniques, software and technologies to make sense of data rich environments 2.3 Understand and deal critically with the uncertainty, ambiguity and complexity associated with comprehensive, extraneous and incomplete data 2.4 Apply and assess data science concepts, theories, practices and tools for designing and managing data discovery investigations in professional environments that draw upon diverse data sources
3- Create value in problem solving and inquiry	3.1 Explore, interrogate, generate, apply, test and evaluate problem solving strategies to extract economic, social, strategic or other value from big data 3.2 Critically examine, articulate and appreciate the speculative or actual value of data analytics outcomes for different stakeholders, whether at a societal, industrial, organisational, group or individual level
4- Persuasive and robust communication	4.1 Explore and craft interpretative narratives that engage key audiences with data analytics and potential significance for action, whether at a societal, industrial, organisational, group or individual level 4.2 Identify and develop communication skills needed for working in a data science team to successfully deliver complex data projects 4.3 Develop, test, justify and deliver data project propositions, methodologies, analytics outcomes and recommendations for informing decision-making, both to specialist and non-specialist audiences.
5- Ethical citizenship and leadership	5.1 Interrogate and appreciate the ethical responsibilities related to data collection, access, storage and distribution 5.2 Take a leadership role in recognising and addressing individual, organisational and community issues concerning all aspects of data science and its outcomes.

Students sought to improve their graduate attributes through writing reflectively about their learning, sharing the outcome within the MDSI community of students, academics and industry partners. Data on blog posts and conversations were gathered but not used via analytics to support teaching or learning, other than through a simple timeline. The desire to improve feedback to students and teachers using analytics tools was set as the overall objective starting with a series of design sessions organised to bring together different stakeholders to define needs, ideas and product specifications.

The following Figure 6-1 shows the map of the three research questions that will be tracked in this chapter as the second case study. Findings and contributions will be later discussed using the map, to demonstrate how all of the research questions are being addressed, linking evidence shown in the multiple iterations.

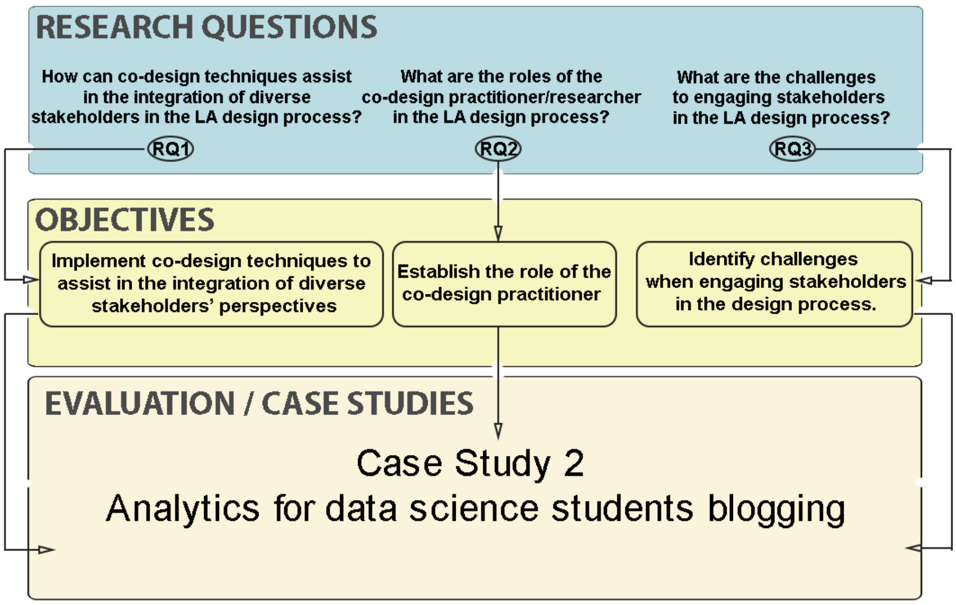


Figure 6-1: Map of the questions and objectives followed in this chapter.

6.2 Study Design

The duration of each session was scheduled, and completed, in 60 minutes. In addition to the facilitator, different configurations of stakeholders attended based on their availability. The selection of stakeholders from different departments helped to ensure a diversity of perspectives when engaging with design objects. Stakeholders and group distribution are shown in Table 24 adding the initials used to identify them through this chapter.

Table 24: Stakeholder distribution part of the case study.

Role	Description	Participants	Groups
Learners (L)	Currently enrolled in the first and second semester of MDSI	15	7
Teachers (T)	Including mentors/teachers in any simulation-based classes.	7	8
Learning designers (LD)	Responsible for giving structure to the pedagogic content and strategies followed during classes.	5	5
Developers (Dev)	Responsible for coding and IT support for the current tools.	2	2
Co-design Practitioner (CP)	Responsible for organizing, guiding, facilitating and orchestrating design sessions through co-design.	2	5
Course Director (CD)	Responsible for management and design of all courses in the MDSI program.	1	1
Data expert (DS)	Researcher with experience in data and analytics practice applied to learning.	3	3

The following sections start with a first iteration used to generate understanding and explore the current issues/practices of new and senior MDSI students and then explained the second iteration as a continuation for the LA project.

For each iteration, the researcher oversaw producing the design materials, become a facilitator, guided participants across all co-design session and conducted the analysis for data gathered from stakeholders' interactions. This same approach followed in the first case study brought consistency across the multiple iterations and improved building better relationships with stakeholders.

6.2.1 Case study 2: Iteration 1 Graduate attributes, blogging and MDSI

This first iteration includes 3 main stages using an upstream approach to generate a new tool without limiting learners to previous systems capabilities. During this part, participants collaborate following the methodology described in section 0, iterations are intended to be short and with the intention of letting students express themselves through the design tools until overall agreement/understanding is achieved according to the researcher objectives. Table 25 describes the overall number of participants and the profile description used for recruiting.

Table 25: Stakeholder distribution invited for iteration 1 case study 1.

Role	Description	Participants	Groups
Novice Learners (NL)	Currently enrolled in the first and second semester of MDSI	5	1
Senior Learners (SL)	Currently enrolled in the third and fourth semester of MDSI.	5	1
Co-design Practitioner (CP)	Responsible for organizing, guiding, facilitate and orchestrate design sessions through co-design.	1	2

For each stage multiple techniques where adopted based on the research goals (further explanation in the following section), participants availability and research objectives. Participants invited for this study were separated into two groups with one group assembled by new learners (5) and the other group set up with senior students (5). Students were invited through an open call for participation for a 60 minute session. Both groups described in Table 25 were invited to all activities to ensure continuity and consistency during the case study. The other participant was the co-design practitioner who provides guidance and assistance through the whole sessions.

For both groups the stages followed were conducted in the same order as described in Figure 6-2 using the following description:

Stage 1 Understand graduate attributes development: A first stage to invite students to explain the current practices, tools and techniques used to track their graduate attributes development path. For this part, the co-design practitioner facilitated focus group design sessions, and a collaborative persona profile activity for user modelling, similar to the one used in case study 1 (Sec.5.3.4), plus a card sorting activity for participants to share current problems in the course.

Stage 2 Create possible solutions: For this stage, both groups engaged with collaborative sketching activities and the further definition of opportunities when implementing a new learning analytics tool. In this stage, the co-design practitioner adapted a collaborative version of Learner/Data Journeys allowing students to describe their daily routine as an MDSI student. Once the group had identified opportunities where a learning analytics tool could make an impact, learners moved to generate ideas through sketching desirable features for the tool.

Stage 3 Deliver a sketch for graduate attributes development: In this stage, learners comment and revised the outcome produce in stage 2 as a low fidelity sketch. The evaluation follows a simple protocol using post-study surveys ranking satisfaction, desirability and further comments on the process.

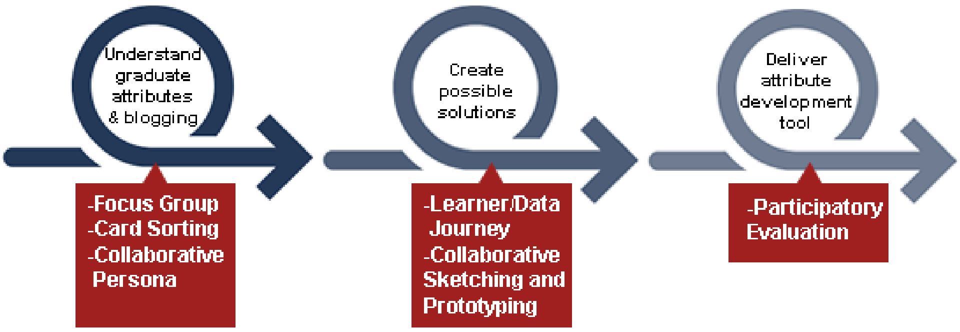


Figure 6-2: Stages and tools used for Iteration 1 with MDSI participants.

Analysis of the results was interpreted through video and audio transcriptions from the sessions in addition to survey responses provided after each session. Transcriptions were analysed using the coding scheme detailed in section 4.3.1, following the methodology for data analysis explained in section 3.2.

Giving that transcriptions can be limited by their source availability, it is important to triangulate findings with other data sources. Individual survey responses, and the co-design practitioner's notes on critical incidents were drawn on to supplement and validate the transcripts.

6.2.2 Case study 2: Iteration 2[2] Using a card-based approach to co-design

Results from the first iteration revealed the need for a new learning analytics tools but also helped us to understand the emerging challenges that emerge when bringing co-design for a data literate audience. For this second iteration, results and design outcomes

[2] Peer-review version published in: Carlos G. Prieto-Alvarez, et al. (2020). LA-DECK: A card-based learning analytics co-design tool. 10th International Conference on Learning Analytics and Knowledge LAK20. Frankfurt, Germany., ACM.

are used to inform other stakeholders when building a learning analytics component acknowledging mostly learners and teachers as the main users. The following sections explained the details of this study, the new set of participants and the introduction of a newly adapted tool called LA-DECK.

The objective of this iteration is to advance our learning analytics component based on the current CIC around blogging platform. For this part of the study, multiple stakeholders were invited through a short-list open to people with experience in using the

This study was conducted in the authentic context of a master's course in Data Science, offered by the UTS. Students use a blogging platform to share their reflections within the community of students, academics and industry partners, while teachers use it to help students improve their writing/communication skills and demonstrate their learning through specific writing tasks. Data on user activity including blog posts and conversations were aggregated on a timeline, but there were no other analytics to support teaching or learning. A series of design sessions was organised to bring together different stakeholders to define needs and generate ideas about potential social learning analytics to enhance their experience. Our study focuses on four of these sessions.

Table 26: Stakeholder distribution part of the case study.

Role	Description	Participants	Groups
Learners (L)	Currently enrolled in first and second semester of MDSI	12	5
Teachers (T)	Including mentors/teachers in any simulation-based classes.	4	4
Learning designers (LD)	Responsible of giving structure to the pedagogic content and strategies followed during classes.	1	1
Developers (Dev)	Responsible of coding and IT support for the current tools.	2	2
Co-design Practitioner (CP)	Responsible of organizing, guiding, facilitate and orchestrate design sessions through co-design.	1	1
Course Director (CD)	Responsible of management and design for all courses part of the MDSI program.	1	1
Data expert (DS)	Researcher with experience in data and analytics practice applied to learning.	2	2

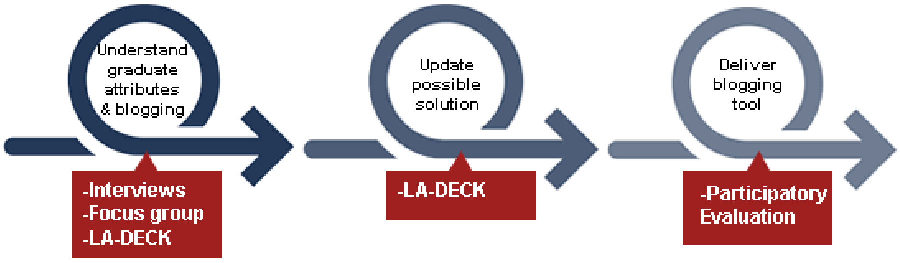


Figure 6-3: Stages and tools used for Iteration 2 with MDSI participants.

6.2.3 Further evidence on the LA-DECK from other design teams.

The following study aims to further test the capabilities of the LA-DECK when used in another context with diverse stakeholders. This section is structured by following the characteristics of the last iteration but is described as an experiment since we consider these results as an extension of iteration 2.

For this study, we invited 17 people to a co-design workshop with the intention of introducing the LA-DECK to design teams in learning analytics. The workshop was conducted during the Australia Learning Analytics Sumer Institute (ALASI) where practitioners and academics from other universities discuss the new trends in the field.

The invitation to participate in the workshop did not require to have experience in design. The invitation remained open to anyone interested in using the LA-DECK to promote collaboration in their current LA projects. As seen in Table 27, people enrolled in the workshop come from diverse technical backgrounds and were separated into 4 different groups

Table 27: Stakeholders invited to the ALASI co-design workshop with the LA-DECK

Role	Description	Participants	teams
Teachers (T)	Including mentors/teachers in any simulation-based classes.	4	4
Learning designers (LD)	Responsible for giving structure to the pedagogic content and strategies followed during classes.	6	4
Developers (Dev)	Responsible for coding and IT support for the current tools.	1	1

Data expert (DS)	Researcher with experience in data and analytics practice applied to learning.	6	4

In this session, we invited people to work in their current learning analytics projects and use the cards as explained in the introduction. The result is that each group invited only people related to the project and the context is specific to their current development process. Table 28 describes the size of each group and the projects description according to their participants.

Table 28: Groups and projects described by participants when using the LA-DECK.

Team	Size	Projects as described by participants
1	5	*"How we can support students with unevenly distributed assessment. So that it doesn't happen that students always have three, or more than three assessments due in the same week, so that's the challenge."*
2	4	*"We worked from e-portfolios, workplace learning, big stuff going on and the sorts of things that we're being asked at the moment is, can you give us analytics that help with workplace learning and e-portfolios? So, we set that as our little task. So, look. So, why do people use the e-portfolios and why do we think it's good for students to show the learning? Because that's something that I'm thinking about translating into an analytics story as well."*
3	4	*"Well I guess for us, we were talking about how learning analytic dashboards and schemers could feature within a broader approach that involved conversation with peers, that involves situated practices. So, in this example, what we wanted to do was provide some kind of at a glance resource to help academic staff reflect on what their practices are with the use of the virtual learning environment."*
4	4	*"We're kind of at that stage where the project is happening to conceptualise what learning strategies look like and Brad is actually leading that project. And then we kind of had two teachers in the team, so we're very focused on the practical problem that we could solve and then him coming in as a sort of learning analyst perspective."*

The session lasted 60 minutes and concluded with a post-interview with the team. The interview was used to collect data on the effectiveness of the cards, challenges emerging when using them and changes suggested to improve the current version.

6.3 Co-design techniques

This section details which co-design techniques were adopted or adapted from existing co-design practice, the purpose of the techniques and their application through the case study. Table 29 maps the techniques adopted and adapted for each iteration with the analysis techniques used to measure their effectiveness. The selection of this co-design techniques is based on their use in similar fields and their flexibility to be adopted into the LA co-design process. Each tool is being described in the following sections including description of the tool and their purpose in learning analytics design.

Table 29: Mapping iterations and techniques for case study 2.

Iteration	Co-design techniques	Analysis technique
1	**Adopt:** Collaborative Sketch, Focus Group **Adapt:** Collaborative Personas, Learner/Data journey	Critical incidents, Survey design, Thematic analysis, Knowledge art framework.
2	**Adopt:** Focus group **Adapt:** LA DECK	Findings triangulation, Critical incidents, Survey design, Thematic analysis.

6.3.1 Adopted: Focus Group

Description: This technique is adopted as described before in section 5.3.1 with some minor changes when applying to this case study. The implementation of the focus group as a design technique is to set up structured meetings for learners to provide insights on the current learning experience. The settings for this session require preparation of the following components:

Script: A predefined dialogue structure to encourage participants to contribute. The purpose of having a script to follow is to structure conversations towards issues related to experiences as a student part of the MDSI program, also, it helps to avoid vague answers and generalizations. The script followed for this activity included questions related to personal experiences in developing their graduate attributes, the challenges of being a new student and personal opinions on the current tools available for students.

Planned activities: A list of planned activities used to inform students on the purpose of the session, the time expected for each activity, the definition of the tasks and instructions to follow when engaging with the design tasks.

Survey: A set of questions to allow students to provide further feedback through a personal voice. This questionnaire was also used to evaluate the effectiveness and comments of the activities during the sessions.

The purpose of the focus group in learning analytics design is to provide a guided conversation and ensure that subjects of interest are being discussed. The adoption of the technique also works on the spirit of allowing students to have open conversations without peer pressure or existing persuasion that may happen when talking about bad experiences in front of teachers.

Another modification to this technique is the strategic merge with other tools and techniques used along the stage. When opening the conversation with participants, tools like the collaborative persona profile (described below) can be explored without breaking the flow of the conversation. The co-design practitioner can jump back to the original enquiry and changing the nature of the initial questions based on the recent partial findings.

6.3.2 Adopted: Collaborative Persona Profile

Description: This adopted tool follows the description provided in the past chapter (section 5.3.4) with some minimal changes to reflect the current context of the case study. A collaborative persona profile in this scenario is used as a design activity for students to generate a personification of a common MDSI student. This activity helps to create a model for everyone to refer and agree when user representation is needed.

The process of generating the model is as important as the visual outcome. When participants are describing the main traits of MDSI students, they mostly use their own experiences to discuss similarities with other participants. At this point, the researcher/designer collects useful information to determine how diverse users can be.

There are simple templates that can be used to generate a collaborative persona profile but, in this case, a personalized template was used to allow participants fill out with their own content including:

Basic information: This field contains demographics related to a common MDSI student. This information requires agreement towards common knowledge background that an MDSI student may have and the current semester enrolled

Like/Preferred tech tools: This section asks learners to describe their preferences in terms of tools used for studying. This also refers to devices and platforms such as LMS, Webtools or any other software/hardware component. In this version, it allows adding social media platform since some activities seem to be organized through them.

Dislike: This field allows participants to express the unpopular opinion in terms of learning tools. It also can list those social media websites that most students avoid while discussing the pros/cons of using them.

Expectations: This section is one of the most useful specifications for the system. It provides an overview of what the persona expects and wants from the learning analytics tool. An explicit statement of expectations may be helpful in scenarios where prototypes are being tested. The purpose of this profile is to create as much understanding as possible and provide support in the design of a learning analytics tool that truly fulfils the actors' expectations.

Learning goals: Aligned with the expectations, learners have their own learning goals that can be compared with the teacher's goal definition. These can range from very general (such as learning how to communicate) to more specific (such as becoming a good data scientist).

In learning analytics design the collaborative persona profile is used for reference for designers and researchers when generating usage scenarios based on learners' preferences.

6.3.3 Adopted: Collaborative sketching and prototyping

Definition: This adopted technique implements the original description found in section 5.3.5 with changes added to the material used during the sessions and steps followed by participants. In traditional sketch/prototyping users make use of pen and paper to draw on ideas, concepts or visual components. Using only pen and paper for this puts some limitations linked to participants drawing skills and clarity of their toughs.

Purpose in designing for learning analytics: A learning analytics tool requires multiple components to design that departs from traditional user interfaces since the data component takes most of the attention. Participants must find a way to clarify their needs through visual components for everyone else in the group to understand. Sometimes learners may have a clear idea of what they expect and how it looks, but their needs may change when they discuss the idea in detail with other people facing the same circumstances. Visual cues are easier to understand and the process that takes from one learner needs to build the first working prototype benefits from a flexible technique such as collaborative sketches.

The sketch activity used in this session invited participants to put together a mock-up of the expected tool by using predefined objects available on the table. Visualizations were printed and made available for them to move around to fit their envisioning of the tool. As seen in Figure 6-4, examples available do not describe specific data and only represent the elements of the visualization. An example of this would be a learner picking the Radial Bar Chart to describe their current progress on graduate attributes.

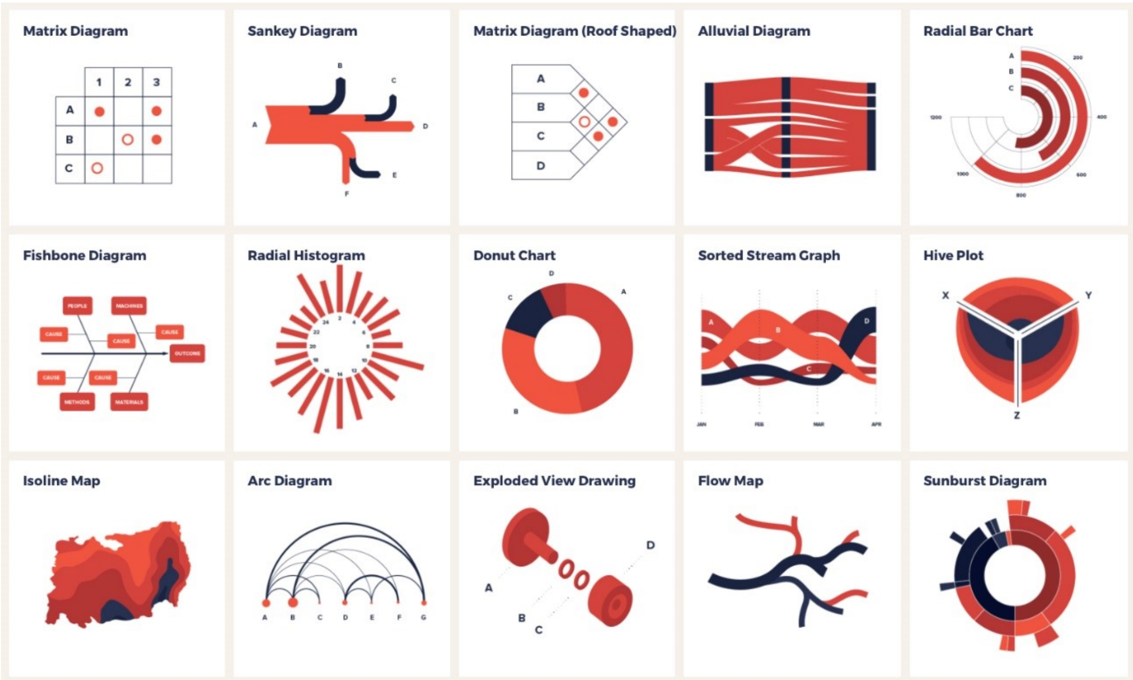


Figure 6-4: Examples of data visualizations printed for participants to use.

Figure 6-5 shows the components distributed on the table. Each set of chart examples are unique to each participant in order to increase communication. In this point, learners must discuss and negotiate the options available and use hand draw notes when required. The difference between traditional implementation of sketching is that all decisions and changes are being made in collaboration in front of everyone. Decisions must be made in place and time making people to think in terms of short tasks used as design deliverables for the session.

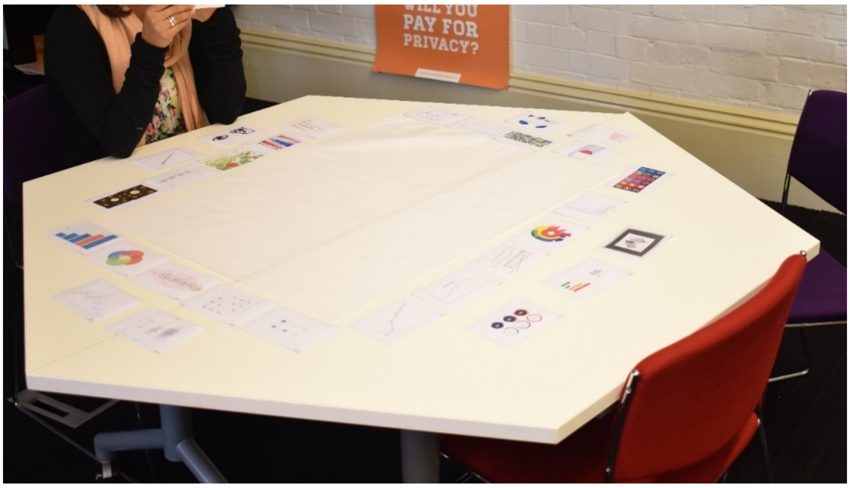


Figure 6-5: Sketch mock-up activity with MDSI students.

6.3.4 Adapted: Learner Journeys

Definition: Setting a common vision and sharing the same goals across stakeholders can be a difficult task if the co-design practitioner cannot understand the context where the analytic tool will be used. Learner journeys can help to generate an image of the whole learning or usage process (Mears, 2017). A Co-design implementation of this requires some simple elements so participants can build their own journey. These elements are:

Context: Specify where the users are (e.g., classroom, home, library, etc.) and what is around them (monitors, books, desks, etc.). This can also include any external factors, which may be distracting them.

Progression: How every step is connected and any other possible connection that occurs at the same time.

Emotion: Emotions are an important part of interaction design. Actors can experience different emotions and these should be assigned to every step (like concern, engaged, bored, annoyed, anxious or satisfied).

Devices: The devices being used by the users at any moment, optionally including their level of expertise and the device's technical capabilities.

Functionality: Learners and educators can specify what functions they are expecting from the learning analytics system.

Data interaction: Define if any data is required at a given step, for instance, a search query, saving data, a software update, making sense of a visualisation.

Purpose in designing learning analytics: This technique can help to identify possible functionality at a high level by understanding the key tasks that need to be accomplished by learners. This representation can help designers understand learner behaviour and how users are going to interact with the learning analytics system. On the same journey representation, we can add where learners interact with data and what kind of information they get in order to help them achieve their goals. In this case, interaction design can help to identify the flow of information and the nature of context where learners may use the learning analytics tool (Mendiburo, Sulcer, & Hasselbring, 2014).

The output of this activity allows participants to produce a visualisation over time for different learning scenarios. Learners are able to map their experience with the current process and researchers can use this information to set better scenarios where the learning analytics tool can be used.

6.3.5 Adapted: LA-DECK[3]

There are a few examples of implementing co-design techniques in LA particularly tailored to the design of data-rich educational technologies. For example, Holstein et al (Holstein K, et al., 2019) document *replay enactments* to allow teachers to experience different representations of data in order for them to provide early feedback. Prieto et al. (Luis Pablo Prieto et al., 2018) propose an approach that includes a series of questions that can be used with different stakeholders (namely teachers, researchers and developers) to externalise their views on learning, data and technology, and comment on others' perspectives.

Notably, most case studies involve teachers, researchers or developers, but students have remained conspicuously absent. An exception is the adaptation of general co-design techniques (e.g. focus groups, storyboarding, persona profiling, and prototyping) for students to create representations of their own activity that can be used by developers to design LA systems.

The concept of using *cards* for stakeholder engagement is a relatively new technique used by designers to provide a structure for ideation (Kwiatkowska, Szostek,

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[3] Peer-review version published in: Carlos G. Prieto-Alvarez, et al. (2020). LA-DECK: A card-based learning analytics co-design tool. 10th International Conference on Learning Analytics and Knowledge LAK20. Frankfurt, Germany., ACM.

& Lamas, 2014), and make the design process more inclusive through a familiar game metaphor. In the area of Learning Design, this approach has been embraced with the purpose of co-designing pedagogical strategies and tools with key stakeholders according to the specific educational context. Examples of these include *Learning Battle* cards, for designing blended learning experiences (Team, 2016), and *Tango* cards for designing educational tangibles (Deng, Antle, & Neustaedter, 2014), but there are many more, collated at Deckaholic library (DECKAHOLIC, 2019) and critically reviewed in (Roy & Warren, 2019).

6.3.5.1 LA-DECK Design

Inspired by card-based approaches, such as those reviewed above, this section proposes a prototyped deck of *Learning Analytics Design* cards (LA-DECK). The analysis provided in Roy and Warren's review of 155 card-based toolkits (Roy & Warren, 2019) shows that an effective card-based approach for design starts with a scaffolded procedure and rules for operation before getting into the visual design. Designing LA-DECK therefore required choices about the key dimensions for operation that the deck should foreground. The LA literature provides several frameworks recommending key considerations for designing and deploying LA, varying depending on the stakeholder groups being targeted, and the framework's purpose (Wolfgang Greller, 2012). While there can be no single, correct framework, there is clearly consensus within the field on some of the key considerations that should be taken into account. The rationale for choosing the 'language' of the cards was thus grounded in a combination of *pragmatics* and *values*. *Pragmatics* refers to common-sense notions derived from the nature of software design (e.g. we cannot design LA without talking about data; since we want students to co-design LA tools that they will use, we have to talk about user interfaces). *Values* are derived from the team's values, as well as from the literature (e.g. data privacy is important; since we want to engage educators, we need to talk about the desired learning objectives). Table 30 summarises sources related to each of the initial dimensions.

Table 30: Sources in LA research motivating the design dimensions expressed in LA-DECK

Dimension	Reference
Data Source, Analytics Type, Developer Tools	(Bakharia et al., 2016; Chatti, Dyckhoff, Schroeder, & Thüs, 2012; Chatti et al., 2014; G. Morgan, 2016; Pardo, Jovanovic, Dawson, Gašević, & Mirriahi, 2019; E. B. N. Sanders & Stappers, 2014)
Testing Site, User Interface	[25; 29]
Privacy and ethics	(Pardo & Siemens, 2014; Slade & Prinsloo, 2013)
Analytics Methods	(Hox, Moerbeek, & van de Schoot, 2010; Khalil & Ebner, 2016)
Learning context and objective	(Hernández-Leo et al., 2019)

The rationale for this organisation is aligned with the notion of breaking the design process into small meaningful components, as has been done in other design card decks (Deng et al., 2014; Team, 2016). Scaffolding the design process into a workable number of dimensions builds on recommended principles for producing a design plan when working with interdisciplinary teams (Münch et al., 2013).

6.3.5.2 Card themes, suits, and designs

Based on our co-design model, we defined eight card 'suits' grouped broadly into three main themes:

Context: Learning Objective (LO), Testing Site (TS)

Strategy: Analytics Type (AT), Data Source (DS), Analytics Method (AM), Privacy (PR)

Action: User Interface (UI), Developer Tools (Dev).

Each suit includes cards following a consistent design including colour, name, icon, and (an optional) description (see Figure 6-6and Figure 6-7). The full deck has 40 cards plus Wildcards for participants to write on them as a way to extend the deck if needed (see Figure 6-6 for examples). Additionally, two types of Resource tokens are provided for participants to estimate the time and money required to implement certain parts of the design.

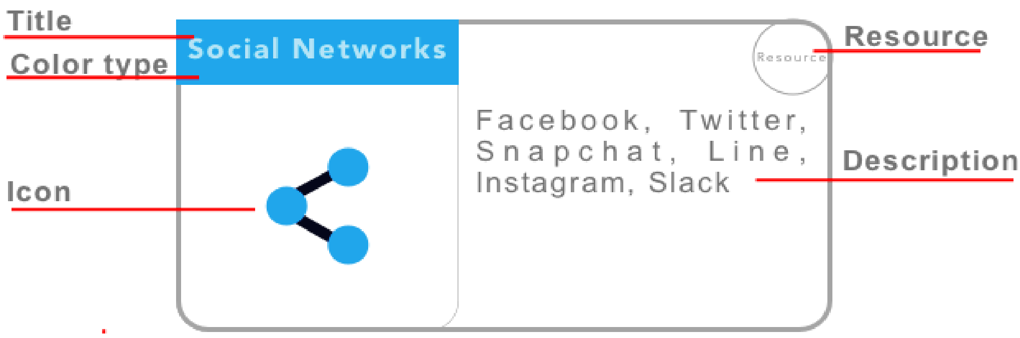


Figure 6-6: Card structure.

As discussed earlier, the choice of cards is a partly based on pragmatic considerations, such as the target stakeholders and the design context. This meant for instance, that there was no card for *Policy* in this first design, although clearly this would be important if we were engaging senior leaders around organisational strategy (cf. (Tsai et al., 2018)). A printable copy of the cards is available through the LA-DECK website [http://ladeck.utscic.edu.au/]. We now describe each suit in more detail.

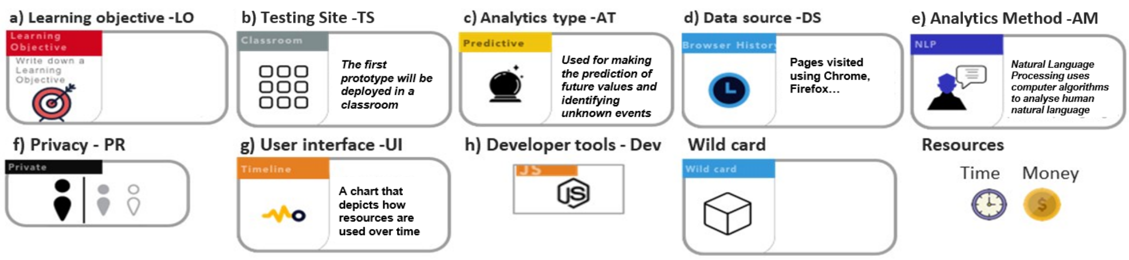


Figure 6-7: Examples of LA-DECK cards.

6.3.5.3 *Context cards*

Learning objective cards (LO-red): This suit was designed to help participants reach agreement on the learning context, by writing down the learning objective(s) that the envisaged LA tool should target. Ideally, the point of departure would be the teacher's explicit learning design, to bridge the gap between the LA outcome and the pedagogical intention (Bakharia et al., 2016), but of course, this might become the focus for conversation. The cards in this suit are *Subject Learning Outcome* (SLO), *Teacher Objective* and *Learning Task*. These provide participants with different options for specificity as the cards are left blank for completion in writing (e.g. see Figure 6-7a).

Testing site cards (TS-grey): The cards within this suit can be related to both context and action. They refer to the unit of analysis for deployment of the LA system, including *individual, small-group, classroom* and *faculty levels.* The selected level(s) would drive the design of the tool but would typically have implications for the logistics that need to be in place to deploy the LA system. Figure 6-7b shows the grey card corresponding to the *classroom level*: "*The first prototype will be deployed in a classroom*".

6.3.5.4 Strategy cards

Analytics type cards (AT-yellow): This suit permits participants to choose the type of analytics envisioned to support learning. Based on classic data science literature (Kaisler, Armour, Espinosa, & Money, 2013) we provide cards for *Descriptive, Prescriptive, Diagnostic* and *Predictive* analytics. For example, Figure 6-7c shows the yellow *Predictive Analytics* card: "*Used for making the prediction of future values and identifying unknown events*".

Data source cards (DS-blue): This suit provides participants with common examples of data sources following current practices in the LA field (G. Morgan, 2016). We provide cards including *blogging activity, LMS data, chat conversations, browser history, social network activity* and *marking results.* For example, Figure 6-7d depicts the blue card corresponding to *browser history*: "*Pages visited using Chrome, Firefox…".*

Analytics method cards (AM-purple): This suit synthesises common techniques and methods used to analyse data (Hox et al., 2010). Cards available in this suit include both general and specific methods that can complement each other, including *machine learning, classification tree, cluster analysis, neural networks, text analysis, regression analysis, spatial analysis, NLP, sentiment analysis, supervised learning, association rule* and ten additional cards. Figure 6-7e depicts the *NLP* card: *"Natural Language Processing uses computer algorithms to analyse human natural language".*

Privacy cards (PR-black): This suit provides examples of privacy configuration used in common information systems (Slade & Prinsloo, 2015). Cards in this suit include *private, public, share with group, share with friends, share with extended network* and *share with specific people.* Figure 6-7f shows the *private* accompanied with an icon representing the concept.

6.3.5.5 Action cards

User interface cards (UI-orange): This suit includes examples of user interface objects common in LA projects. Envisioning how the interface should look like can help participants to place the design object in context and use. Cards in this suit include a *dashboard, timeline, table, report* and *charts.* In Figure 6-7g we depict the orange *timeline* card: *"A chart that depicts how resources are used over time"*.

Developer tools cards (Dev-orange): Current capabilities that may be required to support the LA system should be discussed when the intended interface is being selected, so technology and back-end components specification are available through this suit, with common development technologies used by developers such as *JavaScript, Python, MySQL, R, PHP, Java* and *WordPress.* In Figure 6-7h we depict the orange *JavaScript* card with the familiar icon.

Wildcards: Following the familiar gaming device of the wildcard that can be assigned many powers, participants are encouraged to generate new ideas outside the set of cards provided. This is achieved by writing on a wildcard specified with a colour related to any of the suits or inventing something completely different that is important to represent. Figure 6-7 shows an example wild card for the *Data sources* suit.

Resources: Finally, tokens are provided for participants to negotiate the relative priority of different ideas in terms of where they would assign *Time* and *Money* (Figure 6-7f). Alternatively, participants might choose to use the tokens to show the trade-offs between design options.

6.3.5.6 Layout

An initial layout is proposed to help participants place the cards in a basic sequence (Figure 6-8: Initial layout for LA-DECK sequence.). The LA-DECK is designed to allow participants to follow their own path. However, we wanted to test the use of pre-defined arrangements as other cards approaches use. Each column is linked to one suit and suggests a progression from the learning context, through to evaluation of the tool. This was later proven to not be useful since it adds constraints to the ongoing conversation between participants. (See also Section 7.4 which discusses the structuring affordances of cards.)

Figure 6-8: Initial layout for LA-DECK sequence.

6.3.5.7 Using the cards with Stakeholders

The design session was set up around a circular or symmetric table, offering everyone similar opportunities for participation. The objective of each session was clarified from the beginning by the facilitator of the session. If it is not possible to write on the table, the cards can be placed on a large piece of paper for participants to be able to write inside and around the cards, make connections, and add other comments.

Sessions are structured by the following ‘rules of the game’:

1) Each stakeholder starts with his/her own complete deck, so they can in principle have a voice in any aspect of the design.

2) Each player is instructed that they can ‘play’ a card whenever seems appropriate (there are no formal turns), explaining why they are playing it. When a stakeholder plays a card, they choose where to position it.

3) Participants have the freedom to choose how to commence, but we have found that it helps for the facilitator to suggest the thematic sequence of *Context →Strategy → Action*.

4) Players are shown two examples completed maps to illustrate how different cards can be arranged mostly the colour categories and higher relationships, with no ‘correct’ layout.

5) Resource allocation (time and money) is most naturally done towards the end, although it can arise during the conversation.

Each session resulted in a candidate design represented by the cards placed in different configurations on a large piece of paper. As seen in Figure 6-9, the discussion happens around the table while the cards, and the annotations around them, serve as a representation of the conversation.

Sessions were video-recorded for analysis and transcription. An approximately 15-minute semi-structured interview was conducted at the end of each session to gather participants’ feedback on LA-DECK effectiveness, willingness to use and personal recommendations.

Figure 6-9: Table setup and discussion using the LA-DECK cards.

6.4 Analysis

The analysis conducted to generate evidence towards the research questions uses information taken from transcripts and surveys, video and audio recordings form the 2 iterations and the additional study with stakeholders from other universities. Information resulting from qualitative coding analysis, triangulation and critical incidents are presented using relevant quotes, description of the actions, and summarized charts relevant when using Likert scales results. As in the past case study, results are separated in relation to our three research questions 1) Emerging challenges when working with New/Senior MDSI students, 2) The effectiveness of adopting/adapting co-design techniques, and 3) the role of the co-design practitioner when engaging with design activities and the design process.

For the effectiveness of the LA-DECK analysis was conducted suing Roy & Warren's analysis techniques for card-based design techniques (Roy & Warren, 2019):

- *Cards provide a common basis for understanding and communication in a team;*
- *Cards support creative combinations of information and ideas;*
- *Cards are semi-structured tools between blank Post-it notes and detailed instruction manuals;*
- *Cards provide convenient summaries of useful information and/or methods.*

The analysis is presented using the following techniques:

1. **Design vignettes:** critical incidents from transcript analysis. We present 2, from a total of 22 incidents identified. The 2 vignettes included in the results are used for illustrative purposes showing how the cards were used by participants during

the design sessions. The remaining 20 other examples are variations of the cards in use and were replaced with quotes given the constraints of the formatting. Each vignette contains a partial transcription of the dialogue and the moments where participants play cards.

2. **Flow analysis:** a visualisation of stakeholders' plays using a 'card graph' to summarise the flow, the direction of play and connectedness between card suits
3. **Degree and type of participation:** from the playing of a card, the time spent talking about that topic until the next card is played. This analysis aims to represent participation beyond dialogue reconstruction and focusing on the "materiality of the outcome" (Segalowitz, 2012), that is, the affordances of using paper-based cards and markers.

6.5 Results

6.5.1 Tool effectiveness and strategies followed (RQ1)

Results shown in this section are a contribution towards RQ1 How co-design techniques assist in the integration of diverse stakeholders' perspectives. Figure 6-10 shows a map of our research questions and objectives used to guide our contribution towards generating a co-design toolkit for practitioners. MDSI students and teachers proved to engage in different ways than students in case study 1 based on their expertise in the topic.

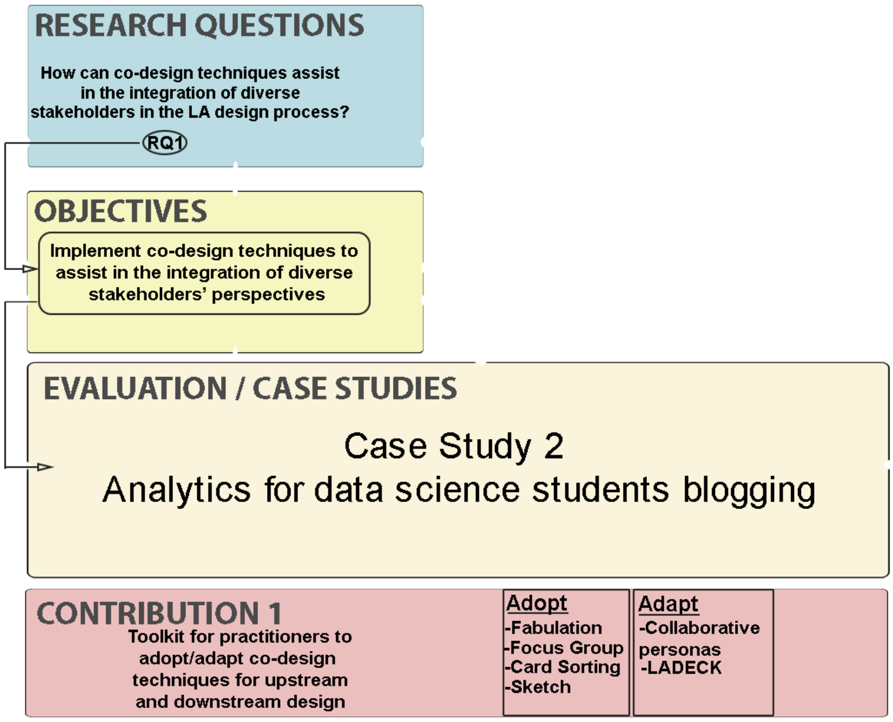


Figure 6-10: Map of contribution 1 in relation to RQ1 Co-design techniques.

6.5.1.1 The effectiveness of face to face design sessions

The focus group followed standard settings to make students feel comfortable while discussing issues and needs for their tools. We established the pauses and time to discuss off topic issues (such as problems with the learning material and their opinion on how data is being handle by the faculty). Seating arrangement is important to promote face-to-face interactions as seen in Figure 6-11. In this session, we started discussing general things like opinions on assignments and life outside of the classroom, this helped to build trust and set a good mood for the session. As the sessions progressed, we look for contrast between their opinions towards using data, the role of graduate attributes and the role of tools to support their learning. We established that the best topics to guide the conversation must be the role of learning, data and the value reflected in using analytics.

Figure 6-11. Six of our learners engaged in a focus group session.

6.5.1.2 Common agreement when implementing a collaborative persona profile

Example: An example of co-creating user personas can be seen in Figure 6-12. In building this Persona, participants discussed the basic characteristics of current learners inside their program, and completed the sections in a free form using sketching and labels. If participants suggested many different characteristics this could motivate two different profiles. The result was discussed between the researcher and participants. To document the result, we translated this into a cleaner digital version to be shared across the team. Other participants like educators also gave direct feedback to supplement the structure. This representation also proved useful when introducing new stakeholders to the learning analytics project.

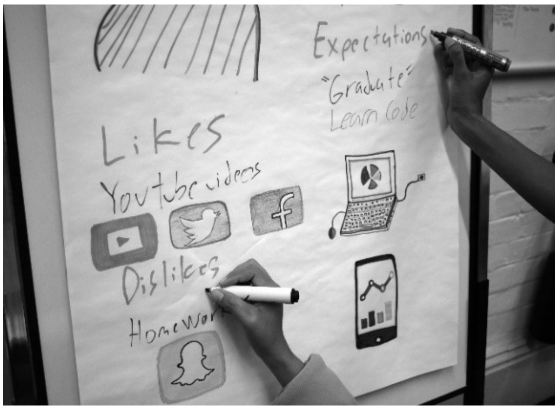


Figure 6-12: Co-creating a persona profile with MDSI students.

6.5.1.3 Effectiveness in collaborative sketching

Example: By sketching their own products, learners can express complex ideas in order to translate them into prototypes. What we have learnt from other areas where prototyping is massively used can be implemented in learning analytics design, especially for developing new data visualisations. In the example shown in Figure 6-13, learners built their own representations of the design of a mobile app for tracking improvement. We provided some basic charts and plots as guidelines to express what they want to see. The result is the first visual representation containing the main features expected after conducting the first implementation. These features ranged from colours, chart types, notification and labels on the screen.

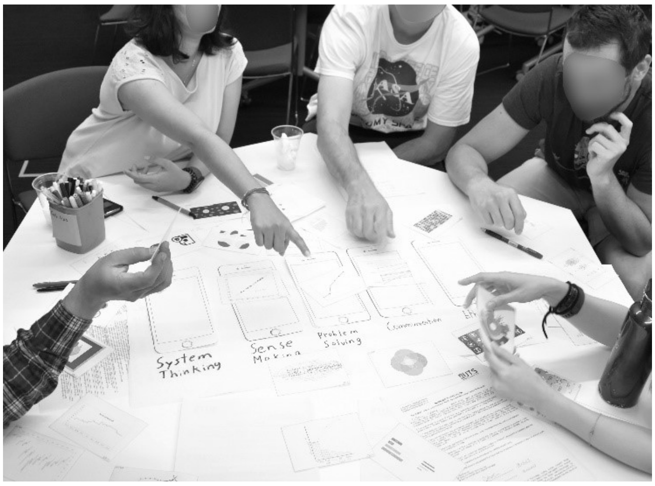


Figure 6-13: A group of our learners co-creating a low fidelity prototype for our mobile application related to personal feedback

Figure 6-14 shows the printings used to produce their first sketch of the LA tool. participants agree to use a representation of the analytics outcome and assign those to each graduate attribute. The collaborative sketch tool allowed learners to debate in real-time using the flexibility of paper-based representations to change thins and fit their argument.

Figure 6-14: Images and printings used in the collaborative sketch techniques.

6.5.1.4 Expressiveness in Learner/Data Journey

An example learner journey can be seen in **Figure 6-15**, which is a synthesis the designer reported back to the students based on their own sketching work and learners' comments. In this activity, the researcher asked participants (learners) to describe their daily routine and explain their expectations from the learning analytics system. The expert/researcher provided the proper annotation useful for documentation purposes, including icons and representations. In this case, an expert specified data interactions inside the diagram, including what processes are happening in terms of data like fetch/read/update or deploy. In this figure, participants separated their usual day into four sections (before class, during the class, library and at home). Most learners in our cases start their day reading material on mobile devices/laptops which is a pleasant experience noted as an emotion on top. During the day, different interactions produce diverse emotions (for example, feeling nervous the moment the class starts). Data interactions can also be pointed as opportunities for tracking, recording or delivering data to learners. When mapping interactions between learners, we can trace the overall experience by setting the learning space and moment where it happens. In this example, pleasant interactions commonly occur when having group conversations, but not in front of the professor.

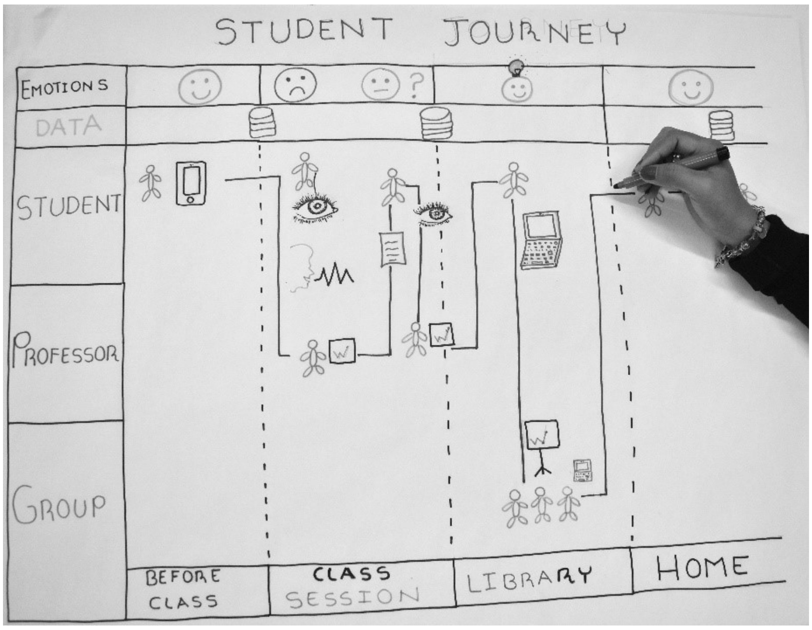


Figure 6-15. Learner journey for learning analytics made by a group of learners for our sessions

6.5.1.5 *LA-DECK effectiveness*

To validate the claim that LA-DECK supports LA co-design, we operationalise quantitatively what "participation" means in a session, in combination with a qualitative account of how the cards appear to shape the conversation. Transcript analysis (Dortins, 2002) of video and audio recordings identified a total of 20 critical incidents (Angelides, 2001) around stakeholders' interactions with the tool. Examples used in the results are a small sample for illustrative purposes. Critical incidents are highlight events that "stand out" (Angelides, 2001) from a larger situation in some way when using the cards. These events include disagreement resolved through the tool, collaborative knowledge construction and how participants proceeded to resolve the design challenge. Additional information about the affordances of the cards, personal opinions and the cards' effectiveness were collected through a post-hoc interview.

We organise the findings around four key roles played by LA-DECK, drawing on Roy & Warren's analysis (Roy & Warren, 2019):

- *Cards provide a common basis for understanding and communication in a team;*
- *Cards support creative combinations of information and ideas;*

- *Cards are semi-structured tools between blank Post-it notes and detailed instruction manuals;*
- *Cards provide convenient summaries of useful information and/or methods.*

We will present three kinds of analysis:

4. **Design vignettes:** critical incidents from transcript analysis. We present 2, from a total of 22 incidents identified. The 2 vignettes included in the results are used for illustrative purposes showing how the cards were used by participants during the design sessions. The remaining 20 other examples are variations of the cards in use and were replaced with quotes given the constraints of the formatting. Each vignette contains a partial transcription of the dialogue and the moments where participants play cards.
5. **Flow analysis:** a visualisation of stakeholders' plays using a 'card graph' to summarise the flow, the direction of play and connectedness between card suits
6. **Degree and type of participation:** from the playing of a card, the time spent talking about that topic until the next card is played. This analysis aims to represent participation beyond dialogue reconstruction and focusing on the "materiality of the outcome" (Segalowitz, 2012), that is, the affordances of using paper-based cards and markers.

6.5.1.5.1 Roles played by LA-DECK in co-design

In this section, we use Roy & Warren's (Roy & Warren, 2019) criteria to reflect LA-DECK's affordances as an LA co-design tool. The themes established in the previous section are used to summarise our findings.

6.5.1.5.2 Providing a common basis for communication

The first example of how the cards provided a common basis for communication is through a vignette. The illustrative vignette is described, containing the transcript, participants and interactions with the cards. This first example focusses on the use of privacy cards by different stakeholders.

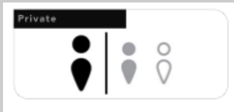
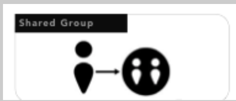
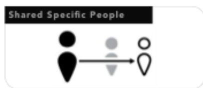
Vignette 1: Table 31 shows where two different stakeholders (a teacher and a student) diverge in their views about privacy and surveillance settings for students' blog posts. In session 3, stakeholders used the LA-DECK cards to deeply discuss privacy issues. The teacher and the student agree on the need for privacy settings, but their opinions differ once the cards are being used to support their argument. The cards proved to be useful to help participants to externalize and visually represent their opinions beyond casual conversation.

Role of the cards: In this case, the cards were used by the student to explore the different privacy options (cards) available, and to summarise arguments given by both participants. In Line 5, the student used the cards to explore her privacy options and picks the one that best represents what the teacher said [*Private Card*]. In line 9, the student reflects on the other possibilities by looking at the cards and convinces the teacher to think about sharing the blog posts with other people, playing both the *Shared Group* card and *Share Specific People* card. Thus, the multiple options available through the Privacy cards allowed participants to explore other privacy settings and gave structure to their arguments.

Another incident can be found in the following session. Here the developer uses the cards to formalize one idea and look for agreement with the student. the developer first introduced his idea in accessible language, before playing the *Natural Language Processing* card:

Developer: "We can analyse the blog post and define style and features of peoples' writing" [looks for a card] "like this" [the Developer plays a Natural Language Processing card]. Student: "Yeah, that works".

Table 31: (Vignette 1) Using LA-DECK for privacy co-design: Facilitator (F), Teacher (TE), Data Scientist (DS), Student ST)

Transcript		Cards played
1.	F: Okay, cool. So the default option that we need is this should be public for people in your own group? Private?	
2.	TE: Private, or if they're all in DVN *(a course)* then, you know, or DAM *(a course)*, then the whole class should be able to see. Like, you know, you would assume they would understand the privacy and the ethics that goes behind what…	
3.	F: So, in this case, if we only use *Private* [Card], then is that only you can see your posts?	
4.	TE: I don't know.	
5.	ST1 (Action - explores her options and plays a [Private] card to reflect the teacher's comment.)	
6.	ST1: Maybe some posts should be set to public. We should be able to define which posts to keep in a shared group and which ones not.	
7.	TE: Because it needs a lot of resources by just keeping it within the same group because a lot of times you would like to learn from experience.	
8.	F: So we do…. This is too big. So just some of them (blog posts) are shared publicly.	
9.	ST1: Because it also helps build your portfolio, like you can show people this is the work I've done and I want to share. (Action - Plays *Shared Group* & *Shared Specific People* cards)	
10.	DS: Well, text analysis, definitely, we'll need this. And we can also analyse the sentiment of the blog post when the people write some... For example, if you write...	

LA-DECK cards helped participants make their ideas visible to others giving them cues on what could be used to solve an analytics challenge. A participant described this in the post-hoc interview as follows: "*It's easier to name parts by looking at these cards, like now that I see the NLP (card) I remember seeing this before*" (Session 4, student). The developer in Session 1 explicitly stated how the cards helped him establish a common, high-level language they could use to communicate with 'less technical' stakeholders, as follows: *"It is easier to just use the cards instead of trying to explain the details of the concept that may not be relevant"*.

Effective communication between participants using LA-DECK relies on how confident and interested stakeholders are in the topic of discussion. Card-based structuring of a LA-DECK session provides the basis for a metric of participation by each stakeholder type. The playing of a card serves as an index point in the transcript, in which each stakeholder contribution is a new paragraph (Table 2). Beyond totalling the number and type of cards played, we logged the time that each stakeholder type spent talking on that card's topic, until the next card was played, but excluding non-substantive contributions (such as fillers and unrelated comments). This provided an indicator of which topics each stakeholder type spent most time contributing to.

Figure 6-16 shows a bar chart of time spent talking about each card suit, showing mean time and standard deviation. The data cleaning process included all sessions with standard 60 minutes duration, 3-5 participants per group and mixed stakeholders profiles. The first insight from this chart is how time was unevenly distributed among categories. In particular, participants spent most of their time discussing the categories UI, DS, AM (highlighted). However, the relationship between cards played and time spent is less relevant in categories like the LO. In this category (LO) participants played more than 20 cards but still, the conversation stayed short in comparison to the anchor categories.

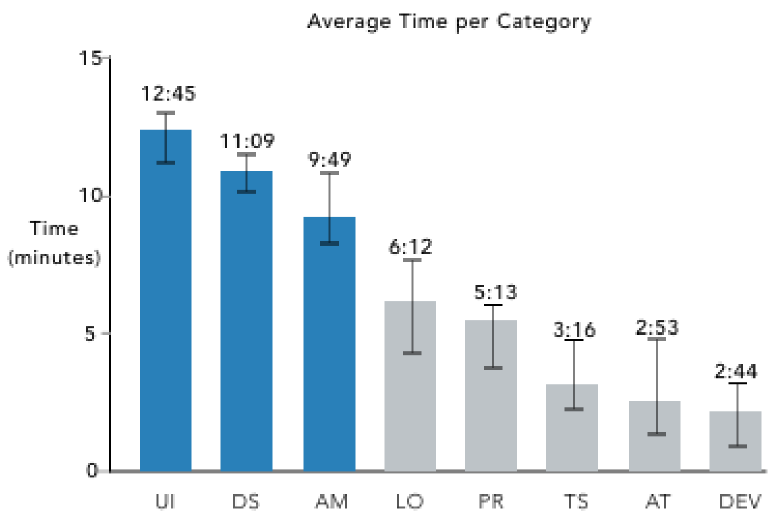


Figure 6-16: Mean time spent talking about each card suit

Figure 6-17 shows the results from counting the cards played per stakeholder and normalized in the chart. This analysis broadly reflects what might be expected from participants based on their roles. Developers tend to play cards related to *Dev Tools*; Teachers/Course Director plays the *Learning Objective* card most; Students played the *User Interface* visual analytics cards (since they are designing this for themselves). We also see that the students, being unusually expert in software and data science, also played the *Analytic Methods* and *Data Science* cards, as well as *Privacy* cards. In fact, these students spent more time discussing *Data Sources* cards than Data Scientists.

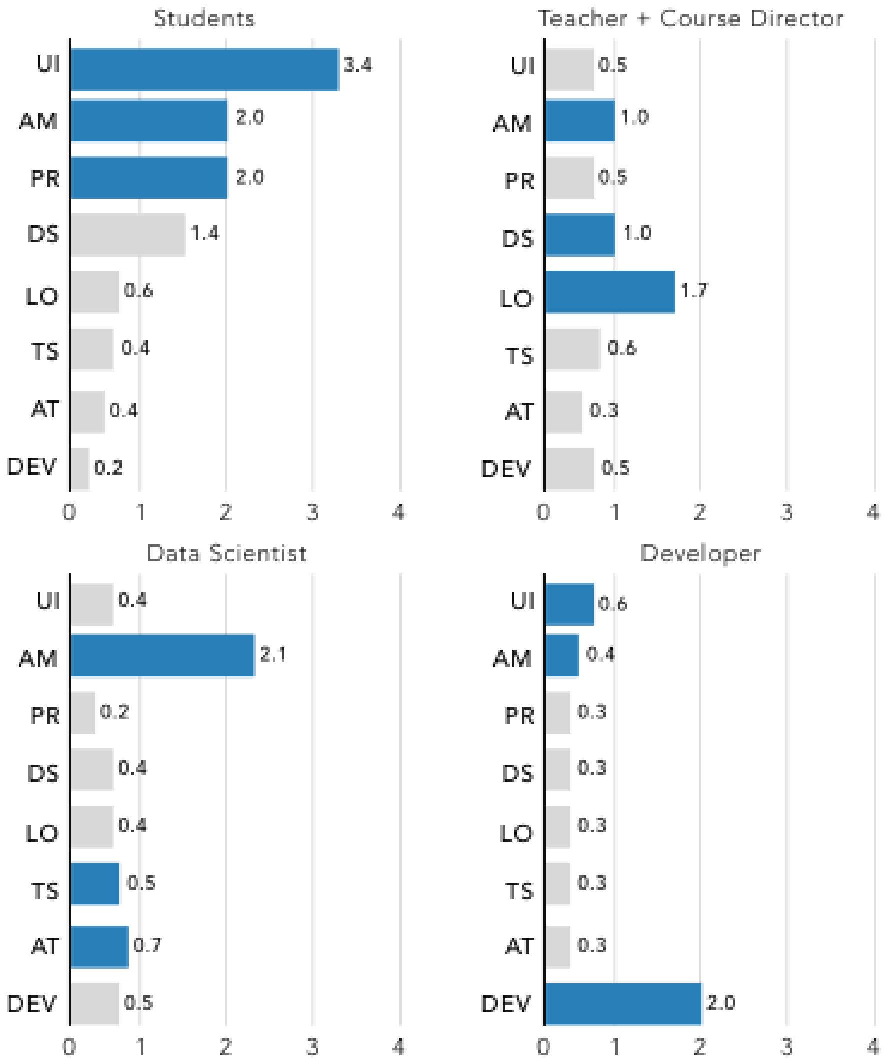


Figure 6-17: Cards types played by stakeholder role normalize for standard representation

The cards played and discussed the least, were the *Testing Site* and *Analytics Type* cards. Although there is low participation in these topics, this does not, of course, mean that they are unimportant in the overall design process. These cards helped participants to move toward other categories and fill information not found in the anchor sections.

This analysis advances the idea proposed by Segalowitz (Segalowitz, 2012) who argued that the outcome produced from collaborative methods/tools may benefit from analysing how the movements and conversation (transcriptions) are played together. The way users interact with the tool depends on the conversation happening and the context of the task.

The *expressiveness* of a language is the variety of moves/utterances that its vocabulary supports. From experiences in the first two sessions, we learnt that the deck offered too many cards, distracting participants, who also ended up discussing issues not directly related to the goal of the session (see analysis in Figure 6-17). For example, we dropped a *Vision* card from a preliminary version of the deck since it added complexity to the discussion of the LA context, making it slower for participants to start talking about the analytics. This trade-off between specificity and simplicity was stated by a Session 1 participant as follows: "*There are enough cards I guess. Just the way we frame the learning objective can be subject to a whole new conversation*" (Session 1, teacher).

In the subsequent debriefing interviews, participants confirmed that the cards in each suit were sufficient to aid as a conversation starter in the five sessions while acknowledging that new cards could be added in the future. In some cases, cards provided the main triggering idea and wildcards were required to complete the details described by participants. This was described by one participant as following: *"some students have their personal blogging sites, we can use that as another source of writing content"* [Session 2, the student proceeds to generate a new *Data Source* card writing on a blue wildcard].

Further examples of how the cards helped participants to summarise their ideas can be seen in the flow analysis and alternative uses of the cards illustrated below.

6.5.1.5.3 Facilitating creative combinations of information and ideas

Some suits generated more discussion than others, like *Privacy* and *User Interface*. This can be mainly because some participants may have different first-hand experiences. In some cases, disagreement between two participants with the same role emerged in *different* sessions but cards were used to merge ideas and agree to move forward. For example, two students disagreed on the way permissions should be handled by the new LA tool: *"The default [privacy] option should be Private, I want to decide which blog posts [and analytics] are available for everyone since the first ones are kind of boring"* (Session 3 Student, playing the card Private). *"Just keep it Public, maybe someone find useful some of my posts unless I can pick which post I want to show"* (Session 4 Student, playing the card Public). The different views towards privacy were mediated through the examples in the cards after each participant expressed their opinion. Combining both ideas requires debate but the cards allowed participants to be concrete and agree on how to continue.

In other cases, agreement over playing the same card came with a different argument during the same session. This does not mean that someone must withdraw a card but rather challenge people to give an argument to keep it on the table. This is illustrated by the short dialogue that emerged in Session 4:

Student: (playing the sentiment analysis card) we can use this to understand peoples' opinions toward the blog post"

Data scientist: "The blogging activity (pointing at a data source card) may be too small to get a good measure, but we can try (also playing the same card) to understand the writer's position on the topic"

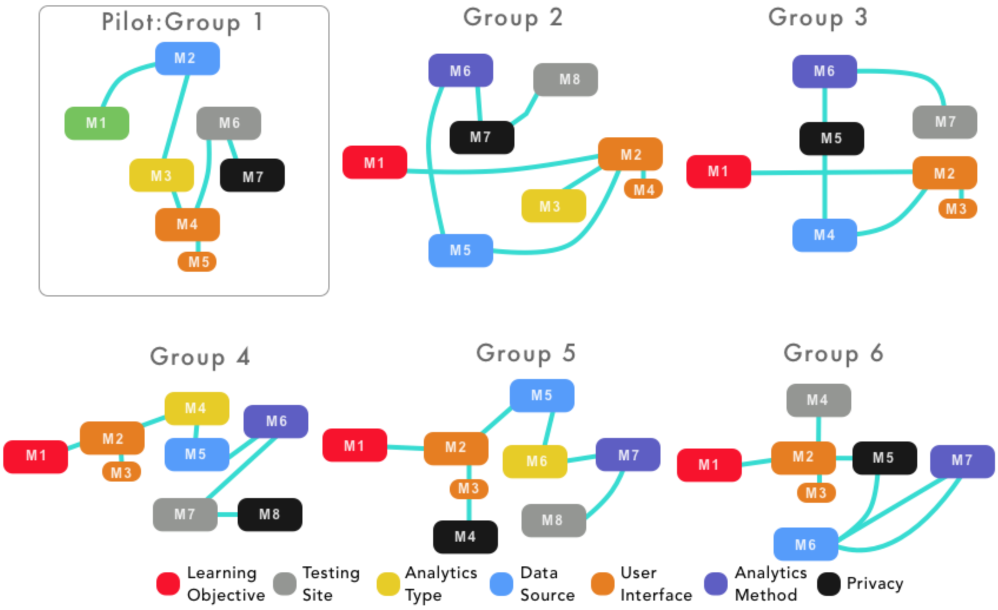


Figure 6-18: Sequence analysis between groups using LA-DECK (Movement, Number)

Another way to understand how LA-DECK supports the active combination of ideas is by looking at the sequence followed by participants. Analysing the card sequences across multiple groups revealed some differences and similarities. Figure 6-18 shows 'flow charts' using the corresponding colour codes. These show at a glance some broad patterns. It can be seen that groups followed the guidance provided and initiated their conversation with the red *Learning Objective* card as suggested by the facilitator. This action can be seen in a similar pattern for all sessions in the beginning. The blue lines show the centrality directed towards specific sections. These sections became "anchors" that were typically built on in the subsequent discussion, shown by their greater connectedness. The anchor cards in all sessions were *user interface, data source* and *analytics type*.

The cards allowed any form of physical arrangement giving participants the flexibility of forming their own layout. Figure 6-19 shows an example where the team generated a new layout, preferring not to write on the cards, but use them as visual markers for their more extensive notes on the paper sheets. They worked from the top to the bottom of two flipchart sheets, in a slightly different sequence from other teams (Figure 6-18), however, the anchor categories remained in sequence as seen in M3-6 and the non-anchor categories like TS were played in different moments.

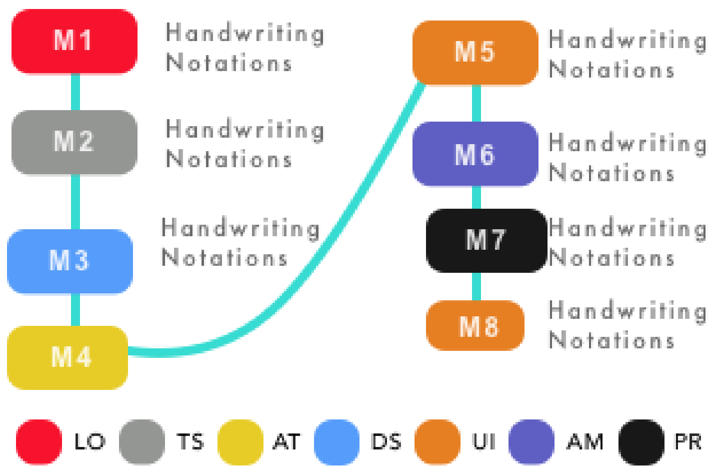


Figure 6-19: Alternative LA-DECK layout using the cards as markers for extensive notes on paper.

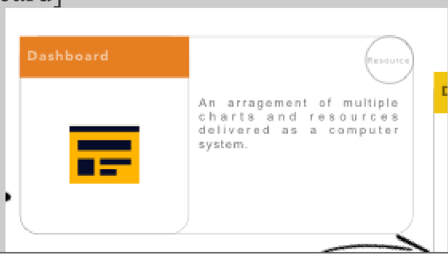
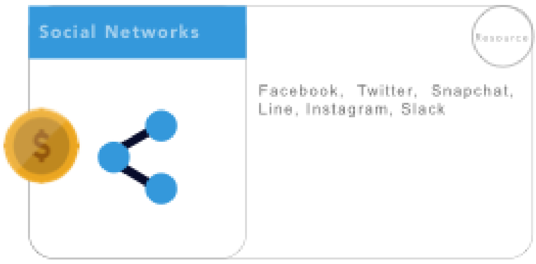
Regardless of layout, the card graphs also illustrate LA-DECK playing a similar role to other design decks, as *"a semi-structured tool between blank Post-it notes and detailed instructions"* — the cards provided a shared memory resource and attentional focus in conversational turn-taking. The sequences in both figures reinforce the idea that the 8 suits in LA-DECK are complementary (benefit from being played in sequence) to each other in some levels (the anchor categories) and non-dependent (can be played at any moment) in others like privacy and testing site cards.

Another example of how the cards can be used to facilitate creative combinations can be seen in next, where stakeholders used two different suits to refine an idea.

Vignette 2: Table 32 shows an instance where two different stakeholders (Data Scientist and Student) move from the student's technically vague idea of having "a dashboard with the most interesting blog posts", to the data scientist's clarification of the possible analytics method and data source required.

Role of the cards: In this session, the cards were used by the student to explore the different options (cards) available in terms of user interface objects and to connect this with possible data sources. In Line 1, the student used the cards to explore their options and picks the one that better represents the visual component in mind [*UI Dashboard Card*]. In line 2, the DS continues to inquire about what constitutes an "interesting" post based the student criteria. This leads to the DS analysing the cards available and suggesting a *Social Network* card (Line 4). Conversation then moves on to consider expanding the data sources (Line 5).

Table 32: (Vignette 2) Combining different suits to form new ideas between Data Scientist and Student.

Transcript	Cards played
ST: I'm thinking about a dashboard with the most interesting blog posts.	Looks at the cards and plays a [UI Dashboard card] 
DS: How would you describe an "interesting" post?	
ST: Those with most comments and shared in [CIC Around]. But I think you can't track those in the current version.	
DS: Then we'll need engagement parameters, maybe their social media.	Looks at the DS suit and plays a [Social Network card] 
ST: It would be good if we use our blog posts outside [CIC Around] and share them with others.	

Vignette 1 (Table 20) and vignette 2 (Table 21) illustrate how LA-DECK *"provided convenient summaries of useful information/methods"*. The cards operate like a menu

reminding participants of their options, providing shorthand summaries of technical concepts to help participants encapsulate their ideas succinctly, making space for others to contribute. However, menus only work if they are not so long that navigating them becomes a distraction, and each item is succinct yet intelligible. Participants would accompany the playing of a card with a verbal summary of their intended meaning and rationale, and the focus group feedback from participants was that LA-DECK had struck this balance in terms of expressiveness and succinctness.

6.5.1.5.4 LA-DECK's limitations

The format of using cards as a medium of expression brings limitations already reported in other card sets (Roy & Warren, 2019). The LA-DECK aims to give a range of choices for each category. However, in categories like *Analytics Methods*, too many cards overloaded participants attention when formulating an argument. In some cases, like Figure 7 participants decided to use the suit as a label and disregard the cards to make their own content. This is due to participants being overwhelmed with too many choices: *"I didn't read all the (AM) cards so I wrote what we discussed as the analysis we wanted for the data, maybe you can break them into two (suits) so I can easily browse them" Session 7 Teacher*.

Given the constraints of the card format, only brief labels and descriptions are possible. Overall, in the post-session interviews, participants confirmed that the cards seemed to achieve the right level of detail in vocabulary. However, some analytics experts criticized the way some concepts had been grouped at the same level, ignoring more nuanced taxonomic distinctions. This trade-off is inevitable: we were always mindful that a larger deck takes longer to become familiar, and more effort to manage and search physically, which could distract from moving the conversation forward.

We recognise that students and educators participating in this first study came from a data science Masters program, bringing far great data and technology literacy than other stakeholders, which was evidenced in the talking time/topic analysis. Other studies have piloted LA-DECK with other user groups, which will be reported elsewhere.

6.5.1.6 Results from the study with stakeholders from other universities

The results of the analysis in this section are based on the same method used in section 6.4 when implementing the LA-DECK with MDSI students. The main categories used to group our findings used the same recommendations to test the effectiveness of the cards drawing on Roy & Warren's analysis (Roy & Warren, 2019) and adding two emerging categories based on the context of this study:

- *Cards provide a common basis for understanding and communication in a team;*
- *Cards support creative combinations of information and ideas;*
- *Involving students and other stakeholders*
- *Supporting the design process and ensure continuity for the following sessions*

6.5.1.6.1 Provide a common basis for understanding and communication in a team

The cards helped participants by providing the technical language to discuss the learning analytics component for participants to communicate. When participants were asked to summarise if the LA-DECK helped them to communicate with their teammates we got positive answers like the ones listed below:

"PA4 Session 1: The one thing to think about is to hold the cards back. So, if you think about layers of when you want the conversation to happen, to structure how it's going to work. So, start with what's the thinking? Then, what's the technology? Then, what's the measure? So, you might actually start the process around forcing people into a pathway and then you bring the next set of cards in…"

"PA4 Session 2: Definitely. It's that sense of who are you doing it for? Who's the purpose? Those purposes are actually multi-tiered as you go through, so if we're only thinking of one structure then you only come up with a very mono-dialogue."

Other results from the same questions regarding effectiveness for communication resulted in participants using the cards as a framework to develop their ideas. This means that the categories became more relevant for them than the content of the cards leading to use of the structure as a guide for their conversation.

"PA2 Session 3: I think the cards are a useful framework because I wouldn't have known where to start with this. So, the cards are useful once I've worked out what they actually meant, it took me a moment."

"PA2 Session 5: Yes, and even the linear structure that isn't a linear structure that we used as a linear structure, was useful because it actually guides you through and that's actually how I worked out what the cards and colours finally meant, it went click. But again, I think using that when you were starting out with this sort of process is good because it does give you, as someone said I think, a scaffold to put around it. But you would get better at it, you ultimately wouldn't need it, but if you're working with a new group of people, they may well need it."

The language used in the cards became a useful intermediary for people with diverse technical backgrounds. When participants try to point at some technical concept, they used the cards to make it visible for the other participants and confirm if everyone understands the message. According to participants in session 2-4, the cards highlight the difference in language and push participants to explain themselves to avoid misunderstandings.

"PA1 Session 3: What this card did though, this is just a process bit, but it kind of highlighted the different language that we use as well. I often asked, so Brad what do you mean by that that? And then actually come to the shared understanding of the impacts that we're making, for whom, and what stakeholders. We had a different understanding of it. So this card helped us to tease out…"

"PA2 Session 2: It was really helpful for me to think this language and highlighting blind spots, I feel more like that I can contribute to the conversation actually from now."

"PA3 Session 4: I'll probably be using this quite a lot. I'm reflecting now on how improved many of my conversations have been across the university this year. I've gone to Deans, sub-Deans, school level, but also the level of an individual."

6.5.1.6.2 Cards support creative combinations of information and ideas

Participants used the cards to guide their ideas into bigger contributions to the design map. Learning specialists used this opportunity to propose new ideas based on the technical commentary from other stakeholders like merging the learning design structure and setting the context for future applications of the tool. Other scenarios where participants used the cards to further elaborate ideas based on the information available can be seen on the following commentary from participants. In these examples playing cards like [Privacy] and [Learning Objective] led to a further discussion about the rules of engagement and bring new perspectives to enhance the quality of the ideas.

PA2 Session 2: [Overtalking] but I loved it and I'm thinking about how this can be used. The whole holding and doing things and we're creating, and the cards are visible reminders of different elements to be considered and bringing in different perspectives. And talking to the card and what it means together. You know, the card is a prompt for that conversation. What was interesting was, David and I spent a little bit of time trying to work out the rules of engagement, because I saw none, but David saw a linear process in the cards. So, in terms of my taking the cards that would be something I'd spend a little bit of time on to try and help the group. Not think of them as so restrictive. Yes.

PA5 Session 3: There's a lot of potential on the cards because there is some real estate left over on the back side, for example. You could have some samples or stuff like that. Some of them I feel like if it's not on the card it needs to be laid out because we talk about stakeholders. The ideas I wanted to discuss were annotated by other people. My idea of using the LMS data could be hard to implement without (the developer) experience with the platform.

The sequence analysis shown in Figure 6-20 represents the way ideas were combine through the card's categories. In this sample, most groups started by defining the learning objective and continue in a similar way as the groups in the first case study (See section 6.5.1.5.3).

Another insight from this analysis is the way anchor categories changed except for the User Interface category. In these groups, the Data Source and User Interface categories became the anchor point to discuss ideas making the team focus on solving these sections before moving to the following category. The design of the LA-DECK cards allowed participants to arrange their workspace as required and effectively engage in conversations around the content proposed by the cards.

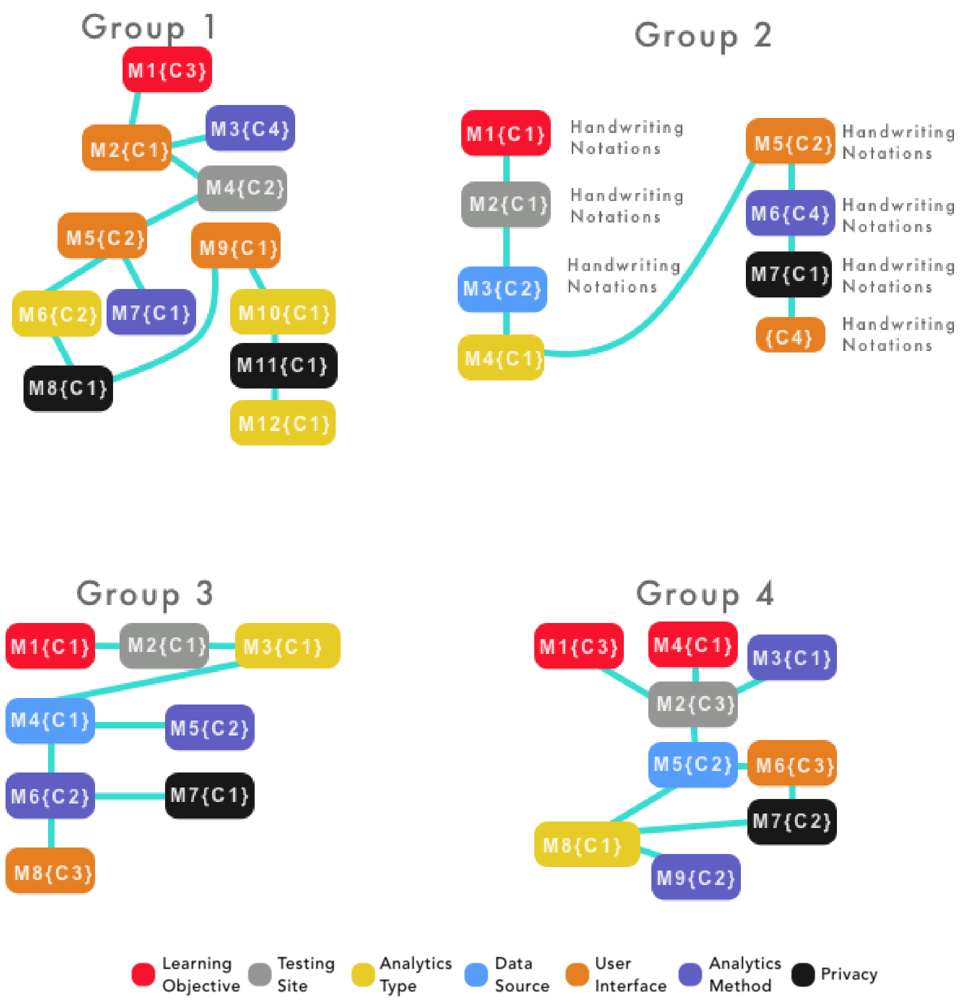


Figure 6-20: Sequence analysis between groups using LA-DECK (Movement, Cards used)

6.5.1.6.3 Involving students and other stakeholders

An emerging theme found from the analysis of participants feedback after using the LA-DECK is how the cards and the process made participants aware of the benefits of doing co-design for learning analytics. According to participants, playing cards like [Privacy] and [Data source] made them think about inviting students and other stakeholders for the following session to complete their design map. The following quotes include further details from participants using the cards to identify key stakeholders and the need for new sessions with a more diverse group:

PA4 Session 3: We did say that the same stakeholders would be involved in both. So, there would be continuity. So, you wouldn't just, just because this tool is only going to be seen by course director level, you wouldn't exclude a student from this, you'd want the student involved, even in the top level decisions…

PA5 Session 3: You get to one level who are the key stakeholders, or who are the decision makers? Then you get to the next technical level and it'll be different people involved, different teams and maybe that would be useful to just put on there, as well. All right we need the dashboard, who's going to give us that? We need a policy, who is it that's responsible for that? Maybe there could be a space to put in just so that we can identify all the key players.

6.5.1.6.4 Supporting the design process and ensure continuity for the following sessions

The LA-DECK structure and categories permitted stakeholders to plan the following sessions using the missing information found in their map. During the sessions, technical things like data capabilities and available resources to make their design possible were missing since none of the participants were experts in those fields. This led stakeholders into making a plan for the following sessions to further discuss these details and start working in the first prototype following the co-design process. The following quotes illustrates how participants from groups 1-4 used the LA-DECK to identify the missing pieces of their design map to plan their following session:

PA4 Session 1: Once you had your overarching goal and then were they discrete goals and then what sources, then it was kind of coming back to your chart of the different breakdown, which were the sources of data that you could use to help you achieve those goals? And then what were you doing with those sources of data? And then who would you need to be involved? It was good that you came in and then prompted, so who are the stakeholders that you would involve in this wider process?

PA3 Session 2: And also just how you get started in the first place by prototyping and trying to find out, does this make sense before you're even building something. PA2: Something you might not think of, also makes the process faster, I would say. But if we do that on a whiteboard it would take half a day, maybe. PA3 But that's not necessary and one of the things that we encountered was, when we started to think about the user interface in the dashboard, or some sort of interactive data analysis that allows you to look at the themes within the text analysis of the qualitative responses within the e-portfolio.

PA4 Session 4: First, I see this as it can be run in many times with different people, different contexts. And I think that a good exercise the first time it is run in a group it *would just use the blank cards because I think even seeing technologies or seeing types of analytics might be a bit leading, or misleading.*

In some cases, participants became aware of the flexibility required to run a project through co-design once they identify technical issues through the LA-DECK. Participants realized that once the team go into a micro-level of detail for their LA tool, the current session should move into solving those details with experts back in their universities. The cards also helped participants to reflect on what should be done to make their design feasible for the university to support their project. The following transcripts illustrate instances where participants tell how the cards made them think about the co-design process and the need for further co-design sessions:

PA5 Session 1: And also, the balance point is with these cards, when you go down to the micro-level and actually put full documentation behind this, the number of the card types help you qualify costs in time and resources. So, you put in a micro-level design document and then how many of these do you have, how many of those do you have?

PA4 Session 3: The other piece is giving time for reflection. So you do this and it's in the moment and it's fast and it's rapid. When you go back a week later and say, okay here's the neatened-up version of the kind of room that we've just built, what do you think about it? And nine times out of ten, people say, oh I spoke to some colleagues back at the office about that and we have to shift this around, or this is not going to work. So, if you don't have that reflection point then it becomes too structured and you lose that impact to think [overtalking].

6.5.1.6.5 Changes suggested increasing usefulness in other contexts

Changes to the current LA-DECK version were suggested by the team according to their experience during the workshop. Most of these changes request additional cards to give more detail to the current categories. Making changes to the current categories were not suggested by any of the groups in this case study, this supports the idea that the current design of the LA-DECK is complete enough to kickstart the co-design process as expected.

Comments described in Table 33 suggest that the following version of the LA-DECK should be compatible with other design tools to make it usable for people further down the design process. Currently, people can modify the LA-DECK to add as many cards as they want as long as they keep the main categories as the basis for their session.

Table 33: Changes suggested by stakeholders to improve the capability of the original LA-DECK.

Team	Changes suggested
1	**PA4:** I think you might need some challenges cards. So, what are the things that are going to restrict this from happening?...
2	**PA3:** Because I've seen similar sorts of cards used for when… like learning spaces. When they're introducing new learning spaces, you know how do we use this new tool? And they just introduce it as an aspect. I would just see this as these additional things in that wider process. Now you need to consider the analytic side as well and how does that play in your planning?
3	**PA2:** That's another card that we changed: who the stakeholders were.MO Would you want a card that actually represented an obstacle? PA4 It's probably like a dollock or a resource but here's a block around process. So, here's a point to innovate from. **PA2:** A heat map, yes. So, this was about trying to get a picture of…

6.5.1.6.6 Additional insights on the effectiveness of the LA-DECK

Finally, this first version of LA-DECK cards is a work in progress that will benefit from a future evaluation. The number of cards per suit is still changing based on what we found in the initial study and we are planning to open its design for other researchers to contribute to the tuning of the suits. We are interested in making the whole deck available for everyone to use this technique and complement suits based on their experiences. LA-DECK cards are part of a bigger strategy to provide a co-design toolkit for researchers to open the LA design process to students, teachers and other stakeholders regardless of their knowledge and literacy in the LA field

LA-DECK proved to be a novel generative tool specifically designed to facilitate inter-stakeholder co-design of learning analytics. The LA-DECK motivates participant to use a pre-defined set of categories based on pragmatic and contextual factors, translated these into a deck of cards with eight suits, and analysed the use of the cards through two main studies.

Using three different forms of analysis (transcript-centric design vignettes, card-graphs and degree of participation), we have characterised in what ways the sessions were "participatory" in nature and argued that the cards succeeded in playing very similar roles to those documented in the literature on card-based design tools. LA-DECK provided a common basis for understanding and communication in a team; supporting creative combinations of information and ideas; serving as semi-structured tool between blank Post-it notes and detailed instruction manuals; and providing convenient summaries of useful information and design methods.

Cards, as we have discussed, play very specific roles in shaping conversations, and are not intended to replace the many other representational design tools. Some participants suggested how other generative tools could be used in conjunction with the cards, including the subsequent use of storyboarding "*to get into more detail*" (Session 3, student), and sketching "*to clarify meaning*" (Session 4, student).

The LA-DECK suits presented here were tuned to facilitate productive co-design of high-level concepts, which would proceed naturally to more detailed design using other tools. We can imagine, however, a different deck with much more detailed suits, suitable for more expert users, and/or for downstream design. Another version for senior leaders in an institution would introduce suits that connected with their concerns.

Another avenue we are investigating is the particular role that the facilitator plays in LA co-design. It will be clear from the vignettes described in section 6.5.2 that this is an important role, one that we are analysing in the videos in order to characterise this skillset clearly. It appears to include fluency with the co-design tool, combined with other group facilitation skills, and depending on the design context, possible additional roles including LA researcher, and subject matter expert.

To conclude, the LA-DECK cards is an evolving co-design tool that will unquestionably benefit from further piloting. The deck has been released in conjunction with other design resources for others to adopt and adapt [http://LA-DECK.utscic.edu.au/], and following our gaming metaphor, we welcome 'expansion packs' that add new suits. LA-DECK is part of a wider strategy to develop a co-design toolkit that gives students, teachers and other non-technical stakeholders a voice in shaping the tools we expect them to use.

6.5.2 Challenges when working with co-design for learning analytics

The challenges expected to emerge during this case study are illustrated suing the critical incidents approach art of our methodology for analysis. These scenarios follow the description written in Chapter 3 and are separated into 5 categories. The following section presents a selection of the most relevant critical indent for each challenge. Further examples can be seen in the *Appendices* section.

Results shown in this section are a contribution towards RQ3 What are the challenges when engaging stakeholders in the design process. Figure 6-21 shows a map of our research question and objective used to guide our contribution towards understanding emerging challenges in co-design practice for LA.

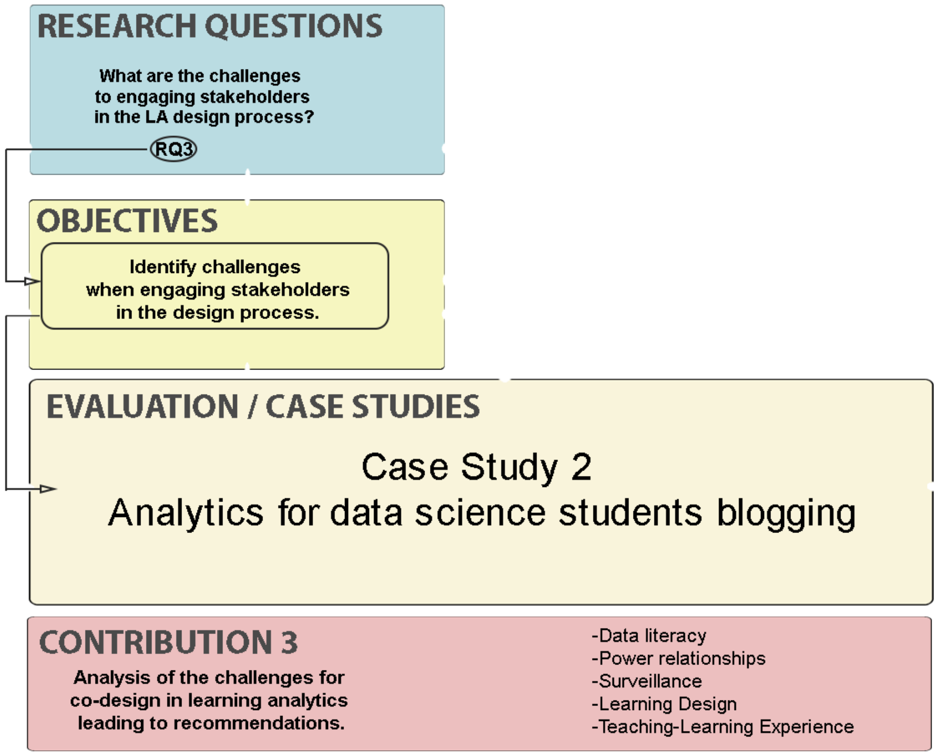


Figure 6-21: Map of contribution 3 in relation to RQ3 Emerging challenges in Co-design for LA.

6.5.2.1 *Surveillance and privacy SP6– Example 3*

Case study: Developing graduate attributes with data science students

Co-design tool: LA-DECK

Design cycle: Iteration 2 Session 2

Key: 2 courses are mentioned – DVN: Data, Visualisation & Narratives; DAM: Data, Algorithms & Meaning

Critical Incident: Teacher and student diverge on their views about privacy and surveillance settings.

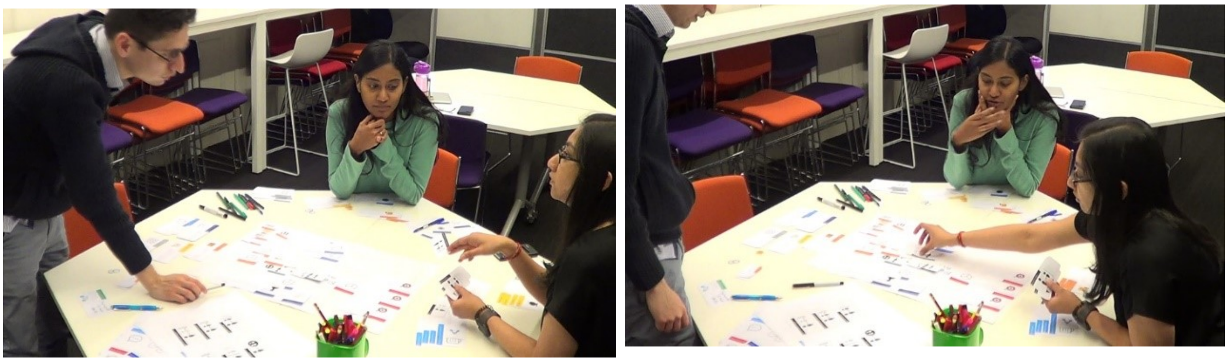


Figure 6-22: Participants discussing privacy and surveillance issues using LA-DECK as an argument tool.

This example shows an instance where two different stakeholders (Teacher and Student) diverge on their views about privacy and surveillance settings for students' blog posts. This was found when the two stakeholders interacted through the design cards part of the LA-DECK (See Section N) in Session 2.

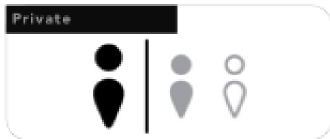
Session 2 included 1 teacher with a data science background and 1 student enrolled in the MDSI programme. The purpose of this session is to define the design components of the current CICAround blogging system using the LA-DECK cards to support their conversation.

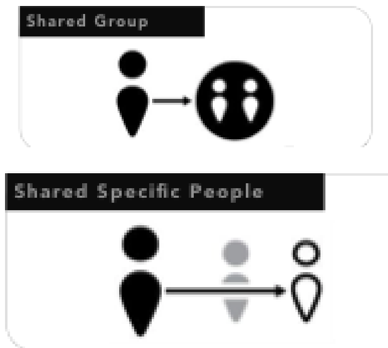
Details of this exchange are presented below through a vignette using a partial transcription of the dialogues, the actions triggered by the practitioner and the interaction with the LA-DECK tool.

Vignette: Using the LA-DECK with a teacher and one student.

The vignette starts with the facilitator summarizing the discussion so far about public settings against group settings for students' blog posts (line 1). The teacher (TE) then proposes that since the current practice allows blog posts to be shared with everyone in the group, all posts should use the same settings, and this should make sense to all students (line 2). The Facilitator provides verbal clarification of which card might be relevant to play to represent the state of privacy settings (line 3), but TE doubts about that choice (line 4). However, student ST1 partially agrees with the TE but diverge on that being the only option and suggest the other two alternatives being *[Shared Group & Shared Specific People cards]* in lines 5 - 9. ST1 continues to explain that the current privacy settings are too narrow and should be customized for each blog post. The teacher understands and agrees by continuing to develop those ideas (line 7). The facilitator then summarised their argument and moves to the next design task (line 8).

Table 34: Vignette 1 includes the conversation between the teacher and the student debating on the options for privacy settings.

Practitioner		Transcription	Co-Design Tool
[KAF] ***Action***			
[Sensemaking] ***Exemplify***	1	**Facilitator**: Okay, cool. So the default option that we need is this should be public for people in your own group? Private?	
	2	**TE**: Private, or if they're all in DVN then, you know, or DAM, then the whole class should be able to see. Like, you know, you would assume they would understand the privacy and the ethics that goes behind what…	
[Sensemaking] ***Exemplify***	3	**Facilitator**: So, in this case, if we only use *Private*[Card], then is that only you can see your posts?	
	4	**TE**: I don't know.	
	5	***ST1*** (Action - *explore her options and play a [Private] card to resume teacher's comment.*)	

	6	**ST1**: Maybe some posts should be set to public. We should be able to define which posts to keep in a shared group and which ones not.	
	7	**TE**: Because it needs a lot of resources by just keeping it within the same group because a lot of times you would like to learn from experience.	
[Narrative] ***Conclude***	8	**Facilitator**: So we do…. This is too big. So just some of them (blogposts) are shared publicly.	
	9	**ST1**: Because it also helps build your portfolio, like you can show people this is the work I've done and I want to share. (Action - *Plays Shared Group & Shared Specific People cards*)	

Vignette Commentary

The challenge

This example became part of the surveillance and privacy challenge when designing with diverse stakeholders. Both participants have different views in term of privacy settings for students' blogposts. The teacher suggested closed settings in Line 2 but after analysing the multiple options, the student created an argument against keeping everything for yourself (Line 6). The argument then became about the limits when sharing students' content since public setting is too broad. Some agreement is reached when the teacher and students acknowledged that some blogpost should at least be shared within the group and maybe specific people (Line 7-9). Managing both views and achieving agreement within the same activity required for both participants to negotiate using the tool and their experience with the CICAround platform. This exchange also illustrates how in co-design, two stakeholders use their views on privacy and inform their design decisions before considering other participants expectations.

The role of the practitioner

To guide the conversation, the practitioner acted as the facilitator. The details of what should be done in terms of privacy were still unclear for everyone (participants and facilitator). This required for the facilitator to use examples (*Exemplify* Line 1&3*)* to make sense [Sensemaking] of the different options and prompt the conversation into an agreement. After reaching a common understanding of private vs public settings, the facilitator required to close the conversation (marked as *Conclude* Line 8) and prepare for the next topic using this information as an anchor to advance the design session [Narrative].

Effectiveness of the tool (LA-DECK)

In this session, the LA-DECK cards were used by the student to explore the different options available in terms of privacy and to summarise arguments given by both participants. In Line 5, the student used the cards to explore her privacy options and picks the one that better represents what the teacher said [Private Card]. In line 9, the student reflects on the other possibilities by looking at the cards and convince the teacher to think about sharing the blog posts to other people using the [Shared Group card] and [Share Specific People card]. The multiple options available through the Privacy cards allowed participants to explore other privacy settings and gave structure to their arguments.

6.5.2.2 Teaching and learning expertise TL3 – Example 1

Case study: Developing graduate attributes with data science students

Co-design tool: Collaborative Sketch Tool

Design cycle: Iteration 1 Session 2

Critical incident: Students misunderstand the importance of graduate attributes development.

In this critical incident participant engaged in a challenge related to teaching and learning expertise when discussing the relevance of graduate attributes in design. The first co-design sessions using the collaborative sketch tool with MDSI students revealed participants misunderstanding the importance of graduate attributes development as part of the course.

Session 2 invited 5 students to use the collaborative sketch tool to set the main interface features for their expected learning analytics tool. The session reached a point where creativity as a graduate attribute was discussed as a non-relevant skill against the MDSI guidelines.

The critical incident mentioned before is presented below as a vignette including the partial transcription of the dialogue, the actions followed by the co-design practitioner and participants' interaction with the co-design tool.

Vignette: Using the collaborative sketch with students.

The conversation starts with the facilitator asking students to elaborate on the relevance of creativity as a graduate attribute (line 1). ST2 responds in line 2 that this is not a relevant feature for all students. The argument comes from a personal experience where ST4 explains that since his background is highly technical, creativity cannot be seen as a skill required to solve all problems (line 3). The less drastic comment from ST2 shows a misunderstanding between technical skills (coding) and creative thinking (graduate attribute).

Table 35: Students using the collaborative sketch tool to discuss the relevance of creativity as a relevant feature in the design.

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***		[Session 2]	
[Sensemaking] Inquire	1	**Facilitator**: So you'd change that (Creativity attribute) It should be a different attribute?	
	2	**ST2**: I think it should be because there are a lot of people that are not engineers but they're good analysts, statisticians. And so many people. So maybe yes, coding for them…	
	3	**ST4**: Yes, I think so, because coming from a programming background, I can solve all the problems, but I wouldn't necessarily say I was the most creative person in the world. Perhaps it's just the environment, but once you've solved that sort of problem, you know how to attack it. But creativity is for me a waste of time.	

Vignette Commentary

The challenge

The challenge for learning analytics design is that creativity as a relevant skill is part of the core attributes explained in Section 6.1 This is supported by the learning designer behind the MDSI program to represents the core skills and abilities needed for future practitioners, all this following the 21st-century skills philosophy. The importance of this to be part of the tool as a rule of progress is to allow all students to become integrate data scientist regardless of their background expertise. Participants' negative attitude towards graduate attributes opens a discussion over their validity using their personal experiences as the only evidence for their claims. At this point, teachers and course designers find these comments the result of not having much experience with learning strategies.

Effectiveness of the co-design tool (Collaborative sketch tool)

The collaborative sketch acted as the starting point for students to consider attributes when defining the interface features for their tool. This allows the conversation to stay in the context of design and avoid getting into learning related topics. In Line 2, ST 2 uses printed examples to explain their argument and facilitated communication using their language.

6.5.2.3 Learning Design LD9 – Example 9

Case study: Developing graduate attributes with MDSI Students

Co-design tool/technique: LA-DECK.

Design cycle: Iteration 2 Group 1

Critical incident: The course director argues about assessing writing skills through the current learning design as very subjective.

This critical incident illustrates how participants engage with learning design issues while using the LA-DECK tools. Participants hesitation when mapping visualizations for writing skills leads to an unclear posture making hard to decide the most effective design decision.

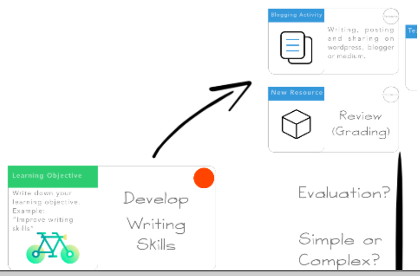
Session 1 part of iteration 2 invited a course director, a developer and a teacher to use the LA-DECK cards to design a learning analytics tool to support writing in CICAround. while engaging with the LA-DECK design session. The moment described in this section emerged when participates started to question different methods to asses writing skills as part of the learning analytics tool algorithm.

The following vignette describes participants interaction with the LA-DECK tool, a transcript of the conversation and the role of the co-design practitioner during the session.

Vignette: Using the LA-DECK with teachers, developers and academics.

The facilitator opens the conversation with a general inquire about mapping writing skills through a visualization (line 1). The course director (CD) hesitates to give an example and elaborate more on how subjective is to judge quality in writing (line 2). After this, the CD uses the LA-DECK cards to point at his argument and uses the [Blogging Activity] cards as an example of sources for writing material. The teacher (TE) intervenes and elaborate on how to use the blogging activity as a way to measure improvement (line 4). The CD then answers with another explanation of the complexity behind writing assessment and this leads to an unclear agreement on how to judge the writing material for the LA tool.

Table 36: Conversation between the CD and TE on the validity of writing material for assessment.

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***		[Session 3]	
[Sensemaking] Inquire	1	**Facilitator:** Did you manage the user interface in CICAround as a teacher in your case what would you like to see either to help you map the writing skills.	
	2	**CD:** So is this like feedback to the student like in AWA or is it for the academics and… The thing is, when you say develop writing skills, the quality of writing is highly subjective.	
	3	**CD** (Action – *points at the data source cards and learning context card* [Blogging activity])	
	4	**TE:** Okay maybe if I want to observe how they… The progress they have been made could be a timeline. Even if I…	
	5	**CD:** And the other thing there… Yes and the other thing is how are you going to judge it. Are you going to judge it one student against the other?, or are you going to judge it in terms of this student over this time has gotten better, and what does that mean	

		and what would that look like?.	

Vignette Commentary

The challenge

The course director in this case hesitates when asked what kind of visualization represents writing skills. The main argument is that writing skills is highly subjective, hence is not possible to come up with a right answer. The teacher tries to come with a temporal solution using a timeline marking students' progress. The course director continues to add more details on the problematic about the epistemic evaluation of good writing and the rules available to judge writing pieces. Both participants do not come into agreement and the result is an implied critique to the learning design behind developing writing skills.

The role of the practitioner

The practitioner helped as a facilitator to remind people of the available cards in the table. The topic introduces design issues for participants to solve and the facilitator makes sure that the conversations stay in that context before moving to the next subject.

Effectiveness of the co-design tool (LA-DECK)

The LA-DECK helped participants to have a deep conversation about evaluating writing skills before thinking on the LA tool implementation. In line 3, we can see an example of using the data source card [Blogging activity] to support the CD argument and go back to the learning objective using the [Learning context] card. This interaction with the tool proves that the LA-DECK can be used to go back in the conversation and evaluate the pieces without losing the context and relationship between the card categories.

6.5.2.4 Data and algorithm literacy DL4 – Example 4

Case study: Developing graduate attributes with MDSI Students

Co-design tool/technique: LA-DECK.

Design cycle: Iteration 2 Group 3

Critical Incident: Student proposition about text analysis is overridden by the expert recommendations.

The following critical incident shows an example where the algorithm literacy of participants influences their capacity to solve a technical problem. The interaction between the Student (ST) and the Data scientist (DS) shown as a conversation below gets to the point where the DS determines the validity of using sentiment analysis as the analytics method for the tool.

Session 3 part of the second iteration in this case study invited 1 student and 1 data scientist to use the LA-DECK and design a learning analytics tool that supports students in their writing skills development. The moment described in this section emerged when the student suggested using sentiment analysis as an analytics method and the data scientist disagrees using his expertise in the topic.

The transcription and details of the interaction between participants and the tool is shown below as a vignette.

Vignette: Using the LA-DECK with participants

The conversation started with the facilitator asking participants to determine which analytics methods would be used to analyse the blogging posts (line 1). ST1 proposed sentiment analysis pointing at the [Sentiment analysis] card used from the LA-DECK (line 2). The DS hesitates to agree and propose text analysis as the main analytics methods (line 3). The DS then commented on the validity of using sentiment analysis and asked the facilitator how much data is available (line 3-4). The facilitator responded citing how many blog posts are available (line 5). The DS determines that there are not enough data to run sentiment analysis as the ST1 proposes (line 6).

Table 37: Students misunderstanding the capabilities of text analysis solved by data science expertise.

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***		[Session 3]	
[Narrative] Inquire	1	**Facilitator:** Which one would you suggest can be the first approach to analyse all this data that we can get from these data sources?	
	2	**ST1:** For me, to be performed on all blog posts. And it depends on who has access to the outcomes of the sentiment analysis. If it shall be public, available for everyone, maybe only the public. But if we have this thing of restricting access for blog posts, maybe the outcomes of the sentiment analysis of these posts should be given just to the staff or to whoever has an interest in assessing this kind of information, the sentiment analysis.	
	3	**DS:** Well, text analysis, definitely, we'll need this. And we can also analyse the sentiment of the blog post when the people write some... For example, if you write...	
	4	**DS:** There's an empty one. Yes, you can use some machine learning. Because you got CIC Around, I don't know how many text you got, how many students are using CIC Around.	

[Narrative] ***Clarify***	5	**Facilitator:** This is almost 500 students in total, and we have almost 2000 blog posts.	
	6	**ST1:** Not too much at the moment.	

Vignette Commentary

The challenge

The disagreement between the student and the data scientist emerges when discussing the technical side of the learning analytics tool. The ST1 proposes sentiment analysis as the main analytics method using is knowledge in the field which turns out is limited according to the data scientist experience. For the purpose of learning analytics design, participants are expected to contribute in each category, however, the areas of expertise influence their commentary and, in the end, gives weight to their arguments when making decisions. The DS argument over the lack of data comes from his experience with the topic and developed data literacy.

The role of the practitioner

The practitioner working as a facilitator guided the conversation into deciding over which analytics methods would be the most effective. In line 1 the *inquire action* introduces the issue for participants to solve. This places the conversation into a specific context around technical components. As the conversation continues, the facilitator *clarifies* question asked by the participant to inform their arguments and support the [Narrative] on data algorithm components.

Effectiveness of the co-design tool (LA-DECK)

The LA-DECK tool helped participants into analysing their options before deciding what to do next. The analytics methods card were used by both the ST and DS in line 3 to demonstrate their choices while explaining the details on how to use them. The analytics method category narrows the extensive library of methods into the most popular categories to give participants a quick look into what can be done. The cards also helped participants to stay in the topic and focus on the analytics methods after discussing the data sources.

6.5.2.5 Other practical challenges for the practitioner/researcher

Participants’ availability: Some sessions require careful scheduling in order to allow students to participate while, at the same time, keep the project within the planned calendar for completion. In cases where students could not participate, individual feedback and interviews helped us extract additional information. The most important thing is to keep students involved even if this means making changes in the schedule or in the original plan. Communication before and after the sessions must be dynamic. The most useful action to do is to set more than one channel to send messages via email, social media or group chats to participants.

Keeping these communication channels open is also critical for managing a third challenge: walking the fine line between remaining open to ideas as they emerge and keeping Co-design sessions (and the project as a whole) on track. Co-design seeks to remain very responsive to the insights and understandings that emerge through the design stages. When working with learners, educators and designers, the co-design practitioner had to remain sensitive to the interests of students, while also ensuring they can glean from the sessions what is needed to move forward. In this project, we used the tools and techniques described in the previous section of this chapter to elicit understandings about the data and the analytics that would best support student learning, but at all times we needed the learners to be free to imagine from their perspective and not ours. Thus, we had to be careful not to presuppose any particular outcome. When trying to keep a project on track this can be an enormous challenge. Alongside the frequent contact with our learners, regular referential conversations within the team helped both students and team goals to shape the project.

One final practical challenge during the Co-design process is the mechanism used for analysis. Most of the information gathered from Co-design sessions is qualitative. Thus, designers or researchers need to spend time trying to extract some knowledge from the sessions in order to take meaningful actions. Each particular Co-design tool may require a specific qualitative analysis methodology or framework for extracting knowledge. The more tools and techniques to be used during the first stages the more analysis time is required to distil critical information useful for design.

6.5.3 The role of the co-design practitioner

The main role of the practitioner focused on how to provide a proper place for collaboration using a facilitation perspective when using the LA-DECK tool. Results shown in this section are a contribution towards RQ2 What are the roles of the co-design practitioner in LA. Figure 6-23 shows a map of our research question and objective used to guide our contribution towards generate understanding on the multiple roles of the co-design practitioner leading to guidelines.

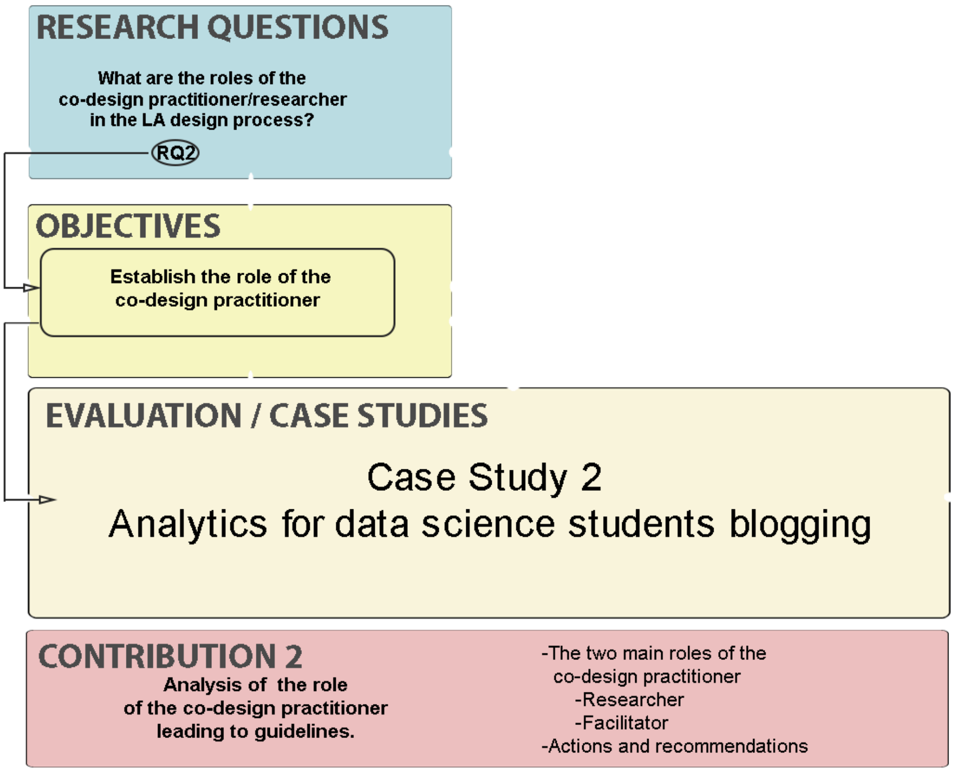


Figure 6-23: Map of contribution 2 in relation to RQ2 Emerging challenges in Co-design for LA.

6.5.3.1 Co-design practitioner as a manager in facilitation

When engaging with the multiple sessions, the co-design practitioner acts as a facilitator involving strategic planning across the iteration. The first action requires the practitioner to Plan and Manage each session following the research objectives as a guide. Each session requires for a mixed of students and academics to make sure stakeholders are being represented by at least one participant. The mix of stakeholders from different backgrounds follow the co-design principles behind our research enquiry of how collaboration emerges. As in many co-design projects, managing people depends on their availability and the practitioner required to establish a time for academics to be present and students to attend.

A recommendation that came out of our experience, in this case, is to set a time and place comfortable for everyone even if the research team must relocate for this. Motivation is tied to the amount of effort participants are willing to put into our project and learning analytics projects are not their main concerns when it comes to using their time. The co-design practitioner required to be able to move the recording equipment, bring the cards and set the co-design settings outside the design team department.

Part of engaging in planning as a facilitator is to make sure sessions and tools are adapted to the current research needs and participants. The co-design practitioner required to adapt the cards approach and come up with multiple versions of the same LA-DECK. The action of adapting the tool for the following session using the information found in the pilot study is a continues action that benefits the effectiveness of the tool. The practitioner describes what cards must be added or modified based on who is participating and what kind of tool is being designed.

6.5.3.2 Co-design practitioner as a Facilitator

The facilitator role is enacted when using the cards during the sessions with stakeholders. The main actions found in the critical incidents and practice can be explained through the multiple dimensions of the Knowledge art framework (Section 0) and introduced as specific actions for the co-design practitioner.

A notable example of new actions found in co-design for LA is the notion of representation when participants are not able to attend all sessions. In some cases, the facilitator acts as a proxy for representation for students. An example during sessions 5.1 the teacher tried to add a social network analysis card as a main feature. The practitioner intervenes and explains that students are not comfortable sharing their social media content with the tool. The conversation is illustrated in the following vignettes.

Table 38: Students stating the limits on sharing their social media

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***			
	1	**DS**: We can use information from their	

		social network profiles to fit their preferences	
	2	***ST1*** (Action – *Plays a [Social network] card.*	*[Social Network] Card*
[Ethics] ***Represent***	*3*	**ST2**: I never thought of that.	
	4	**ST3**: It's quite personal information.	
	5	**ST2**: Information should be shared. If information is retained, it's pointless.	

Table 39: Facilitator representing student interests when the DS suggest sharing social media data.

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***			
	1	**DS**: We can use information from their social network profiles to fit their preferences	
	2	***ST1*** (Action – *Plays a [Social network] card.*	*[Social Network] Card*
[Ethics] ***Represent***	*3*	**ST2**: I never thought of that.	
	4	**ST3**: It's quite personal information.	
	5	**ST2**: Information should be shared. If information is retained, it's pointless.	

Table 40 shows a summary of how the actions emerged through the sessions and the results from the practitioner following this practice.

Table 40: Actions enacted by the co-design practitioner as the facilitator.

Framework Dimension	**Action**	**Result**
Aesthetics	*Adapt* generic templates to participants needs and profile.	Personalized templates and rules of the cards made the communication
	Display the LA-DECK outcome to everyone at the end of the session.	Participants are able to go back and further discuss the relationship between the cards

Ethics	*Represent* MDSI students interests when their attendance to design sessions is limited.	The co-design practitioner works as a proxy for students interests when decisions on what features should be included and what data is considered private for them. See example 5.1
Sensemaking and improvisation	*Inquire*	The co-design practitioner requires to improvise by bringing examples and elements found in other tools to make sure the conversation keeps flowing.
Narrative	*Exemplify* conversations with stakeholders to make sure research interest are being discussed across multiple sessions.	The co-design process required to shape activities around the 3 year iterative process. This action often required for the practitioner to guide conversations, keep participants on track to finish activities and shape questionnaires to make it relevant to researchers' interests.
Improvisation	*Improvise* when participants find difficult to use available tools. This also refers to design tools flexible enough to support participants' improvisation.	Participants found difficult to use some of the tools available when designing their journeys. Improvising by using pen and paper became the only way for them to keep the process going.
Software & Technology	*Manipulate* technology features to facilitate things for participants. Picking the right software & technology medium for generating/showing visualizations brings benefits and constraints unique to their application.	The co-design practitioner decides when to shift from paper-based tools to software applications. Initial design sessions required a flexible medium such as pen and paper, but later iterations required digital tools to fit information.

6.6 Conclusions from case study 2: co-designing blog analytics with data science students

Findings from running co-design session with the data science students can be summarised following our three research questions. The following list includes insights about the adoption/adaptation co-design techniques into LA design:

- Adopting co-design techniques like focus group, sketching and collaborative personas are effective co-design techniques to kickstart the design process with learners. The face-to-face collaboration allows stakeholders to debate and reach a solution in real time while understanding technical concepts relevant for LA.
- Adapting traditional card-based games using the LA-DECK is an effective technique to introduce a common language for all stakeholders regardless of their experience with learning analytics design. The cards can be used as a framework to identify the components required for an LA tool to function. Also, learners' familiarity with card-based games made the LA-DECK easier to understand by inexperienced learners with design tasks.

A summary of our findings when looking for an answer to our second researcher question involving the role of the co-design practitioner can be listed as:

- The co-design practitioner/researcher oversees setting up the co-design process, invite relevant stakeholders to design sessions and keep the process evolving into what becomes an LA tool.
- There are two roles that the co-design practitioner must perform in co-design for LA: The facilitator and the researcher.
- The co-design practitioner performing as a researcher in this case study involved understanding the research work behind graduate attributes development and translating things back to stakeholders through the co-design techniques. It also involves documenting results towards the effectiveness of the tools with MDSI students, adapting the tools to fit the diverse expertise found in stakeholders and make sure that the research questions are being answered.

- The co-design practitioner performing as a facilitator involves actions like guiding learners into using the co-design techniques to debate their interest towards LA tools. Keeping the collaborative space in a format that stakeholders can revisit information produced during the sessions, inquire stakeholders into reflecting on their practice and communicate their expectations towards the LA tool.

Insights about challenges emerging when interacting with stakeholders can be summarised as follows:

- Surveillance and privacy is a topic that MDSI students are well informed to request fair use of their data. It also introduced the concept of trading their data in exchange for an accurate LA tool understanding the value of personal data in academia. This is different than our findings in case study 1 where nursing students were not capable of negotiating their data use since data literacy played an important role when expressing their concerns.
- Leaners made suggestions towards the learning design that mostly come from their inexperience with teaching and learning theory. The course director and other teachers must provide expert commentary to analyse students request and make an informed decision.
- The co-design techniques like LA-DECK helped stakeholders minimize these challenges. Debate using the co-design techniques clarify many of the concerns that leaners had in relation to privacy and learning design and were clarified in the same session allowing the co-design process to continue.
- Implementing DBR in this case study helped to structure effective iterations to deploy instruments to gather data, while at the same time develop the learning analytics tool. At one point, the methodology was adapted to introduce short design sprints combining teachers and learners with other stakeholders. For each intervention, the tools and physical space changed, hence the need for adapting the DBR iterations and capture data using more than surveys.

7 Case Study 3: Co-designing rules for automated feedback

Chapter overview

This chapter describes a case study in which teachers, academics, researchers and EdTech designers from multiple universities engaged in a co-design session to design rules for a learning analytics tool called OnTask.

OnTask is a learning analytics tool that enables teachers to send personalised feedback messages at scale. However, it is necessary to understand how to set up the messages and conditional rules. In this case study, participants were invited to use an adapted version of the LA-DECK to produce the rules required for OnTask to function.

1) The card base approach technique can be used to co-design components on already existing LA tools like OnTask. Nevertheless, it is necessary to adapt the tool to fit the language used by participants.

2) The adaptation of the LA-DECK for this case study proved to be useful when generating the rules in collaboration but still requires some improvements when it comes to the language used for non-technical stakeholders.

3) There is an emerging challenge that involves participants' capabilities to understand technical concepts mostly attributed to IT department. The co-design practitioner must ensure that the adapted co-design techniques are able to minimize this challenge by using common terms for complex topics in LA.

This chapter describes a case study in which teachers, academics, researchers and EdTech designers from multiple universities used an adaptation of the LA-DECK card-based approach (Chapter 6) to co-design rules for a personalised feedback platform called *OnTask* (Pardo et al, 2018). The chapter starts with a description of the current OnTask capabilities and the intention to use co-design as an approach to generating rules inside the platform. Next, the adaptation of the LA-DECK tool is detailed, introducing a new set of cards only relevant for OnTask. Finally, results are described in terms of emerging challenges when engaging with the co-design task, the effectiveness of the tool and the role of the co-design practitioner.

The following figure shows the map of the three research questions that will be track along this chapter as the third case study. Findings and contributions will be later discussed using the map to make sure all questions are being solved linking evidence shown in the multiple iterations.

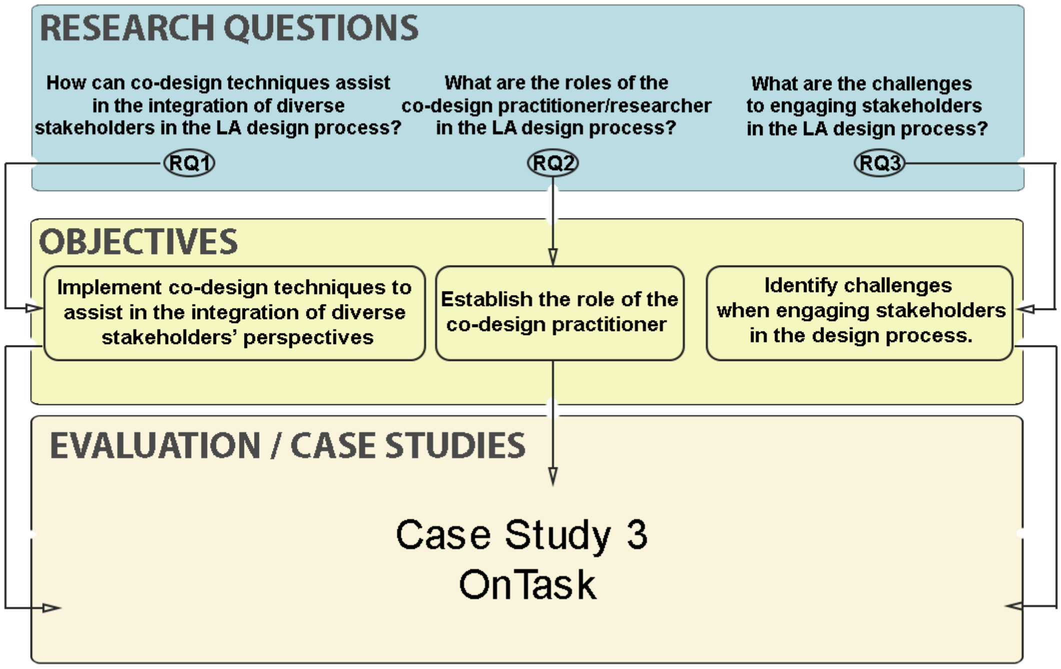


Figure 7-1: Map of contribution 1 in relation to RQ1 Co-design techniques.

7.1 Context and Stakeholders

This case study tested the scenario where a downstream design approach meets the capabilities of co-design as the main philosophy. Ontask is a learning analytics project that "*aims to improve the academic experience of students through the delivery of timely, personalised and actionable student feedback throughout their participation in a course*" (Pardo et al., 2018). OnTask feedback is sent through personalized emails to hundreds or even thousands of students, using an approach similar to "mail merge". For teachers and academics to deliver so many emails, they have to understand how to set up rules defining conditions in the student data which will trigger the inclusion of a feedback message in the email.

A simplified example of how rules are managed in OnTask can be seen in the following figure.

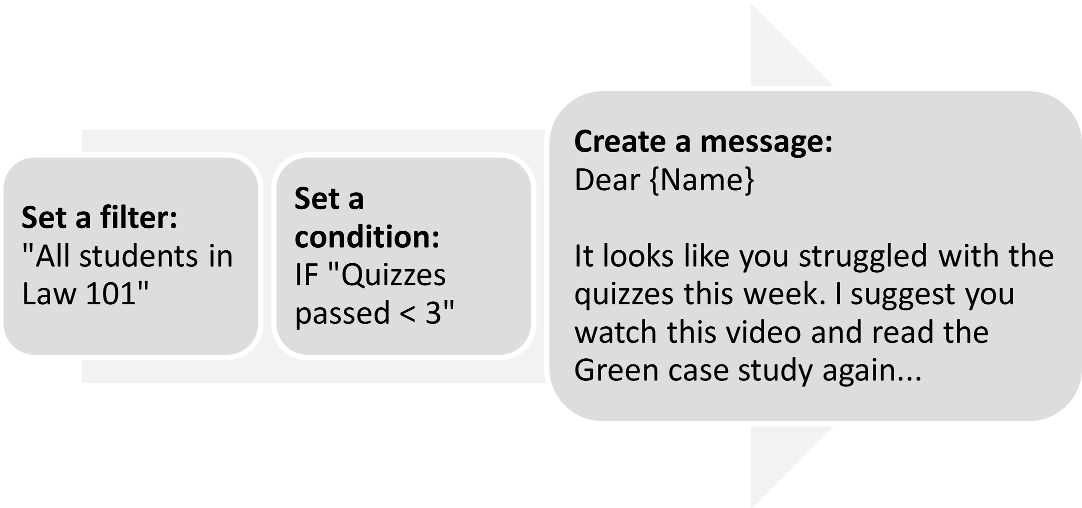


Figure 7-2: Shows the rule authoring interface for building IF… THEN... rules

Figure 7-3 shows the email authoring interface, in which the names of rules are inserted into the template

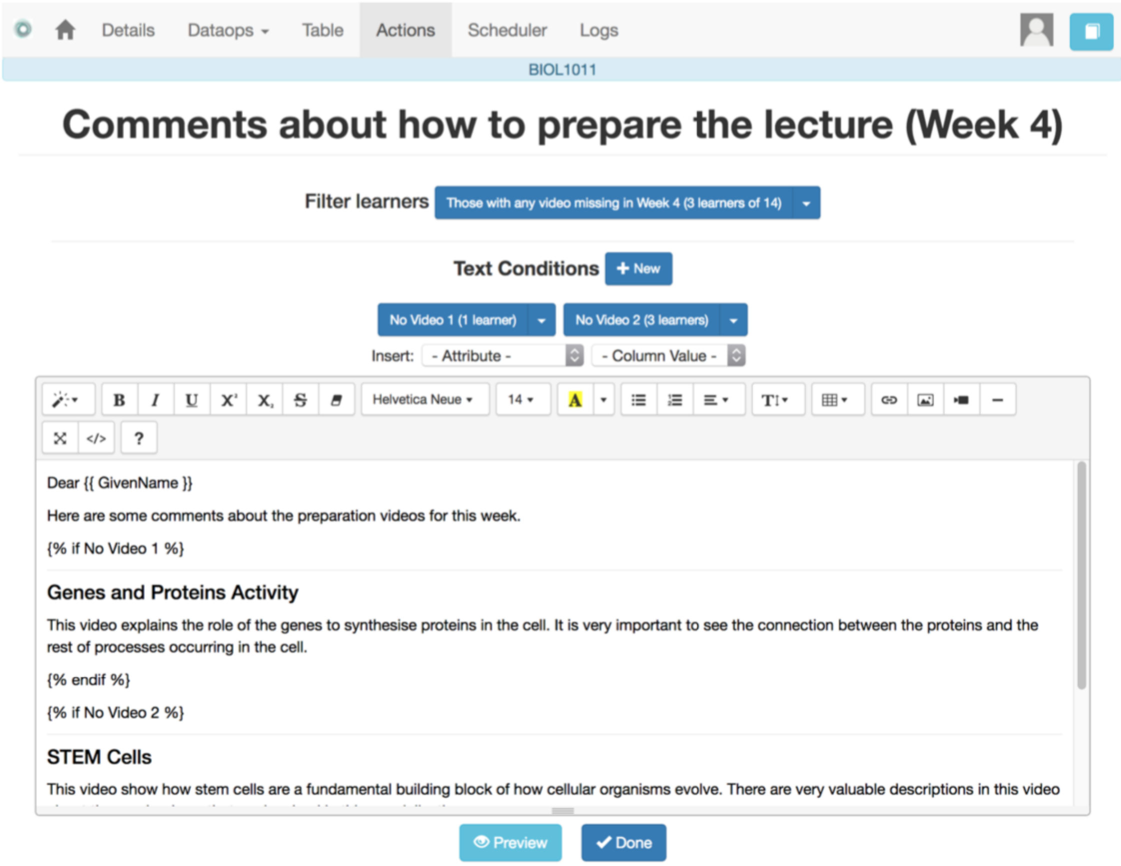
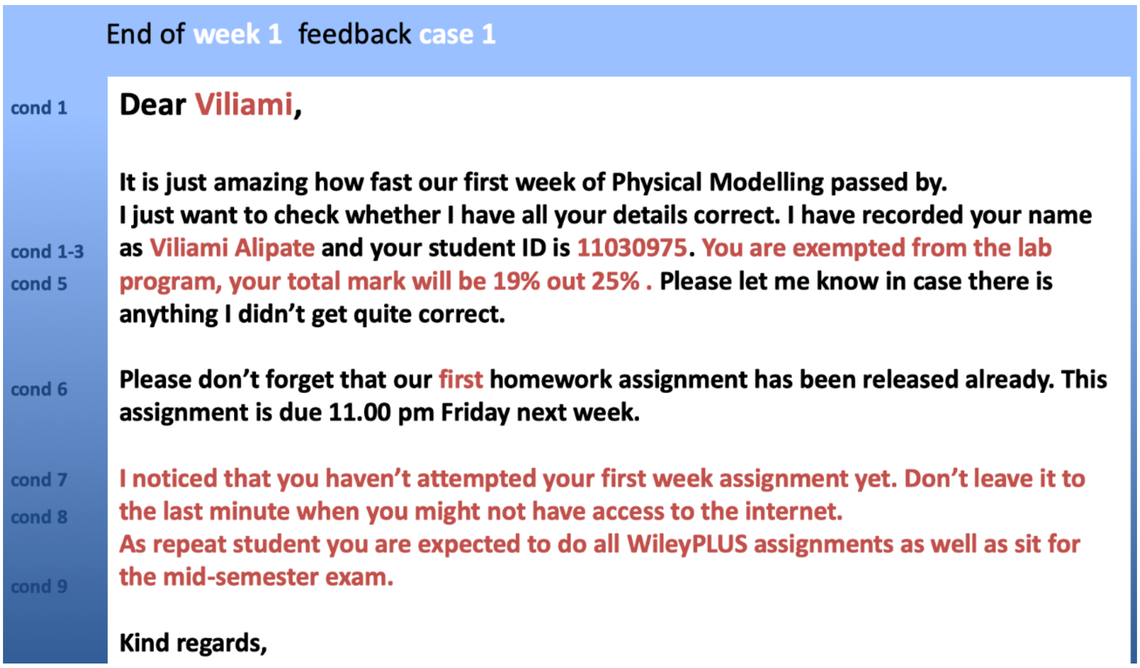
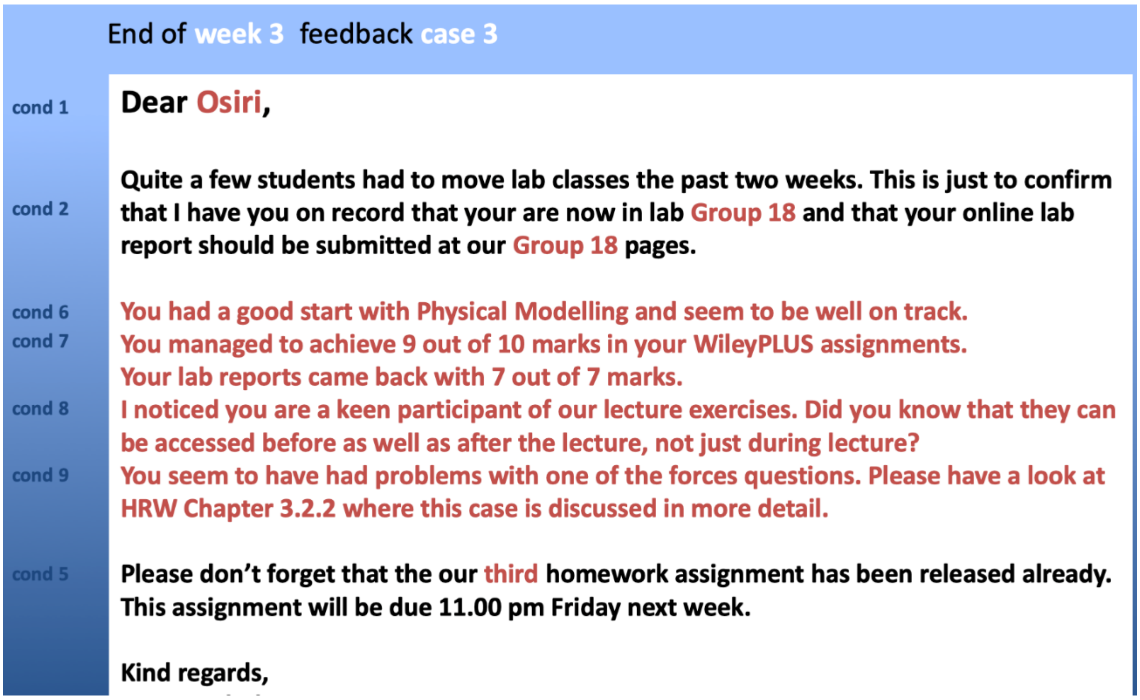


Figure 7-3: User interface for designing personalised email feedback in OnTask From (Pardo et al., 2018).

Figure 7-4 shows examples of two automatically generated emails once rules have fired and inserted feedback relevant for the student.




End of week 3 feedback case 3

cond 1 Dear Osiri,

cond 2 Quite a few students had to move lab classes the past two weeks. This is just to confirm that I have you on record that your are now in lab Group 18 and that your online lab report should be submitted at our Group 18 pages.

cond 6 You had a good start with Physical Modelling and seem to be well on track.
cond 7 You managed to achieve 9 out of 10 marks in your WileyPLUS assignments.
Your lab reports came back with 7 out of 7 marks.
cond 8 I noticed you are a keen participant of our lecture exercises. Did you know that they can be accessed before as well as after the lecture, not just during lecture?
cond 9 You seem to have had problems with one of the forces questions. Please have a look at HRW Chapter 3.2.2 where this case is discussed in more detail.

cond 5 Please don't forget that the our third homework assignment has been released already. This assignment will be due 11.00 pm Friday next week.

Kind regards,

Figure 7-4: Examples of automated emails in which the red text is inserted dynamically, depending on the student's activity data (Acknowledgements: Jurgen Schulte, UTS Faculty of Science)

Academics can set as many rules as needed, this is where the rule design process and tool capabilities can be improved through co-design when opening the design process to learners and other stakeholders.

7.1.1 The rationale for a card-based approach to rule co-design

The rationale for testing a version of LA-DECK for OnTask rule co-design was that it might show potential to give non-technical stakeholders a voice by making the elements of rules tangible, as physical cards. The concept of using visual representations for technical concepts is an area of creative exploration considering user knowledge limitations.

Some example include rules for the abstraction of concepts to create icons and visualisations that represent connection and ideas (Chang, 1986). In recent examples, digital tools have been implemented to provide a creative space focused on the application of programming concepts without focusing on the syntax of programming languages (Repenning, 2017). An example used in school to teach kids how coding works is Scratch. In Figure 7-5 Examples of how to use Scratch through a visual tool illustrates how depictions of objects and connectors are used to represent relationships and cycles in coding.

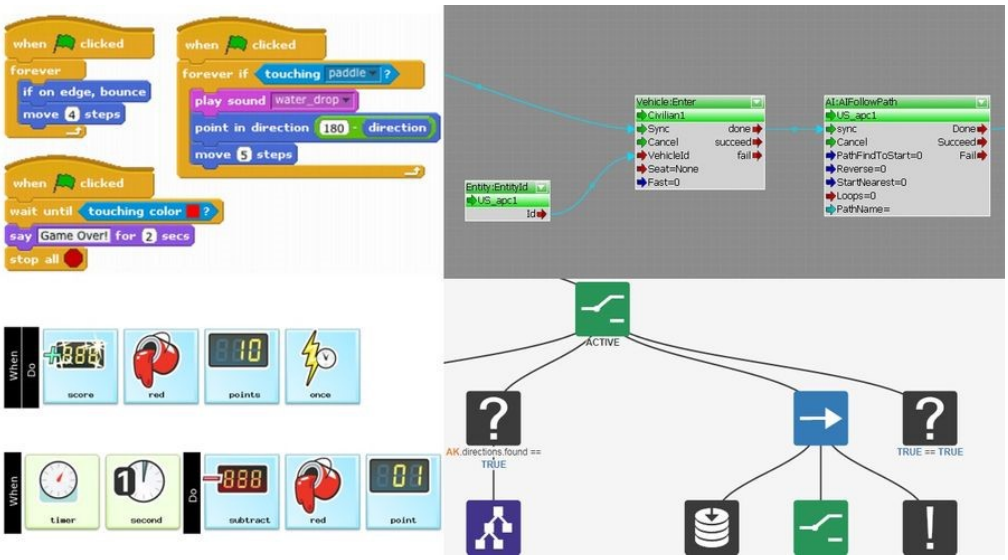


Figure 7-5: Example of Scratch programming (MIT, 2020).

This version of using card-based design for OnTask rules generation is based on the concept of using abstract representations to allow non-technical stakeholders to collaborate in the design process. Instead of using a digital space, the card-based approach takes advantage of the physicality of paper and bring flexibility into stakeholders' collaborative space.

7.2 Study and analysis

This iteration is defined as a Downstream approach to design since OnTask is an ongoing project documented and maintained to its latest version by multiple research teams. As shown in Figure 7-6, all documentation found in the OnTask project is used to adapt the card approach and generate better understanding towards better co-design technique. The previous research allows us to focus on one aspect that is suitable for collaboration referring to the rule generation and data source management.

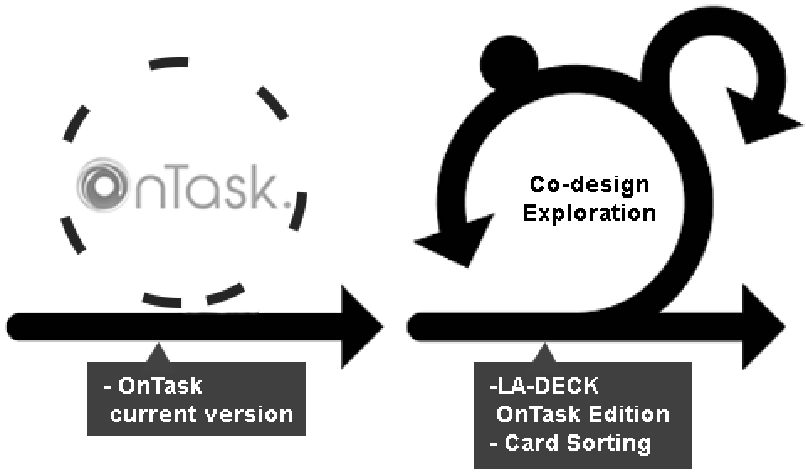


Figure 7-6: Stages and tools used for an explorative iteration over OnTask current version.

This iteration comprised a design workshop, as part of a larger workshop attended by participants interested in, or actually engaged with, OnTask or similar systems. The list of participants and their role descriptions is included in the following table.

Table 41: Participants in Case Study 3.

Role	Description	Participants
Learning Designer (LD)	Responsible for giving structure to the pedagogic content and strategies for teachers to implement in their courses.	1
Head of Learning Department (HL)	In charge of design, manage and improve the faculty tools and resources.	1
Support Education Department (SE)	Provides learning resources and tools for teachers and faculty members.	1
Teacher (T)	Interested in using OnTask as part of their course.	2
Learning Program Manager (LP)	Designs and manage the current learning programs followed across faculties.	1
Co-design Practitioner (CP)	Responsible for organizing, guiding, facilitate and orchestrate design sessions through co-design.	1

Information was gathered through end-of-session surveys, plus notes and audio recordings from the groups and the plenary discussion. Evidence was analysed through a thematic analysis similar to the one used in the original LA-DECK. This form of analysis allowed us to look for specific characteristics to determine if the card-based approached used by de LA-DECK Ontask Edition. The pre-set themes are based on Roy & Warren's analysis for card-based tools (Roy & Warren, 2019), maintaining continuity with Case Study 2. These headings guide the results section:

- *Cards provide a common basis for understanding and communication in a team;*
- *Cards support creative combinations of information and ideas;*
- *Cards are semi-structured tools between blank Post-it notes and detailed instruction manuals;*

We ignored the last theme proposed by (Roy & Warren, 2019) analysis of card-based tools, referring to cards being used as convenient summaries of useful information and/or methods. The reason for this is that the design of LA-DECK OnTask edition is not intended to work as a summary for concepts behind OnTask inner workings but rather as a tool to break the task into workable sections and support stakeholders collaboration.

7.2.1 Task and sessions

Participants worked in 5 teams. The distribution was done as a self-organized team since participants were given the option to pick their teammates. The objective of the session was to generate rules to fit into the design problem under the 60 minutes session length using the LA-DECK OnTask edition cards available for them in each table. We had set a general problem found in learning analytics practice for participants to use as an example: "Imagine you have 300 students in week 3 and you have a compulsory rule that students must receive feedback by week 3". After designing their rules, participants were asked to complete a research survey where they could give feedback on the cards.

7.3 Tools and Methods (LA-DECK OnTask Edition)

The LA-DECK OnTask Edition (LA-DECK-OE) is an adapted version of the original LA-DECK introduced in Chapter 5. In this version, we provide 6 Categories and 18 different cards that use the language and structure of OnTask rules. The different categories and cards available are shown in Figure 7-7.

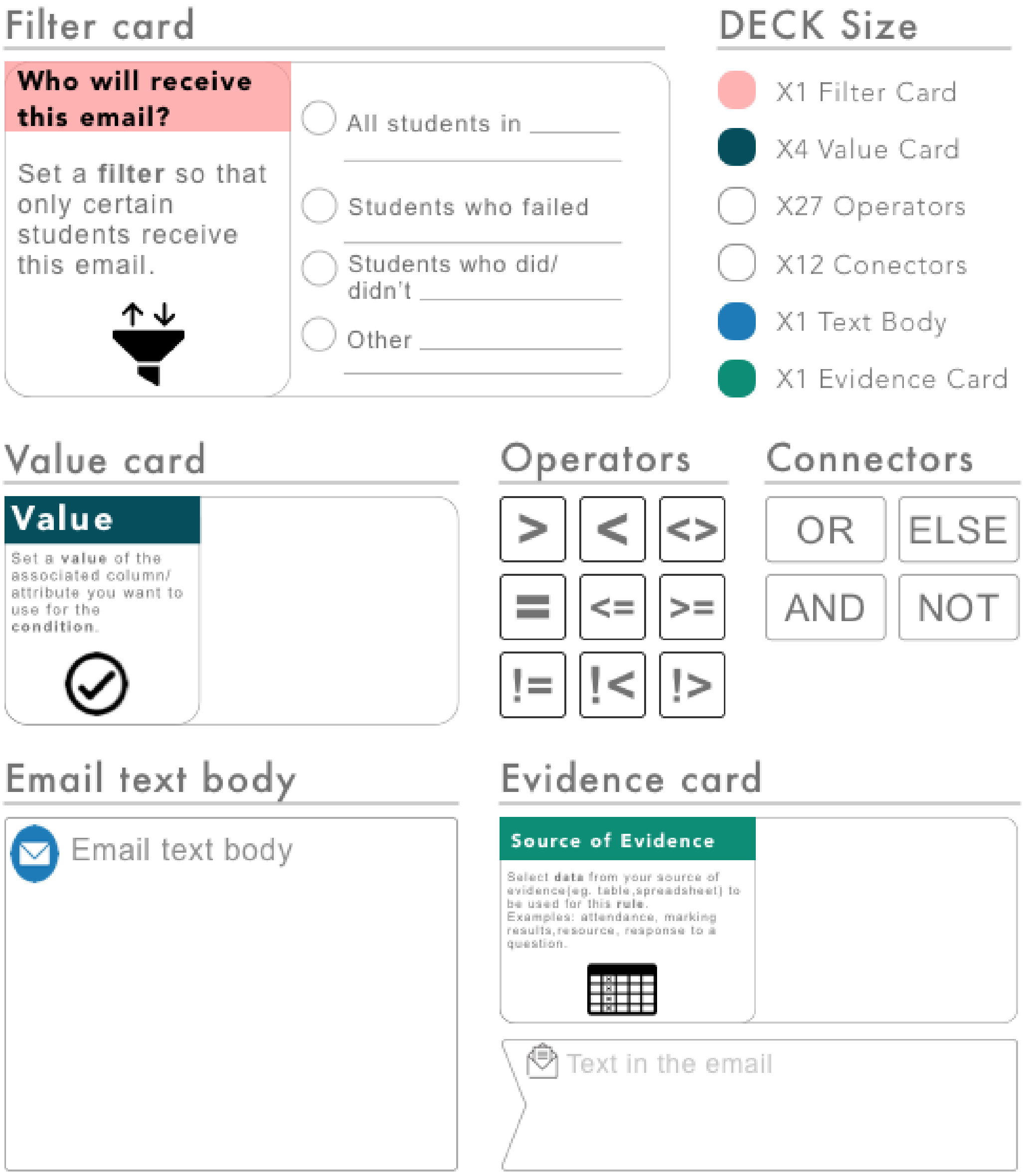


Figure 7-7: LA-DECK OnTask edition set.

Filter card: The objective of this card is to allow participants to identify the recipient for the personalized email. The card provides options for participants to pick from a whole set of students, students with specific characteristics or a free form to set students profiles. As an example, participants can mark the first option [All Students in] and then write the intended cohort like "Computer Science 01". This means that all students part of the Computer Science 01 course will be used as the main recipient.

Evidence card: The objective of this card is to allow participants to identify the source of evidence for OnTask to use as the data set. An example of this could be selecting all assessment results from the Computer Science 01 in Moodle (Or any other LMS).

Operator card: These cards are intended to be used as mathematical symbols to compare the evidence with the values. Examples of the cards include equal, not equal, greater than, less than, greater than or equal, less than or equal. An example of this card in use is to reference all students who got an assessment mark [Evidence card] greater than [Operator Card] a specific value [Value card].

Value card: This card is intended to be used as a placeholder for participants to select a value associated with the source of evidence. The blank space can be used to write a number of words that will trigger an action in the OnTask system. An example of this can be in combination with the other cards like all students who got an assessment mark [Evidence card] greater than [Operator Card] 5 [Value card].

Connector card: These cards can be used to connect different rules and create bigger conditions. Examples of the cards in this category are logical connectors like And, Else, Or, Not. An example of this card in use could be All students who got an assessment mark = 8 AND [Connector card] All students who got an assessment mark < 7.

Email text body placeholder: These cards are used as a blank space for participants to write the intended message for delivery. This is a free form space where stakeholders have control over the style, wording and intentions when students get the message. An example could be a positive message like "I see your work improved over the last 2 months, good job and keep going".

The instructions to use the cards recommended participants to use the categories following three main steps. The sections guarantee that all of the different types of card will be used but participants also had the possibility to make their own arrangement, and add new contents through blank sticky notes if required.

- Section 1: Participants must decide who will receive a personalized message using the Filter card.
- Section 2: Participants selected the source of evidence and create the conditions using the Evidence, Operators, Value and Connectors card.

- Section 3: Participants write the intended message using their own words and results from the condition being applied. The message can be written using the Email Text body card as a whole email or a partial message using the small version of the card.

7.4 Results

The results show what was learned from adapting the LA-DECK cards to the rule-editing scenario. The first analysis presents the task completion across groups, the second part explores in more detail the interactions between participants and the tool using the three themes introduced in section 7.2.1.

7.4.1 Task Completion

We considered a task as *complete* when the participants are able to use all types of cards as intended within the 60min session. A task was classified as *partially complete* when participants did not use the cards as intended but completed all the sections, and *incomplete* when the participants neither used all types of cards, nor completed all the sections. Using these criteria, we found that 2 out of the 5 groups were able to complete the task as expected, summarised in Table 42.

Table 42: Task completion across groups using the LA-DECK OnTask edition

Group	Section	Cards Used	Completion	Section	Cards Used	Completion	Section	Cards Used	Completion
1	1	1	Complete	2	15	Completed	3	4	Complete
2	1	1	Complete	2	5	Completed	3	1	Complete
3	1	1	Complete	2	4	Incomplete	3	0	Incomplete
4	1	1	Complete	2	5	Incomplete	3	0	Incomplete
5	1	4	Complete	2	16	Incomplete	3	6	Partially Complete

Note that the number of cards used is not related to successful task completion task in all cases. For example group 1 and group 5 used almost the same number of cards in section 2, but while group 1 had experience in using the OnTask and understood the intention of the cards. Group 1 and group 2 proved to have experience with the OnTask structure and language making this easy for them to use the cards as intended. Figure 7-8 shows the cards and conditions created by group 1. This example is considered a successful use of the cards, but groups 3-5 failed to complete the last two sections.

Figure 7-8: Conditions created by group 1 using the cards as intended.

Analysis of the sheets showed that section 2 was the most difficult part to design process based on the number of cards being used and questions raised to the facilitator. Participants not being able to define the evidence and values part of section 2 were not able to continue and generate the personalized message (section 3). This explains why section 3 is marked as incomplete for these groups even when the message can be written at any time during the process. (Roy & Warren, 2019) three themes provide further insights into why most groups failed to complete section 2 and 3. Figure 7-9 shows the cards being used by the first 4 groups and the incomplete steps in group 3 and 4.

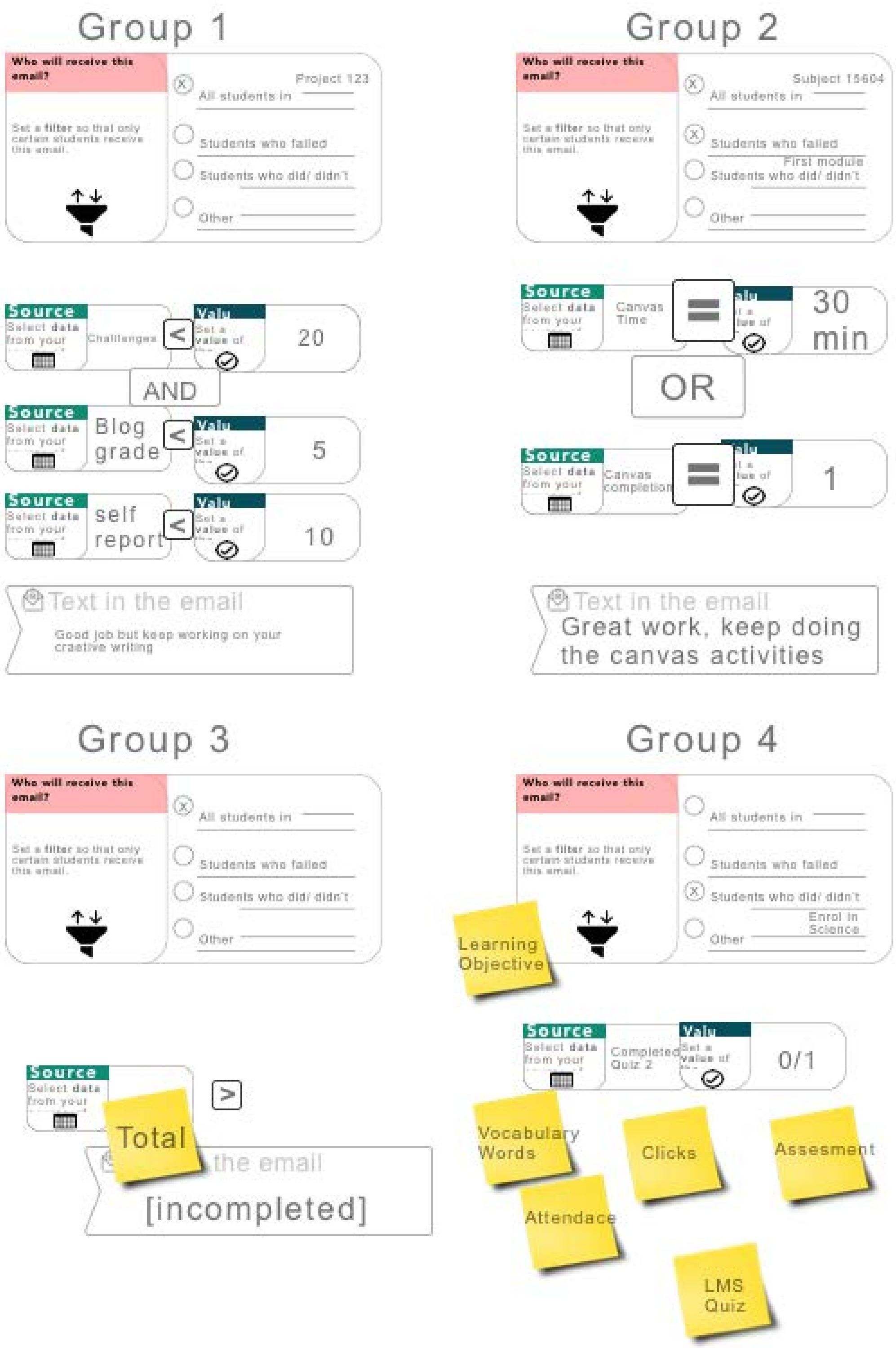


Figure 7-9: Sample of the cards used for the first 4 groups.

7.4.2 Cards provide a common basis for understanding and communication in a team

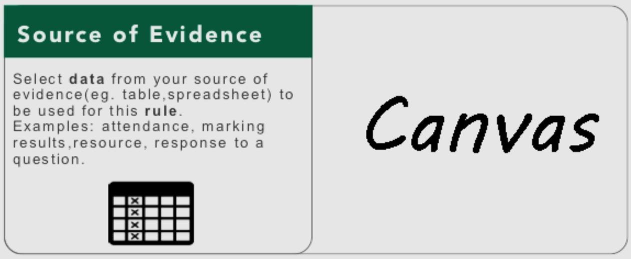
The design of the cards proved to be successful in terms of representing simple OnTask rules. However, the language used in the cards turned out to be too technical for participants without an IT background. As explained by a teacher (TE 1) and learning designer (LD1) in group 3 and 4, *"The term Value and Evidence mean something different for me, I know this is the IT lingo but as a teacher, I find this confusing." (TE1*) "*Calling these conditions and operators sound like something from IT and in my experience most teachers are not used to this" LD1.* This sort of debate between participants made the task hard to complete in the expected time. We learnt from this that the cards must mimic teachers' language rather than technical terms, since the expected users of OnTask are teachers and academics from other departments outside IT. These comments helped the OnTask project team to think about interface implications, to address the problems that participants were having when using the cards.

7.4.3 Cards support creative combinations of information and ideas

The structure of cards proved to be useful when merging multiple conditions for those groups familiar with the language. An example of this can be seen in the map from group 1 (Figure 7-8). The [Connector] card worked as intended since the participants worked out how to create conditions. From the other sessions, when participants are not able to define a condition, the [Connector] card became useless and participants debated the purpose of conditions.

The [Evidence] card became a subject of discussion in all groups by providing a space/time to discuss and combine multiple ideas. The example shown in the following vignette presents a conversation were a teacher (TE) and a learning designer (LD) discuss two ideas when it comes to picking sources of evidence to deliver feedback to students currently struggling with their assessments.

Table 43: Vignette showing 2 participants using the [Evidence] card to combine two ideas.

<table>
<tr><th>Line</th><th>Comment</th><th>LA-DECK</th></tr>
<tr><td>1</td><td>TE: The REVIEW system can be a good source for this (people failing the assessment), we can start from there. [Plays an Evidence card]</td><td>
</td></tr>
<tr><td>2</td><td>LD: If we get access to Canvas, we can see if they are also failing to submit their assessment. [Plays an Evidence card]</td><td>
</td></tr>
<tr><td>3</td><td>TE: Yeah, not sending the document is different than getting a low mark.</td><td></td></tr>
</table>

7.4.4 Cards are semi-structured tools between blank Post-it notes and detailed instruction

The cards provided a space for participants to write their own notes and allowed them to re-arrange the sequence if required. However, some participants decided to use the cards as a guide and replace them with post-its with their own content. An example of this action can be seen in Figure 7-10. In this example from Group 5, the Learning Designer (LD) and Head of Learning Department (HL) used the Evidence card as a guide to define as many sources of evidence useful to work with OnTask, reflected by their comment, "*The cards are useful when discussing data sources with your team but still we couldn't finish the other sections*".

The HL also introduced the idea of a missing card that could make the design task easier. The suggested card marked as [Learning Objective] was introduced in their map using a post-it, since the deck did not provide this card. The reason for this card according to them is "*It is hard to pick the evidence and values when you are not sure what are you trying to accomplish, we had to set a learning objective at the beginning so all the thing proposed to make sense*". This led us to introduce the [Learning Objective] Card as an update to our first deck. In addition, the developer took note of this comment as a potential new field in OnTask, for users to record the learning objective when writing their rules.

Figure 7-10: Using sticky notes to create new categories and content not provided by the deck.

7.4.5 The role of the co-design practitioner

This case study reinforces the idea that several different roles are played by the co-design practitioner/researcher, depending on the task and time in the design process. In this case most of the tasks required for the practitioner to play the role of the facilitator and made sure the tool is being used during the sessions. The other role played by the practitioner is the facilitator, this role is particularly useful when adapting the cards to the OnTask context and deciding the best place/time in the design process to use them.

The actions enacted by the facilitator in this case study required direct interaction with stakeholders. This means that the practitioner/researcher introduces the tool at the beginning of the design sessions, makes sure that participants understand the rules to use the cards and resolves any questions during the sessions.

The practitioner acting as a facilitator role is enacted through actions when putting together the LA-DECK OnTask edition. The actions referred to the design of the visual components for each card, stablish the categories to make sure conversation stays in the context of the OnTask platform and writes the rules for implementation if the tool is intended to be used in other parts of the design process. This role is enacted without stakeholders' intervention and requires the practitioner to focus on the tool capabilities to be used in collaboration.

7.5 Conclusions from case study 3: co-designing automated feedback rules with learning analytics professionals

In this study, the cards were usable by more technical people familiar with writing rules about data tables, and there were signs of similar benefits to those observed with the LA-DECK cards. However, the fundamental problem identified in this case study seemed to be that less technical people needed training to understand how to write good rules, but this lack of literacy is not something the card deck could solve. We might conclude therefore, that for less technical people, the deck is better used for less formal, more upstream requirements gathering, to help them think through what the sources of student evidence will be, and indeed, there was evidence of the cards assisting in a general discussion about this.

In this pilot, the cards did not assist non-technical people in thinking through the *thresholds* that differentiate students for feedback, which is necessary to agree on the *values* of variables in the rules. If ways can be found to augment discussion about data sources and thresholds, prior to introducing rule notation, the cards could help to bridge the *formalisation gulf* that often prevents practitioners from using modelling tools developed by HCI researchers (Shum & Hammond, 1994) . Future work could, therefore, focus on cards that do not try to mimic formal rules so closely, but seek to support conversations about requirements, prior to formalisation.

8 Discussion

Chapter overview

This chapter discuss the results and findings reported in the three case studies. The insights in this section provide future co-design practitioners with practical instructions to implement co-design techniques, insights on the co-design practice, the responsibilities and actions that can be taken as a co-design practitioner and the connection between the emerging challenges from co-design practice.

The highlights of the chapter can be summarised as follows:

1) Each co-design techniques brings a benefit to facilitate co-design in learning analytics. Collaborative tasks like focus groups, card sorting, persona profile open the design process to stakeholders by facilitating learning analytics conversations.

2) The co-design practitioner acts as a facilitator when engaging with stakeholders in face-to-face sessions. The other role played by the co-design practitioner is to support the research practice and engage as a co-design researcher during the case studies.

3) Beside challenges emerging as expected, there are instances where interacting challenges appear to influence the co-design practice. Stakeholders' *data literacy* reduces their capacity to negotiate solutions to their *privacy and surveillance* concerns. Learners' will suggest unrealistic changes to the *learning design* based on their limited *teaching and learning expertise*. *Power relationships* affected co-design practice in LA when stakeholders used their influence to support personal objectives in exchange for access to resources.

8.1 Adopting/adapting co-design techniques in learning analytics design (RQ1).

This thesis has documented how co-design techniques can serve as instruments that help give participants a voice in the design process. The following sections distill insights and recommendations for the different co-design techniques that were evaluated across the case studies, which engaged nursing and data science students, teachers, and academics with learning analytics researchers and developers.

8.1.1 Focus groups as a gateway into co-design

The use of focus groups as a co-design technique for learning analytics became a gateway for the students and academics to have a first experience of learning analytics design. Focus groups provided a way to introduce novel concepts for LA design including data use/collection, learning design and context specific terms required to effectively communicate along the design process. Furthermore, students used this space to also discuss their concerns, values and expectations beyond the learning analytics design.

During our three case studies, focus groups proved to be an effective way to have structured conversations with diverse stakeholders, a space in which they could contribute using their own language. For instance, in Case Study 1 nursing students use the focus groups to discuss their expectations of a learning analytics tools to provide automatic feedback, their concerns around the use of their multimodal activity data from clinical simulations, and their experiences of the current simulation learning designs. The design team not only used this information to define possible features for the tool but also to understand students' perspectives towards learning analytics tools and the learning context where the tool would be used.

In Case Study 2, students from the data science program diverted the conversation away from their current experience with a learning analytics tool towards problems with the course structure and definition of graduate attributes. Although the LA tool could not solve these, the groups still provided researchers with contextual insights into the student experience, which 'fills out the picture' when designing new tools.

Focus groups as co-design technique were thus an effective first step to invite stakeholders into learning analytics projects. However, planning a focus group session requires time and effort that the co-design practitioner must foresee to make sure all stakeholders are being represented.

8.1.2 The limits of collaborative sketching

Adoption of the collaborative sketch technique for co-design in LA demonstrated that the visual interface design of the tool can be a shared responsibility between the main designer and stakeholders. We tested different approaches to collaborative sketching over multiple iterations in case studies 1 and 2. In the beginning, nursing students were provided with post-its, a template simulating a web browser and markers to write and draw on them. Although we invited them to draw imagined future interfaces, participants ended up using the materials to only write descriptions of the features. This taught the co-design practitioner that participants' drawing capabilities should not be overestimated as a way to gather interface requirements. In the following sessions, the co-design practitioner brought printed examples of interface objects that participants could use to modify and paste wherever they want. These examples include data charts, different timelines, buttons and icons. Bringing these pre-designed objects facilitated the task for participants envisaging what they described as solving a puzzle, without having to learn how to draw.

These variations on the original collaborative sketching technique made the relationship between the designer and stakeholders more effective. Learners and teachers became familiar with the design process through their participation, and the main software designer was able to use this information to build a first prototype.

As a recommendation, the co-design practitioner should consider participants experience with design tools before bringing complex design tasks that may require time to learn. Not all participants know how to draw, and the co-design practitioner must intervene to help them develop their ideas into visual representations.

8.1.3 Collaborative personas to build confidence and consensus

Adapting the collaborative persona tool into learning analytics design allowed learners to create an accurate representation of their skills, goals, capabilities and needs.

When learners participated in creating this representation, communication between them became an exercise in reflection (as seen in 5.3.4). Most students struggled to describe themselves and the collaborative persona profile helped them to start with the basics of user modelling. The activity of describing common learners also helped them to find similarities with other students in the same course. Activities such as sharing preferences for social media outside Facebook, and their aversion to lengthy?? reading materials, led to further conversations that the co-design practitioner and the researcher used to improve the first prototype.

Learners are rarely asked to describe themselves, and they used this opportunity to express how different students can be. These differences when discussed in front of their team-mates led to the realization that their current tools provided by the university follow a common mistake in the design field "One size fits all". The co-design practitioner and the researcher used this information to avoid delivering results through the LA tool based on useless generalizations.

It is recommended to bring a template that fits the context where participants will collaborate. Allow participants to modify the template and collect as many examples as possible to build a more accurate description. After 5 sessions building multiple persona profiles in collaboration with learners, the co-design practitioner and the researcher were able to settle on one version including the most common details discussed by participants.

8.1.4 From user journeys to learner/data journeys

Adapting the established concept of user journeys for learning analytics made the *learner/data journey* an effective co-design tool for sharing knowledge between stakeholders (Case Study 1 Section 5.5.1.4.1). Implementing a learner/data journey as a teamwork activity permitted stakeholders to communicate and build a story that represented their struggles with their learning environment. During this process, students realized that problems that they attributed to their lack of skills were in fact a shared problem among peers. This improved their confidence to contribute details that made the learner/data journey an affective medium of expression. The way learners used the learner/data journey tool helped the co-design practitioners to better understand the relationship between the learning design, the group dynamics between learners, and stakeholders' expectations towards learning analytics innovations.

Instead of delivering insights only to the designer/researcher team (the primary function of conventional user journeys), this information was fed back in synthesized form to other stakeholders (teachers and academic course directors). This provided them with the chance to corroborate some of these findings and clarify when misunderstanding occurs between learners. This illustrated a benefit of using co-design as the driving principle for collaboration, with analysis becoming a shared activity, reducing bias and generating further ideas.

It is recommended to use the learner/data journey in combination with another tool better suited for starting design conversations like the focus group. This due that going through the three phases of the technique (Paper based, Analysis, Digital version) may take more than one session to produce results. The co-design practitioner must allocate time for the learner/data journey map to mature and be complemented with information from later sessions.

8.1.5 Card-based co-design with LA-DECK

Adapting the concept of card-based design tools for learning analytics helped us to better understand the capabilities of paper-based tools, participants' abilities to negotiate via design objects, and the need for customizable design environments.

To synthesise the results detailed in Case Study 2 (section 6.5.1), the LA-DECK card-based tool integrated and balanced technical, pedagogical and data-centric conversations. Feedback from participants indicated that they experienced the session as productive, and the tool as intuitive, regardless of their background. Language used in the cards when working with MDSI students (6.3.5.2) proved to be accessible and, in some cases, the conversation through the cards was not only used to give details to the co-design practitioner but also as an opportunity for stakeholders to learn about the other aspects required for an effective implementation of the LA tool.

However, not all implementations of the LA-DECK resulted as effective as case study 2. In Case Study 3's piloting of the *LA-DECK OnTask edition*, participants struggled to overcome the learning curve and failed to use the cards in their co-design sessions. We attribute this to the language used in the cards' representations, and the formality of the rules that the cards were designed to help build. Participants from a non-technical background struggled to understated IT concepts like Connectors, Data Evidence, Values and Conditions. The co-design practitioner did not anticipate that teachers from humanities and learning oriented departments would struggle to the extent that they did.

From our experience adapting the LA-DECK tool for sessions with diverse stakeholders, we recommend that all visual representations must consider participant's context and familiarity with the field. The co-design practitioner must be aware that IT, Data and Learning concepts are not things that stakeholders use in their tools every day.

8.1.6 Recommendations: adopting/adapting co-design techniques for LA

This section presents a series of recommendations for co-design practitioners/researchers to adopt/adapt tools and techniques for their learning analytics design projects. The structure of each recommendation is written so the practitioners can understand the concept and use the examples provided through the case studies.

8.1.7 Co-design techniques are more effective for upstream design deliberation

After two years facilitating and researching learning analytics co-design case studies, it is clear that co-design techniques were most effective when implemented in upstream stages of design iterations. This refers to the Understanding and Ideation stages where communication with relevant stakeholders is critical to defining the problem to be solved, as well as what might count as a reasonable solution. Since most software design is iterative, rather than an idealised waterfall model, this means that co-design techniques could be used at many points (not only at the beginning) — whenever the design team needs to step back and (re)frame the design problem or solution requirements. The huge array of other user-centred design tools can then be recruited for more detailed prototyping.

From the moment the co-design process starts, co-design techniques allowed the practitioner to collect evidence that later was used to solve design issues. Information collected with students in the first stages became a guide to write software requirements and plan the following meetings to accommodate their needs. This can only be done when participants are invited to design sessions before the development team starts to work in the technical aspects.

Meetings between stakeholders are more common at the beginning of learning analytics projects. This allowed the co-design practitioner to take advantage of this, inviting people to participate in the design sessions and test the co-design techniques. For example, in case study 1 we invited nursing students to give feedback on their current experience with simulations. Instead of asking this as a simple questionnaire, we designed a whole session using the focus group, learner/data journey, collaborative persona and collaborative sketch tool to make participants feel like collaborators instead of subjects.

Inviting participants to collaborate through the co-design process from the beginning permitted stakeholders to get familiar with the project and gave enough information for the practitioner to adapt the tools to their intended context in each case study. Learners who were invited to the first sessions with the co-design techniques were keener to participate in the following sessions.

8.1.8 Affordances of the co-design techniques are linked to their materiality

Co-design sessions with stakeholders required participants to get in contact with the objects on the table and react according to what is happening in front of them. After analysing the situations where participants interact with the tools, it was determined that the medium of expression influence the debate, actions and reflection in co-design.

The relationship between the material used in design tools and affordances for participants is examined in detail by (Eriksen, 2012) work on the materiality of design artifacts. In this work, Eriksen explains that using paper-based tools allows participants to explore ideas in a different way than providing the same meanings through a digital tool. The difference when working with paper based tools is that the physicality of the medium dose not constrained by the characteristics of existing devices, they can be quickly

An example can be seen in case study 1 and 2 when participants used the collaborative sketch through colour markers and paper to communicate their ideas. Before this, we asked participants to describe how they imagine the learning analytics tool to look like. Communication without the physical medium of expression led to simple answers that were hard to understand for the research team. However, when participants used the markers to draw their ideas, they started to reflect on the details like colour, size and language that were missing in their first explanation.

Another example is how the learner/data journey tool made use of two different materials, taking advantage of the affordances of paper and then the digital medium. As explained in section 5.5.1.4.2, participants used markers, printed emoticons and a printed map to illustrate their experience with the current learning environment and pointing at the pain points where a learning analytics tool could be used. Using paper took advantage of learners' familiarity with the objects (pencils, markers, paper, boardgame-like paper tokens) and minimum constraints to change the map. This minimised the learning curve allowing them to focus on the conversation from the start.

In the second phase of the learner/data journey, students and educators were introduced to a digital synthesis of the paper maps. This website-like medium did require them to learn how to navigate around the space, but this was not complex, and enabled teachers to better navigate the integrated information from multiple paper maps.

The value of paper as a "high-touch, low-tech" medium was seen with the other co-design techniques such as the LA-DECK and collaborative persona. Paper's flexibility, availability and familiarity makes it the preferred medium for LA co-design techniques to engage diverse stakeholders.

8.1.9 Co-design techniques can produce boundary objects for further co-design

Co-design techniques obviously justify their use by assisting the *process* of the design session in which they are used. However, they can in principle also help future co-design by producing representations that serve:

1. as a *record* for that team to refer back to;
2. as *evidence* of what took place for others (e.g. to give students confidence that their peers have already engaged in the process and were listened to);
3. as *input to subsequent meetings* that may build on these representations (assuming they are intelligible to new participants).

All of these functions were seen in the case studies, although not all three functions in every case. Following each co-design session, the resulting artefact(s) were used to share information with other stakeholders, sometimes as a map like the learner/data journey or LA-DECK and sometimes as a commented low-fidelity prototype, like the collaborative sketch.

The concept of sharing the same design object as a meaning for communication can be related to the idea proposed as "boundary objects"(Star & Griesemer, 1989). A boundary object is described as:

> "Objects to be flexible enough to adapt to local needs but also 'robust enough to maintain a common identity across sites.' In other words, even the same boundary objects have different meanings in different communities, but their structure is recognizable and understandable across different contexts." (Kinnunen, 2018)

In the context of LA, Suthers & Verbert (2013) have framed the very concept of "learning analytics" as a *conceptual* boundary object providing common ground for the *learning* and *analytics* communities to meet:

> "Boundary objects can exist and be leveraged in multiple layers. The middle space itself serves as a topical boundary object, as Learning Analytics brings multidisciplinary voices into discourse around the question of how analytic tools

can help our understanding of learning and design of educational practices." (Suthers & Verbert, 2013)

In contrast, the co-design artifacts produced from our research are more tangible boundary objects, in Star and Greisemer's original sense.

An example of this was the resulting map after learners interact with the learner/data journey (section 5.5.1.4.2). The map contains notes and explanations from learners expressed in a visual object that can be shared with other learners or teachers. We shared the map with teachers to have their opinion towards what students need from a learning analytics tool and what they find difficult with the current learning context. Teachers had a different perspective to what is really happening and the map becomes the point of reference for them. In the same way, when the course director interacted with the same map, it introduced a new perspective on the subject. The same map was used as a boundary object that can be annotated, taken to a digital space or modified without losing his meaning which is represent students experience.

Another example was the resulting map after using the LA-DECK with learners, data scientists, developers and teachers. The co-design practitioner analysed the results in a different way than other participants look at the map. When learners looked at the map they paid attention to those sections where they are more familiar with the terms. The data scientist paid more attention to what analytics methods they used and the developer analysed the technical cards other groups played. All of them interacted with the same map but their perspective on how to use it differs based on their expertise and context.

Using co-design techniques as boundary objects may benefit the LA design process when results are aimed to inform multiple iterations. Some of the results produced in the first sessions were still relevant after 2 years and revisited by other researchers. This may be due to the co-design tool capability to produce relevant boundary objects.

8.1.10 The *Learning Analytics Co-design Playbook*

Delivering our findings and recommendations for new co-design practitioners is part of our contribution to the field of co-design in learning analytics. A common format used by designers to deliver their material back to other communities is to create a playbook. A playbook is a compilation of notes and design materials used to deliver an introduction to co-design practice, recommendations and instructions written in a non-technical language (Gray, Brown, & Macanufo, 2010). This format can help make co-design findings more accessible not only for people in the field of learning analytics but also for co-design practitioners in related fields, such as educational technology and 'students as partners' (Lewrick, Link, & Leifer, 2018).

The design of the *Learning Analytics Co-design Playbook* distills the contributions of this thesis into three main sections. The first section introduces practitioners to the concept of co-design and the benefits of adopting this approach. The following section presents an overview of the co-design process in action using including a map of the multiple stages. Finally, the tools are explained including a description of the tool, duration of the tool in action, group size and design stage where practitioners can implement the tool for better results. Figure 8-1 presents a sample of the playbook design describing more than 10 co-design techniques as a slide-deck of 30 pages for printing or online viewing.

Figure 8-1: Design sample from the co-design playbook.

The Co-design Playbook can be downloaded through the website https://masterprieto.com/playbook.html and is available under a Creative Commons license for free distribution and remixing for non-commercial purposes. Making the playbook freely available facilitates the replication of our findings and invites participants to share their results with the co-design community.

8.1.11 Beyond 1st generation co-design adoption/adaptation

A contribution of this thesis has been to identify exemplar co-design techniques to facilitate stakeholder engagement with the LA design process. It seems a reasonable first step to first adopt or adapt existing techniques for which there is a body of good practices and evidence of utility in other fields, before creating completely new tools. Understanding the contributions of each co-design technique described in the case studies is thus a first step towards making co-design a more common practice in LA research and design.

We might see this as the first stage, but how might LA co-design mature as a discipline? Building on:

Stage 1: Co-design adoption/adaptation (1st generation)

— a plausible next step is:

Stage 2: Co-design refinement (2nd / 3rd / generation…)

Once the limitations of adopted tools, or early generations of adapted tools, become evident, we would envisage further cycles of evolutionary adaptation. The findings of this thesis would be tested in similar and different contexts, perhaps partially replicated, but most likely also found to be lacking, leading to further iterations. We may also anticipate the invention of new techniques inspired by approaches not discussed in this thesis.

Stage 3: Co-design propagation

As LA co-design tools and techniques and their associated practices establish their credentials, they may become transferable to related fields. In fields like Human-Computer Interaction (Grudin, 2005) and Interaction Design (Cooper, Reimann, & Cronin, 2007) this usually takes a few years of implementing, testing and modifying the techniques to build awareness, and work practices among researchers and practitioners.

8.2 The role of the co-design practitioner in learning analytics design (RQ2).

As introduced in Section 2.4, previous research has established that the role played by participatory design facilitators is an important but understudied phenomenon. A contribution of this thesis, therefore, has been to document explicitly the roles that the co-design practitioner was playing across the multiple scenarios, and the skillset that this required. After analysing the multiple interventions and tasks required for the co-design practitioner to lead the LA projects into a successful design delivery, we can distill the key responsibilities that the LA co-design practitioner performs into 2 main roles: *Researcher* and *Facilitator*, elaborated below.

During the case studies presented in chapter 4-6, the role of the co-design practitioner emerged as an interwoven mindset that converges when the design task is conducted and concludes when the research goals are completed. The design road starts with the practitioner assuming the role from a *researcher* perspective and this includes specific actions such as *theorize, analyze* and *conclude* research findings. The *facilitator* role emerges when the practitioner plans, conducts and consolidates face to face sessions with stakeholders, performing specific actions to facilitate the co-design process: *inquire, clean, display, represent, adopt* and *exemplify* given the design context. Table 44 summarises the definitions of these actions.

Table 44: The three key roles played by the LA co-design practitioner, and associated actions.

LA co-design practitioner role	Key actions	Definition
Researcher	*Theorize*	The concept of using research insights from the field to generate design/research objectives, hypothesis and strategies for data collection.
	Analyze	The process of inspecting, cleansing, transforming and modelling data with the goal of discovering useful information, informing conclusion and supporting decision-making.
	Conclude	Summarize findings based on decisions made at the end of each design stage.
Facilitator	*Plan*	Building a scheme/method beforehand to enact actions in design, prepare materials for collaboration and foresee complications when scheduling sessions.
	Manage	Create strategies to control and administrate design resources during the multiple stages. Resources in co-design include the tools, stakeholders, places, time and money.

	Decide	The process of making choices by identifying an action to follow, gathering information, and assessing alternative resolutions. The decision process in co-design looks for balanced, impartial and comprehensive way.
	Adapt	Change the source material to fit the intended context in design, complement the current tools in use and comply with the design constraint.
	Inquire	Posing questions, problems or scenarios for stakeholders to reflect and formalize an answer to the design task.
	Clean	Arrange, organize and delete components in visualizations for the purpose of generate an uncluttered representation. This also applies to data by detecting and correcting (or removing) corrupt or inaccurate records from the data set collected.
	Display	Make visible design components to stakeholders using a range of interactive media, printed materials or data visualizations.
	Represent	Speak or act in place of other stakeholders when their presence is limited
	Adopt	Select and use the source material, tools or design objects without posing any modifications.
	Exemplify	Illustrate possible scenarios using stakeholders' context, vocabulary and known materials to help them formalized an argument to the design taks.

The relationships between the two roles and how they converge during the design process can be seen in Figure 8-2. In this representation, the lines marked in different colors involves the actions listed under each role.

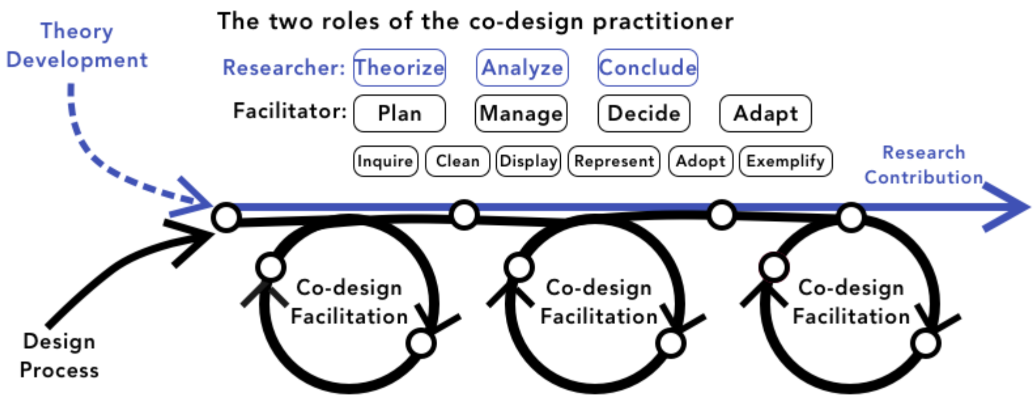


Figure 8-2: Mapping the role and actions of the co-design practitioner for learning analytics design.

An in-depth definition of each role for the co-design practitioner/researcher in learning analytics is presented in the following section. For each role we present the current research insights from other researchers in the field, a series of examples that emerged while conducting the case studies and a series of guidelines/recommendations for other practitioners to bring co-design into their own projects.

8.2.1 Co-design practitioner as Researcher

While in principle any co-design practitioner may undertake personal research as a reflective practitioner, if the practitioner is conducting formally affiliated research (such as a PhD), their host institution will dictate a particular timeline, and expect tangible research outputs, a somewhat different metric to profits from commercial success. If the design project is also in an academic setting, this introduces the specific opportunities and constraints of schools, colleges and universities, not found in other contexts. Regardless, the co-design practitioner as researcher has new goals and responsibilities to apply proper methods for analysis, theory contribution and management of academic resources to facilitate stakeholder collaboration.

The perspective of using research concepts to guide co-design projects is aligned with the work of Marcus Foth (2006) and (Ingle, 2013) on establishing the responsibilities of researchers in active design. In their work, co-design is compared to the process followed in action research. From this perspective, the researcher provokes change through action and in the long run invites stakeholders to act as co-investigators.

The implications of the co-design practitioner acting as a researcher explained by (Ingle, 2013) in design thinking can be applied to our context in learning analytics design. Being the researcher in this context requires for the co-design practitioner to enact actions that benefit from the researcher mindset before engaging with stakeholders as a facilitator. The researcher role is enacted through direct actions that most of the time are given to design leaders. From our experience, the main actions attributed to the researcher can be summarized as *Theorizing, Analyzing* and *Concluding* findings. These actions are illustrated in the following section, written as guidelines and recommendations using current theory in the field and insights from our experience as co-design practitioners.

8.2.1.1 Support your research implications in relationship with the co-design

The field of learning analytics tools depends on many knowledge foundations where learning, pedagogy and analytics are responsibility of learning experts and data scientists. However, when implementing co-design into the LA design process the co-design practitioner becomes responsible of bringing co-design theory into practice. To bring co-design theory into practice, the co-design practitioner must act as a researcher. This means that the co-design practitioner must be aware of what current co-design knowledge will help the team to effectively collaborate.

In our case studies, the action of looking for relevant theories and knowledge foundation emerged at the beginning of each design iteration. At this point the research team established the topic for exploration and the current findings that can be used to support their work. In the nurse case study (Case study 1 Chapter 0), the research team started with the idea of providing a learning analytics feedback tool using indoor tracking devices. This research objective led the main researcher to look for current examples and theory behind tracking user's position, providing automated feedback and the role of critical incidents in nursing training. At the same time the co-design practitioner acting as a researcher required to look for research in co-design techniques and current collaboration techniques to bring his current expertise into action. The co-design theories and examples picked by the practitioner had to be compatible with the context of nurse training and delimiting the number of tools that better suit for these settings.

In our second case study (Case study 2) the co-design practitioner set the research context using knowledge in graduate attributes for higher education and skills development. The action of *theorizing* in this case means that the co-design practitioner acted as a researcher bringing current theories from the co-design field and adapted them to fit their purpose in co-design for LA when proposing what co-design tools/techniques may work. The co-design tools/techniques selected came from the practitioner understanding current guidelines and recommendations from similar research projects and use that knowledge to kickstart the co-design process.

One example of using co-design theory to bring co-design techniques into learning analytics can be seen when proposing using a card-based design approach in case study 2. The card-based approach in theory helped other fields to facilitated collaboration in design sessions. The co-design practitioner had to use contributions in other fields to theorize how a card-based approach can be adapted to bring co-design into LA which in the end led to produce the LA-DECK (Section 6.5.1).

Applying co-design theories to practice in co-design for LA (theorizing) helped the co-design practitioner into adapting concepts, techniques and recommendations to inform other members of the research project. When other researchers consulted the co-design practitioner into what techniques could be applied to bring co-design into their projects, the practitioner acting as a researcher brought their knowledge in co-design theory to speculate if the same concept from other fields may work in the LA context and how to proceed if adaptation is required.

8.2.1.2 Contribute to learning analytics and co-design research

Working in our case studies in academic settings brings the opportunity to contribute to the field of learning analytics and co-design as a product of the researcher duties. The co-design practitioner acting as a researcher will benefit from documenting and analysing data towards other contributions than delivering the design tool. These contributions are mainly communicated through academic papers and can be used by other researchers working in similar projects.

In terms of delivering contributions to the field of co-design, findings were delivered through publishing analysis from the case studies. This was done through documenting how to use the LA-DECK (Carlos G. Prieto-Alvarez, Roberto Martinez-Maldonado, & Shum, 2020) and delivering recommendations on how to implement the learner/data journey (Carlos G. Prieto-Alvarez, Martinez-Maldonado, & Shum, 2018).

Collecting data to produce further contributions beyond developing the LA tool requires for the co-design practitioner to modify the data collecting methods and fit the expected contributions to the field. This also means that time and resources to analyse this data should be added to the project timeline since this task requires attentions from the co-design practitioner and researchers.

Bringing in other researcher skills to assist

The multiple tasks that the co-design practitioner must conduct as part of the researcher role include analysing multiple sources of data, feeding back surveys and collecting data during the co-design sessions. These tasks became an overwhelming duty for only one researcher which led to invite other researchers to bring their own perspective mostly for the data analysis and collection.

During the first iteration in case study 1, the same co-design practitioner collected all data from the co-design sessions to inform the research team about the nursing issues when getting effective feedback, also, the co-design practitioner used this opportunity to collect data about the effectiveness of the co-design techniques and inform his research practise for future applications. After iteration 3, the co-design practitioner started to work with a different team part of case study 2 which led to a conflicting point of managing resources and time. The co-design practitioner then asked the main researcher in case study 1 to keep running sessions and collect data to keep supporting the co-design research interests on the effectiveness of the co-design techniques. Participating in two projects at the same time while looking to inform the co-design practice is a task that can be delegate once other researchers in the team get familiar with the data collection tools, in this case mostly surveys and video recording of participants in action.

Documenting the co-design process

The co-design practitioner acting as a researcher involves more rigorously documenting and reflecting on process than a practitioner typically would, moving beyond only producing design deliverables. All notes from practice and implementation of co-design techniques and designing sessions should be implemented in a way to make it possible to gather evidence of different sorts that will be strong enough to make evidence-based claims, that will pass peer review.

The design thinking mentality of agile design was good enough to make deliverables in a short time for learners to evaluate which facilitated implementing co-design techniques. However, documenting the process required to be implemented was a meticulous task responsibility of the co-design practitioner. Documenting evidence was done using standard research practices from the field (e.g. video recording; transcript analysis) that went beyond casual data collection (e.g. post-its, uncategorized notes, general insights).

In all case studies, the co-design practitioner as researcher was required to read multiple researcher papers from other practitioners to make sure information is being collected in a format that other practitioners would consider complete. This facilitated the peer-review process part of the publications done during this thesis project.

Ensuring that the co-design practitioner's research interests do not distract from supporting the co-design process.

The co-design practitioner's research interests were mostly on applying and measure multiple co-design techniques while collecting data on the emerging challenges from practice. This main interest gave the co-design practitioner an agenda to fulfil which at some point created tensions between the main researcher and the co-design practitioner.

The focus group technique used in case study 1 (section 5.3.1) was originally introduced to gather qualitative data from sessions with learners. The co-design practitioner designed a script with all the questions looking for information about nursing practice. On top of this, questions were added by the lead nursing researcher about nurses' current experience with their tools, and perspectives on their values to develop as future nurses following the co-design practitioner research interests. The problem started when all these questions required at least 40 minutes to go through, compared to the 20 minutes originally envisaged. The co-design practitioner wanted to keep all the question regarding his interests, but the lead nursing researcher also wanted to keep the other questions on nursing practice. In the end, the main researcher and the co-design practitioner agreed to cut some of those questions with the promise that the co-design practitioner won't use more time than the allocated for the co-design sessions with learners.

8.2.2 Co-design practitioner as Facilitator

Guidance, mediation and assistance during co-design session with stakeholders were responsibilities that rely on the co-design practitioner/researcher. In co-design for LA the practitioner/researcher acting as a Facilitator is described as the person responsible for managing the resources, tools and constraints of the current work with stakeholders during face-to-face sessions (Aguirre, Agudelo, & Romm, 2017).

The facilitator was a role that became critical for stakeholders to get in contact with the design process and the co-design techniques. It is particularly useful to understand the function of key-participants fostering a given design process (Barcellini, Prost, & Marianne, 2015). The role of the facilitator in this case is what (Heron, 1999) described as a co-operative mode for facilitation. The facilitator is considered "*a full participant in the inquiry process sharing the experience of taking action during sessions*" (Yorks, 2015).

This section uses findings and insights described in the Knowledge Art framework developed by (Selvin & Buckingham Shum, 2014) to identify actions linked to the facilitator role. These actions described before under Table 44 includes movements that the practitioner/researcher uses in relationship with the dimensions shown in Figure 8-3.

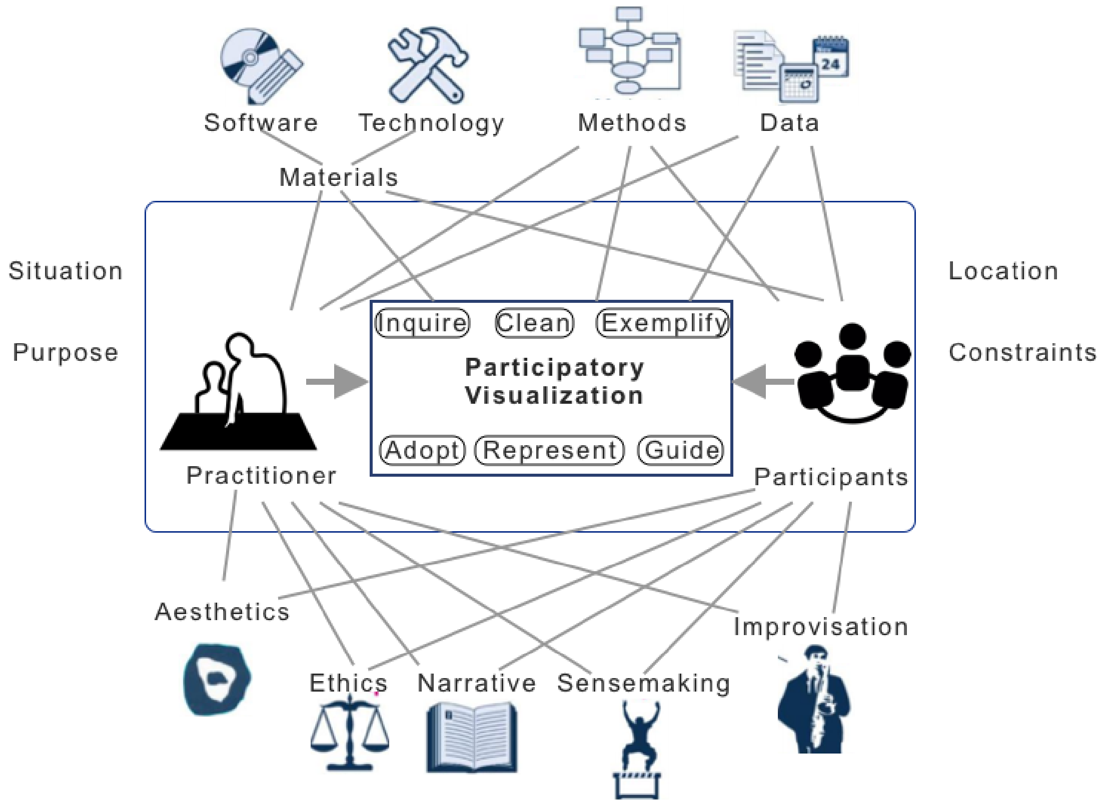


Figure 8-3: Complementing the Knowledge Art Framework (KAF) with actions from co-design practice.

The actions added in the middle clarifies what the facilitator does and how the participants interact with the participatory visualization. The Aesthetics, Ethics, Narrative, Sensemaking and Improvisation dimensions added context to when the action emerged and the purpose behind it. The following section includes insights and recommendations for co-design practitioner/researcher to engage with stakeholders and identify the proper actions.

8.2.2.1 Provoke stakeholder reflection through practitioner inquiry

The facilitator became the responsible of keeping the conversation flowing into the topics of interest and look for answers to the design problems. In case study 1 & 2, the action called *Inquire* emerged as a recurrent first step to start conversations with participants and support the [Sensemaking] process.

In the vignettes TL1 explained in section 5.5.2 part of case study 1, The *Inquire* action involved asking nurse students to describe their experience with the learning design, data practices and current learning environment for simulations. The facilitator gave participants the opportunity to use the learner/data journey tool to illustrate their answer and make sure that information is being collected. The questions must stimulate the reasoning behind their answers. This includes asking "*Why do you think this is a problem?"*, *"How would you describe your experience*?", *"How do you think the LA tool would help you?"*.

In case study 2, the vignettes shown in section 0-6.5.2.4 introduced the *Inquire* actions to understand students positions towards privacy, learning experience and the use of analytics tools. The facilitator used two different tools being the collaborative sketch and the LA-DECK to allow participants illustrate their answers. The *Inquire* actions included questions like *"How do you feel about being tracked for academic purposes?", "What would you propose to solve this?", "What do you think should change in the current learning material?"*.

In other instances, the Inquire action was introduced to keep the [Narrative] between design activities and between iterations. When the *Inquire* action emerged to support the [Narrative], the questions introduced by the facilitator were to recall the intention of the sessions and summarise what was being said. Some example of these questions are *"Retaking what we discussed in the last session, Do you think something else can be done?", "Let's go back to privacy options, what details would you add?"*.

As a recommendation, the co-design practitioner acting as facilitator should *Inquire* participants into giving information that will help the design team to solve their research questions. Data, learning and analytic tools are very specific topics that may not emerge in a natural way like simple things as personal preferences. The facilitator must plan this ahead and make sure to include this question in a script and notes to give structure to the participatory activities.

8.2.2.2 Maintain the clarity of the representational space

When participants engaged in constant deliberation, the participatory space became a canvas for them to use the co-design techniques as a medium of expression. Participants tend to draw, mark, write and move the design objects and many times this results in a cluttered map that makes analysis a harder task for the practitioner/researcher.

The practitioner/researcher acting as facilitator must keep information in a format that everyone can understand and *clean* the design space to reflect what participants explained. As a co-design practitioner, the *clean* action emerged after using paper-based tools (Learner/data journey, collaborative sketch, fabulation) with stakeholders. The results were hard to read and reconstruct during the analysis phase without the assistance of participants. After this the facilitator added a rule that all maps produced should be *cleaned* at the end of each session in front of participants.

In vignette 3 Section 5.5.2, learners used the learner/data journey map to communicate their issues with the teaching practice. Participants were asked to use the markers and emoticons available to add reference notes that helped them to explain their argument. The map results in three different lines marked with different colours that were hard to follow without formatting. The practitioner proceeded to *clean* and add format to the results as a summary to what was discussed in front of the participants. This also was used as an opportunity to confirm if the practitioner understands what learners tried to communicate.

It is recommended that the facilitator implements the *clean* action as a part of the protocol when using co-design techniques. Since co-design techniques rely on user generated visual representations [Aesthetics], *clean* becomes an action that helps the facilitator to recollect and summarize ideas while validating this in front of stakeholders.

8.2.2.3 Improvise and avoid the anchoring effect

The co-design techniques used by participants allowed them to manipulate their design space to represent their ideas. The materials provided through the tools like design cards, templates and maps often provided enough flexibility to let people create content. However, there are instances where people would get stuck and lead to what is known as an "Anchoring Effect".

The anchoring effect in co-design is when participants focus in a single piece of information, which influences how they estimate and make subsequent decisions (Fessenden, 2018). In the case studies, there are moments where participants focus on the visual component of the tools that all comments become constraint by them.

One example presented in Vignette 3 LD4 section 5.5.2, illustrates how the template used to represent simulation rooms for nursing practice places the beds in a vertical set up. When learners were asked to describe their experience using the map as a reference, they started to base their comments on the bed representations and avoided to comment on any other example where a different bed arrangement is relevant.

This example required for the facilitator to [Improvise] by using markers and icons to draft a bed in a horizonal setting. After this, participants realize that it is possible to modify the map and comments where shifted towards different scenarios using other bed arrangements. Using a paper-based tools like the learner/data journey provides space for the facilitator and participants to [Improvise] to keep the conversation flowing.

In co-design for LA, the facilitator must be prepared to [Improvise] by using any materials available at the time. Improvisation can be enacted through quick *drawing*, *notes* on the map, *connecting* two different arguments and *modifying* the participatory visualization to solve the problem. Ability to improvise is a main responsibility of the facilitator, nevertheless, there are instances where participants could improvise once they get to know the co-design tool capabilities (See further examples of participants improvising in LA-DECK 6.2.3).

8.2.2.4 Exemplify when the topic of discussion is too complex for new participants.

Co-design for LA requires for participants to discuss topics that are mostly attributed to data experts or learning specialists. When participants are considered non-experts in those areas (like most learners), the facilitator must be able to provide examples that can be relatable to them. This demands for the facilitator to be knowledgeable in data/learning concepts and have experience with the available co-design techniques.

The ability to provide examples helps the facilitator into keeping the [Narrative] focus on one technical section and maintain participants engaged in the design process. In other instances, *exemplify* was used to help the facilitator into further understand what participants were saying [Sensemaking].

In case study 1, Vignette 5 DL1 section 5.5.2 presents two cases where learners struggle to understand what tracking data in practice means for them. It is understandable that nursing students are not literate in data practices and the facilitator must come up with examples using common terms to refer to their data, and using common scenarios in nursing practice. The learners trust what the facilitator says which can also be related to [ethics] responsibility for the facilitator to not lie to them with the intention of making them approve "shady' data practices.

Another example can be seen in vignette 6.5.2.1. In this example the facilitator *Exemplifies* different privacy settings to help participants decide and constraint the answer into the options available. In this case, the *exemplify* action is used to support the [sensemaking] process required for the facilitator and other participants to understand learners' expectations towards surveillance and privacy.

As a recommendation, the co-design practitioner/researcher acting as a facilitator must be knowledgeable in learning, data and design concepts to be able to give proper examples. The language used must be relatable to participants and most be done with the purpose of clarification rather than to convince since this could be considered biased towards the design findings.

Decide to benefit stakeholders and the design process in balance: There are many instances where the co-design practitioner must make decisions to ensure the design process keeps flowing. It is understandable that not all requests made by participants should be implemented but people put certain trust into practitioner's hands. Keeping the idea that decisions should always benefit learners helped us to debate those decisions that have a negative impact on learners' experience with simulations.

An example of this can be seen in Case study 2 while doing the first two iterations. when access to social media data was discussed. In this example, the team had an idea on what tool could be used to track learner's activity, however, the team couldn't find any significant benefit from this beyond exploration. This is interesting for the research team but seems an aggressive and useless practice for learners.

As a facilitator, suggesting design features that learners or teachers are not comfortable with can bring a negative feeling towards the following sessions. Participants will stop responding to invitations and debate can turn aggressive since learners may feel the need to defend their ideas.

Get comfortable with ambiguity: Having multiple perspectives on the same problem may become too much when making the right decision. People may disagree over details, but disagreement is easier to recognize than ambiguity. Sometimes participants are not capable of verbalize their expectations and the design team must make the best interpretation of what they consider is the problem.

In case study 1, learners had dispersed ideas and expressed doubt over implementing a learning analytics tool to solve their issues with feedback but at the same time where happy to receive any sort of help. As a researcher it makes you think if the problem is more related to the course design rather than the lack of tools.

The facilitator must be aware that getting a straight answer after co-design sessions is rare. Most of the decisions will come from a combination of insights, data and recommendations from participants pushing the facilitator to act in uncertainty. More details over how to navigate decisions in collaboration can be seen in section 8.2.3.

Communicate back your findings: The co-design process for LA is a long journey that benefits from continuity and shared information between participants. Communicating back research findings to participants keeps them engage in the discussion. Summarize research findings into understandable pieces for participants helps them to interpret what's behind design decisions regardless of their experience with data and learning concepts.

In case study 1, the digital version of the learning-data journey helped teachers to understand the challenges faced by learners. Also, learners found usable to see what other learners find difficult and confirm their personal views. Creating objects that summarise information using non-technical language for everyone is a facilitator task that helps to reconcile stakeholder perspectives.

Provide a space for free communication: Participants like most people feel grateful when giving the chance to talk about their problems. The objective of the sessions is to generate design requirements but giving people some time to express themselves open the space for more honest communication.

During case study 1, the facilitator implemented open questions before jumping into learning analytics technicalities. These questions include ”How do you feel when..” or “What do you think can be changed?”. This sort of questions helps participants to vent and feel comfortable with using their own language. Participants will learn to use the right language but should not be the priority since the design space is not about being right or wrong.

8.2.3 Making decisions as a co-design practitioner in learning analytics

The action of *Decide* in learning analytics co-design projects is a required step to conciliate, conclude and push design objectives after constant collaboration with stakeholders. As explained by Frauenberger, Good, Fitzpatrick, and Iversen (2015) “*accountability and rigour in collaboration are nuanced concepts that are delivered through debate, critique and reflection*”. However, all these ideas and constant debate and deliberation happening during the sessions must converge into an agreement while making the decisions fair for everyone involved.

Making decisions in co-design is an action that merges the role of the researcher and the facilitator. Decisions being made from a researcher perspective aimed to benefit the research practice, achieve our research goals and report our findings to the research community. An example of this can be seen in Chapter 5 Case study 1. In this case study, the concept of tracking stress levels and using a timeline as the user interface was added to the automated feedback tool following one of the researchers interest instead of what students requested during the co-design sessions. The researcher follows a slightly different agenda that has an impact on the decision-making process for other stakeholders.

When decisions are being made in the role of the facilitator, the intention is to benefit the design process most of the time by planning the future sessions with a different mix of participants, adapting new tools or inviting new people to collaborate. An example of this can be found in section 8.2.2. In this example, the practitioner in the facilitator role decides to create design groups by mixing students, teachers, data scientists and other stakeholders. The decision of having mixed groups over interviews or focus groups was made to balanced perspectives when interacting with the LA-DECK and the design task. Making this move had an impact on how the practitioner used partial agreement between stakeholders to generate a first dashboard and avoided the researchers to keep running sessions just to study collaboration more in detail.

In learning analytics design, most decisions are being made in a similar way to other design projects coming from academia and moving to massive adoption. This involves people in higher positions making the last call when it comes to planning where to invest money and time. However, in LA design the combination between learning theory and analytics development demands for people in charge to use their area of expertise (being learning, data science or design) to support their decisions.

People in charge of planning what is the best through the co-design process must be aware of the impact of making uninformed decisions. Using the work of Culmsee and Awati (2013) on best practices to decision making, we translate 5 obstacles that were found through our case studies that co-design practitioners may encounter when making decisions in collaboration.

Availability: This concept refers to the tendency to base decisions on information that can be easily recalled, neglecting potentially more important information. This was a problem when the co-design practitioner and researcher had to decide what features should be done next in case study 1 and 2. When selecting those features to become a priority, the co-design practitioner/researcher and the designer sometimes used what people documented as the main problem and neglected those issues that were unspecified but still require further investigation.

Confirmation bias: This concept refers to the tendency of people to favour (or selectively seek) information that confirms their opinions. Another manifestation of this bias is when people interpret information in a way that supports their opinions. This emerged in case study 2 while working with students using the cards. The students were asked to decide where the team should use available time and money. Students suggested focusing on the things they proposed and advocated for this to be the priority.

Representativeness: The tendency to make judgements based on seemingly representative, known samples. This emerged during case study 1 when the co-design practitioner tried to push the idea that tracking stress levels is not a feature of interest for learners. This was only done based on the opinions of students available during the sessions. After gathering more data, it was found that stress levels are something that most students will find useful but the ones participating in the sessions found it difficult to understand.

Selective perception: The tendency to give undue importance to data that supports one's own views *"We hear what we want to hear, see what we choose to see and remain deaf and blind to the rest"* (Culmsee & Awati, 2013). An example of this happened while doing the first iteration with nursing students. The co-design practitioner recommended implementing a tool that allows learners to replay their own videos to look for their mistakes. Before continuing with the design process, the researcher and the designer convinced the co-design practitioner that the other options are more feasible to do and provide the same amount of details requested by learners.

Information bias: This concept refers to the tendency for people to seek as much data as they can lay their hands on prior to making a decision. At the beginning of case study 1 and 2, the co-design practitioner invited as many learners as possible to make sure enough information is being collected. After working with 10 different groups, the co-design practitioner realized that there is not enough time to keep having sessions. Without prior experience on running co-design sessions for LA, it was easy to fall into the assumption that the more students the more useful data would be collected.

All these obstacles found while running the co-design process helped the co-design practitioner/researcher to identify how to make decisions as a collaborative effort and when to take the lead. The section below illustrates 4 different styles to make decisions and avoid the obstacles explained before using Brause (2016) recommendations.

Consensus decision making: A consensus style tried to avoid winners and losers by requiring that everyone agree. *"All legitimate concerns must be raised, and members must keep working until they address and integrate all perspectives"*. This can be extremely time-consuming, and members must resist the temptation to reach agreement too quickly. If a group has the skill or can gain the skill to do so, then a consensus model will enable the group to "own" the decision so that they can advance the project and implement the verdict.

An example of this is when all stakeholders in case study 1 agreed that identifying mistakes and critical incidents using the timeline should be the main objective for the automated feedback tool. This was done in a consensus style since students, teachers and researchers are literate enough in nursing practice and all of them agreed.

Co-design practitioner-led decision making: "*When a fast-paced decision must be made, and when there is an individual who is knowledgeable and trusted by the people affected by the decision, a leader can be designated to make an independent decision".* This practitioner-led style can also be effective and appropriate when stakes are low. Regardless, the leader should inform the stakeholders of the decision and give any directives for participation so that member know what is expected of them.

A clear example of this can be seen in case study 1 when all stakeholders recommended implementing video analysis to recreate learners actions. Participants wanted to receive short clips of their mistakes. The co-design practitioner was the only person informed enough to identify the complexity to implement this and the probability that it won't be enough to answer all their questions. The co-design practitioner took the decisions to not use video as the only source of data and communicate this to learners through the first prototype.

Decision by voting: There are a variety of voting methods, including ranking alternatives and establishing a majority by a percentage of vote. On a social and emotional level, voting produces a series of "winners" and "losers", with the winners determining the course of action. Voting is fine if the stakes are low and the option are acceptable to all members, but this method also often dismisses minority opinions early on. When making significant decisions, voting can create an adversarial atmosphere: it should be avoided if you need all members to be highly committed for the duration of the co-design project.

During case study 2, while using the LA-DECK the co-design practitioner gave participants the option to allocate money and time using a voting system. It was expected that learners, teachers, data scientists and developers would have different perspectives, but everyone had the opportunity to vote. Participants who selected those categories with fewer votes had the opportunity to understand others' people position leading to a lesser feeling of losing and taking the decision as a common agreement.

Consultative decision making: For greater buy-in, the group leader might consult with the team members for recommendations (Individually or as a whole) prior to making a final decision. This consultative model can be useful for inclusivity, balancing speed while involving stakeholders.

Retaking the example illustrated in case 1 on tracking stress levels. Learners didn't find interesting to track stress levels when doing the simulations. On the other hand, teachers found stress levels as a good source of data to identify critical situations. The co-design practitioner didn't have enough experience with the concept and decided to leave it for consultation with other researchers involved in the project.

8.2.4 Co-design practitioners as "meta-designers"

The range of roles that have been identified suggest that the co-design practitioner can be thought of as a *meta-designer*. This concept refers to taking responsibility for creating and improving spaces for stakeholders to design their own ideas (Gajendar, 2019). It can be seen that there are some similarities between the challenge for meta-designers and the challenge for co-design practitioners:

> "this is the profound challenge of meta-design: actually designing the conditions for good design to emerge and thrive, for the long term, with a sustained sense of continuity and value, not some random spark of luck or defined by a single strong personality" (Gajendar, 2019).

In a different strand of work arising from the Scandinavian PD tradition, Ehn proposes using meta-design as a concept where the practitioner anticipates and envisions the "potential design to take place in use after project delivering" (Ehn, 2008). This idea matches with the emerging responsibilities that this thesis has identified, as the practitioner organises co-design sessions while proposing sustainable design spaces. While the ideal is to have a facilitator who is expert in both data and education, this will often not be possible, making the meta-design concept more attractive for future practitioners.

In the case studies, the researcher assumed the role of meta-designer in preparing the tools and techniques for use (Focus groups, LA-DECK, Learner/Data Journeys), and arranging the physical space for learners and teachers to collaborate. The meta-design role in LA benefits from a basic understanding of learning strategies, epistemic language, data concepts and design strategies that fit stakeholder's skills. For example, in case study 1 (Chapter 0), some of the co-design sessions were intentionally held in the nursing simulation wards in order to help students describe their experiences and actions, by referring directly to the locations and affordances of the physical space. The researcher continued to enact a meta-designer role when identifying nurse students' characteristics, language and domain knowledge, in order to create the Learner/Data Journey map. The co-design practitioner/researcher competencies that this thesis has identified contribute to our understanding of what it means to be a meta-designer in learning analytics.

8.3 Revisiting the challenges for learning analytics co-design (RQ3)

Chapter 3 introduced five key challenges that LA co-design must tackle, motivated from the literature and well-established phenomena in co-design practice: *power relationships, surveillance, learning design dependencies, teaching and learning expertise* and *data/algorithm literacy.* Having detailed in each case study how these were encountered in different contexts, this section steps back to reflect on these challenges, including contextual factors, in some cases emerging in a different way to what was expected based on the evidence, and recommendations for the practitioner/researcher to minimize their impact.

8.3.1 Power relationships as a challenge in co-design for LA

As explained in section 3.2, we expected power relationships to emerge in the context of meetings between participants, most likely academics and students. However, due to the low number of sessions where learners interacted face-to-face with teachers, it was found that power relationships emerge from other interactions with higher figures of authority.

Instead, as exemplified in the nursing case study (Section 5.5.2.1), the effect of power relationships emerged between team members, in the context of the researcher gaining access to resources (people, equipment, laboratories), and requests from the nursing academic to change the empirical studies, in ways that conflicted with the PhD researcher's goals.

To summarise, in these case studies, power relationships turned out not to be as much a problem for student-academic relationships as had been expected, although clearly this could be an issue in other contexts. When the LA researcher/developer was a PhD student, then power differentials with academic staff did come into play. Staff seniority played an important role in planning and managing the projects. If the course director had concluded that the time and effort required to engage in the co-design collaboration was not worth it, access to nursing students and facilities would have ended. It should also be noted that the organisational position of the LA team within the university, and their senior team's track record in managing productive collaborative projects, was also critical to get initial buy-in from academics. A recommendation would be that the co-design team ensures that leaders with 'gate-keeper' power understand the role that they play in releasing resources, and those senior stakeholders must be kept 'on board'. While power dynamics accompany any design project, especially one that spans divisional boundaries that require the collaboration of gatekeepers, these examples demonstrate how they play out specifically in LA co-design.

8.3.2 Learners' attitudes to privacy and surveillance are influenced by their data literacy

Surveillance and *data literacy* as challenges influenced co-design sessions as expected in the theoretical description found in section 3.3 and 3.4. Students' capability to participate in designing the technical aspects regarding privacy and surveillance mechanisms were dependent on their knowledge regarding data concepts. However, participants were able to contribute to the LA tool requirements beyond giving consent.

The contrast between contributions from learners in case study 1 (Nursing students) and learners in case study 2 (data science students) regarding tracking their data for academic reasons illustrates how their concerns comes from their lack of experience in the field. The example shown in Case study 1 (Examples DL1 section 5.5.2) illustrate how less data-literate learners focused on understanding the repercussions of being judged based on their data traces. In their experience, the concept of being tracked came with a negative connotation expressed when interacting with the tools. The co-design practitioner's intention was to discuss privacy from an ethical stance but also to understand students' perspectives towards privacy policies in the university.

As this comment from the main LA researcher in case study 1 shows, asking non-technical students what their preferences are about surveillance does not always elicit helpful information, when they have never experienced activity tracking in their studies:

> "the students are not sure about what they want, because maybe they don't have this kind of data literacy, which is something that I was reading now. They don't know what data could do, how data could be gathered. So, they don't realise that maybe if it is possible, what kind of information we'd like to have on hand. They are just restricted by the tools that they have. And because of that restriction, we cannot even think of any other kind of innovation for them. So, it's harder then to get those ideas reflected in the tool that we were developing." Main Researcher Case study 1.

On the other hand, case study 2 (examples 0-0) shows a different stance when discussing privacy and surveillance with learners from a data intensive course. In these examples, learners showed a pessimistic but understandable position towards being tracked regardless of the purpose. In some instances, learners tried to negotiate rather than block any intention to track their data for the purpose of delivering a learning analytics tool. Learners experienced in the field allowed the developers, data scientists and teachers to build their own privacy mechanisms as a shared responsibility through the co-design sessions. In this case, further implementations did not depend on researchers whiling to respect their decisions but rather as a settle requirement from all stakeholders.

8.3.3 Learning design and asymmetric teaching & learning expertise

The theoretical explanation described in section 3.4 mentions scenarios where working in design for learning analytics tools leads towards changes in the learning design. This loop of constant back and forth between tool-specific and epistemic argumentation can be seen in examples for case study 1 TL1 section 5.5.2 for case study 2 TL3 section 6.5.2. However, there are instances where learning design conversations is a product of asymmetric teaching and learning expertise from students.

Differentiating when the conversation turns into a learning design activity as a product of learners' inexperience in learning theory is a task that the co-design practitioner struggles to know by himself. This is due to the co-design practitioner/researcher lack of knowledge in the details of the learning design structure. This requires a third stakeholder expert in learning design, like the course director, to analyze the results and help the co-design practitioner classify those comments as personal opinions based on learners' limited experience with the learning environment.

If the purpose of learning analytics tools is to support learners and teachers to improve their practice, changing the learning design becomes an inevitable challenge that the co-design practitioner and stakeholders must face. This leads to a new level of detail for a future challenge where reflection after interacting with LA tools triggers changes in the way the course is being implemented. In a conversation with the main practitioner/researcher of case study 1, after further implementations of the automated feedback tool the examples of this loop emerged in the following form:

> "For example, if they could see that all of the students are failing in one particular activity of the simulation, then they can think that, okay, this is wrong. So, it means that. Or we need to change the simulation, or maybe we are not explaining this as we supposed to. But I mean, it's kind of a reflecting tool for the teachers, not for the students. But also, for the teachers. So, they could change the strategy of teaching, or they could change the learning design based on the information that is going to be gathered from the tool."

The co-design practitioner and the research team should therefore expect this to happen and, in the future, change the learning analytics tool to fit the new learning design. This motivates an iterative methodology as the most effective way to maintain the alignment between learning design and analytics. Another finding in our case studies is that co-design works as a mechanism to help learners understand learning concepts such as tasks, assessment, feedback and reflection. This is particularly useful when they must describe their current experience with the learning process (examples being the way that nursing students recount how simulations work, or fail to work, for them, and the data science students describing how hard it was to track their improvement with writing tasks).

8.4 Limitations of this thesis

The limitations of time and resources in a 3.5 year PhD research program necessarily constrained the diversity of participants who were engaged in the co-design cases. It is recognised that data science students and academics are atypically literate in technical matters, but this was balanced to some degree by the nursing case study. It is hoped that the public release of the co-design techniques will expand the disciplines and contexts who have the opportunity to move into co-design, generating future evidence. A related limitation is that recruiting volunteer students will inevitably bias towards "champion students" who are more engaged with their learning community, and dedicate more time to improve their practice. To generalize findings more widely, future work should endeavour to engage struggling, less motivated students, but this is challenging.

Design-Based Research and Design Thinking were justified as an appropriate research methodology in Chapter 4, but it does, of course, bring its own methodological trade-offs. This work must be mindful that, "*if a researcher is intimately involved in the conceptualization, design, development, implementation, and re-searching of a pedagogical approach, then ensuring that researchers can make credible and trustworthy assertions is a challenge"* (Barab & Squire, 2004). After 3 years working with multiple stakeholders, it is understandable that as the co-design researcher and practitioner, my reporting will have subjective aspects to it, and is potentially subject to biases. To mitigate this risk, the ways in which studies were designed, and then interpreted, were the subject of extensive deliberation within the research team.

DBR does not specify a specific number of iterations, This has been reported in similar studies using DBR (Anderson & Shattuck, 2012). This research conducted as many iterations as possible within the constraints, with variable numbers of iterations in different case studies.

9 Thesis Contributions and Conclusions

Chapter overview

This chapter summarises all findings in relationship to our three research questions. First, it presents the primary conclusions regarding the array of co-design techniques used to engage stakeholders in the learning analytics case studies. Next, the role of the co-design practitioner/researcher is considered, including the importance of serving the context and stakeholders involved. Finally, the chapter highlights important factors to consider when confronting the emerging challenges in co-design practice.

Returning to the research questions, section 9.1 provides a summary of what has been learned regarding the first research question *1) How can co-design techniques assist in the integration of diverse stakeholders in the LA design process?* Section 9.2 provides a summary of what was found in relation to the second research question *2) What are the roles of the co-design practitioner/researcher in the LA design process?* The final section 9.3 provides a brief summary of the role of the codesign practitioner in relation to the third research question *3) What are the challenges in engaging stakeholders in the LA design process?*

9.1 How co-design techniques assist in the integration of diverse stakeholders in the LA design process (RQ1)

The co-design techniques proved to be the link for active engagement between the co-design practitioner and stakeholders. Each technique helped participants to have a voice in the design process which is the ultimate objective of engaging learners, teachers, designers, data scientist and researchers relevant in learning analytics design. Other important insights into the first research question *(How can co-design techniques assist in the integration of diverse stakeholders in the LA design process?)* are:

- Adopting co-design techniques such as *focus group, fabulation and personas* help the co-design practitioner understand the main beneficiaries for an LA tool, which analytics innovations should be implemented, the root of the learning problem and documenting the design process. As discussed in section 8.1, these approaches helped learners and other stakeholders communicate and debate about the design of learning analytics.
- Generating *sketches and prototypes* during the multiple iterations helped participants understand the limitations and characteristics required for a learning analytics tool to function. Moreover, as discussed in section 8.1.2 the features suggested using these techniques helped the co-design practitioner and stakeholders to define the visual components for better interaction and usability.
- In contrast to the above tools, *adopted* from widespread co-design practice, the *adaptation* of the familiar *user journey mapping* approach to create the *Learner/Data Journey* tool provided co-design practitioners with the possibility to understand students' pain points, and opportunities to deliver a LA tool to better help students. As discussed in section 8.1.4, the process described in this work also offers guidance to better adapt other co-design techniques to different LA design contexts.
- The adaptation of common card-based design approaches to produce the *LA-DECK* provided a common language for diverse stakeholders such as learners, developers and data scientists to have effective discussions, by 'playing cards' as they contributed to the meeting. This happens all too rarely at present, and may be the first such structured approach for LA as seen in section 8.1.5.
- Together, these provide a Learning Analytics Co-design Toolkit as a contribution towards our research question on helping co-design practitioner/researchers understand what techniques can be used based on the context of their LA project. The LA Co-design Playbook (section 8.1.10) aims to summarise the toolkit in a more accessible format for both practitioners and researchers.

9.2 The roles of the co-design practitioner/researcher in the LA design process (RQ2)

The literature review identified that the skillset of the co-design facilitator is an under-studied phenomenon, so the thesis made this a key focus, and makes contributions to this important question. In response to the second research question *(What are the roles of the co-design practitioner/researcher in the LA design process?),* the thesis has been able to describe in detail, and exemplify, the two main roles of co-design *facilitator* and *researcher* that the co-design practitioner/researcher played:

- The *facilitator* role (as discussed in section 8.2.2) involved taking actions to manage collaboration during and between the co-design sessions with stakeholders. The Knowledge Art Framework (KAF) on which this thesis builds already identified the context of what may happen during co-design sessions, such as supporting the narrative, sensemaking, making ethical decisions and improvising. The thesis extends KAF by demonstrating six specific actions that the facilitator took: *inquiring* to help participants engage, *adopting/adapting* co-design techniques, *exemplifying* when there was doubt, *guiding* participants into the relevant topics, *cleaning* the collaborative representational space to maintain its clarity, and *representing* other stakeholders when they could not attend co-design sessions.
- When the co-design practitioner is also acting as a *researcher* (as discussed in section 8.2.1), they document process and products in significantly greater detail than a practitioner might, create contributions to the field and generate new theories of co-design practice. At some points, the co-design practitioner plays both roles simultaneously, and their research objectives may influence the actions they take when facilitating, introducing ethical considerations which must be managed.

9.3 The challenges when engaging stakeholders in the LA design process (RQ3)

This thesis identified five critical, interacting challenges that emerge when engaging stakeholders in the LA design process. While some challenges are archetypal in participatory/co-design, and so will emerge in any educational technology context, they take particular forms in LA co-design, and some of these challenges may be unique to

LA. As detailed in Chapter 3 and revisited in the discussion (Chapter 8.3), this thesis has documented insights into how these challenges emerged, summarised very briefly as follows:

- **Surveillance** (Described in section 3.3) concerns emerged the moment stakeholders begin to consider data sources and analytics methods, the defining feature of learning analytics tools. The co-design practitioner can take this opportunity to settle policies in collaboration, bring transparency into data practices and make sure that explicit consent is being given by letting stakeholders create their own rules. The thesis demonstrates how the co-design practitioner can use techniques such as the *LA-DECK* and *Learner/Data Journey* to surface such concerns, explore potential solutions, and capture that deliberation for future design sessions and stakeholders.
- **Learning Design Dependencies** (Described in section 3.4) emerged in LA design, since the design of new tools often leads to reflections on how the newly augmented task could or should change — which in LA will often implicate student assignments and grading. The thesis argues that this is something that the co-design practitioner should recognise and work with, to maintain a balance between discussing the learning design while producing the other relevant components like analytics methods, data sources and user interfaces. The co-design techniques in the toolkit produced by this thesis can help clarify implications for learning related topics, and technical topics like algorithms and data policies.
- **Asymmetric Teaching and Learning Expertise** (Described in section 3.5) is central to the design of effective learning analytics, but this expertise is distributed very differently between stakeholders, with learners and data scientists being rarely experts in learning/teaching strategies. This asymmetric expertise means that teachers may, for instance, challenge what learners suggest. The thesis documented instances where students made poor learning design proposals.
- **Asymmetric Data/Algorithm Literacy** (Described in section 3.6) plays an important role when stakeholders are being asked to consider analytics methods, data sources and other technical components of LA tools.

However, participants were able to contribute to LA tool requirements when supported by the co-design practitioner using the techniques invented in this project, such as *LA-DECK* and the *Learner/Data Journey* to provide learners with the language they needed.

- **Power relationships** (Described in section 3.2) can be a challenge in any co-design project, and in the context of LA, data scientists, developers, academic administrators, teachers and learners clearly occupy very different positions of influence. Stakeholders in higher organisational positions held control over learning spaces, communication with participants, money and data. The case studies in this thesis found that power disparities between students and educators caused fewer problems than anticipated, but emerged in other contexts (e.g. how an LA PhD student engages with a faculty academic to gain access to students). The co-design practitioner must be alert to such dynamics, and may have an important to role to play in helping stakeholders share their concerns, and possibly represent them to others.

9.4 Conclusion

In conclusion, co-design methods and tools offer a practical response to justified concerns that learning analytics innovations risk becoming just the latest genre of ill-fitting educational tools to be imposed on teachers and learners. This thesis has motivated the adoption and adaptation of co-design techniques specifically for learning analytics, presenting evidence that such tools can give stakeholders a meaningful voice when they engage with analytics experts. This thesis has provided detailed accounts of, and new insights into, the dynamics of LA co-design, including the critical role of the co-design practitioner/researcher. It is hoped that this helps to accelerate the adoption of co-design methods and tools by educational institutions and LA tool developers.

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Appendices

Appendix 1: Ethics Application ETH16-0958

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INFORMATION SHEET

ETH16-0958 Adoption of Learning Analytics Artefacts and Participatory Design for Students

WHO IS DOING THE RESEARCH?

The team of the Connected Intelligence Centre (CIC) directed by A. Professor Theresa Anderson, in collaboration with Professor Simon Buckingham Shum, Research fellow Roberto Martinez Maldonado and PhD Student Carlos Prieto Alvarez at the University of Technology Sydney.

WHAT IS THIS RESEARCH ABOUT?

This research has three main goals:

1) measuring the involvement in the design of learning analytics tools by students, teachers and researchers;
2) exploring ways to provide immediate or delayed feedback to the design team to make data visualization objects and/or increase adoption through a participatory design between student, professors and data specialists
3) finding new approaches to implement participatory design in the data analysis, design and implementation process.

IF I SAY YES, WHAT WILL IT INVOLVE?

The design sessions will consist in a series of focus groups, workshops and/or interviews. The sessions will take place outside of class. You may be asked to participate in at least one session. The session will be video-recorded as part of the transcript process and analysis of interaction. Some small activities like mind mapping, writing using post-it notes and drawing on white boards will be required for these sessions.

Each session will not be longer than 2 hours. You will be asked to:

- be part of one or more 1 hour group activity sessions each of approximately 1 hour
- answer a post- experiment questionnaire that will take approximately 15 minutes to complete
- participate in a focus group around one of the topics provided
- participate in the design activities using the tools provided by the research team

ARE THERE ANY RISKS/INCONVENIENCE?

There are very few if any risks because the research has been carefully designed. Recordings, log files and contact information will be secured on password protected UTS machines. Paper materials such as participants' notes, questionnaires, consent forms, etc. will be physically stored in locked containers at CIC. Any personal information will be only disclosed within the research team.

WHY HAVE I BEEN ASKED?

Because your input can provide researchers with key information to address the goals of the project.

DO I HAVE TO SAY YES?

You don’t have to say yes.

WHAT WILL HAPPEN IF I SAY NO?

Nothing. We will thank you for your time so far and won’t contact you about this research again. Involvement in these design sessions is voluntary and has no direct bearing on any assessment.

IF I SAY YES, CAN I CHANGE MY MIND LATER?

You can change your mind at any time and you don’t have to say why. We will thank you for your time so far and won’t contact you about this research again. You can drop out from this project at any stage without any repercussion or penalty.

WHAT IF I HAVE CONCERNS OR A COMPLAINT?

If you have concerns about the research that you think I can help you with, please feel free to contact us on Theresa.Anderson@uts.edu.au or Simon.BuckinghamShum@uts.edu.au. If you would like to talk to someone who is not connected with the research, you may contact the Research Ethics Officer via Research.Ethics@uts.edu.au, and quote this number ETH*16-0958*

Appendix 2: Additional examples

This appendix presents additional examples from the video recorded co-design sessions, illustrating how the five different challenges for LA co-design (Chapter 3) arose in the case studies.

Surveillance and privacy SP2 – Example 2

Case study 1: Automated Feedback tool for nurse students

Co-design tool: Learner/Data journey.

Design Cycle: Iteration 1 Session 2

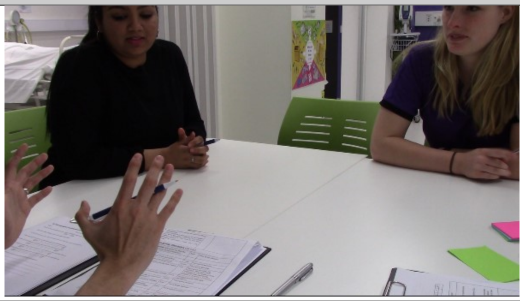
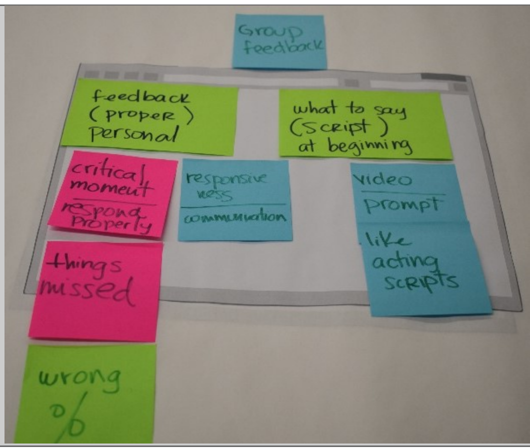
Critical Incident: Students opinions on privacy and surveillance changed over time after discussing with the facilitator and engaging with the co-design techniques.

This example illustrates an instance where students' privacy and surveillance concerns changed after engaging with the facilitator and the co-design activities. The critical incident emerged during session 2 which was part of the first iteration of the case study focused on designing an automated feedback tool for nursing students.

The participants are 2 students explaining their concerns around sharing their personal data with other students. This conversation was guided through the focus group technique (Section 5.3.1) and later supported with the collaborative sketch tool guided by the facilitator.

Vignette 1: focus group and collaborative sketch with students

The arguments shown in the following conversation start with the facilitator asking about sharing students' data within their team (line 1). After this, ST1 and ST2 responded with not being bothered as long as it shows positive results (lines 2-4). The facilitator then asked about sharing the same data with other teams (line 5). ST2 expressed not being interested in getting access to other people results as a comparison between groups, ST1 non-verbally agreed with ST2 (line 6-7) The facilitator then asked for clarification (line 8). ST2 answered by giving an example of using a simple score to show if your performance is good enough (line 9). The facilitator then proceeded to write examples of their data and asked again about their position on sharing their data with other groups for comparison (line 10-11). After seeing these examples, ST2 and ST1 agreed that it would be interesting to compare results and see if you missed the same things (line 12-16).

Practitioner		Transcription	Co-design Tool
[KAF] *Action*			
[Sensemaking] ***Inquire***	1	**Facilitator**: What about with your teammates at that moment, would you like to see your name there?	Follow script for Focus group
	2	**ST1**: It wouldn't bother me if I did okay.	
	3	**Facilitator** Would you like to compare between your own team?	
	4	**ST1**: Yes.	
[Sensemaking] ***Inquire***	5	**Facilitator** What if I have to compare with other teammates, would you like to see a cooperation between teams there, or it's not useful for you to compare it with your teammate?	
	6	**ST2**: No.	
	7	**ST2**: I don't see how with these.	
[Sensemaking] ***Inquire***	8	**Facilitator:** Why don't you? Can you tell us why not?	
	9	**ST2**: I think it's just better to know if you did as good or correctly, and so comparing it with her score is not applicable.	
[Sensemaking] ***Exemplify***	10	***Facilitator*** (Action- *Write examples using mock-up data on the collaborative sketch tool and showed them to ST1, ST2)*	
[Sensemaking] ***Inquire***	11	**Facilitator**: Like these examples (Action - *points at*	

		the collaborative sketch), would you find it useful if we showed you the difference between groups through this data and which study is the most forgotten?	
	12	**ST1**: Yes, that would be interesting.	
	13	**ST2**: Yes.	
	14	**ST2**: It would be interesting.	
	15	**Facilitator**: Why?	
	16	**ST2**: Purely just because it would be interesting to see if we all missed the same common thing; if it's not just me missing it.	

Vignette Commentary

The challenge

The conversation started with an open question during the focus group resulted in a negative position towards comparing data results with other students. After further conversation using examples with the collaborative sketch, they found a reason to compare results between teammates to improve their practice. This unclear stance towards privacy policies poses a challenge for the co-design process since decisions are hard to make without a clear posture.

The role of the practitioner

The co-design practitioner acted as the facilitator that made sure the collaborative sketch was used following the design protocol. At this point, the facilitator used the co-design tool to get participants re-consider their positions towards sharing data once they had the opportunity to see an example.

Effectiveness of the co-design tool (focus group+ collaborative sketch)

In this part of the session, the focus group allowed the facilitator to introduce the topic for learners to debate. The practitioner wanted to make sure that learners understood what data privacy means in terms of data collection for the LA tool. The facilitator had to combine the collaborative sketch with the focus group to bring visual examples of how the tool may look like if sharing data across teams were implemented. This step convinced learners to change their posture and the practitioner could continue with the other activities.

Surveillance and privacy SP3 – Example 3

Case study 1: Automated Feedback tool for nurse students.

Co-design tool/technique: Collaborative sketch

Design Cycle: Iteration 1 session 3

Critical Incident: Students hesitate when defining who can have access to their performance data.

This example illustrates how students' hesitation and unresolved concerns led to vague privacy settings. During session 3, students showed concerns over other students gaining access to their performance data and being judged on their mistakes. As a result, participants could not make a decision, and the facilitator was required to mark this as unresolved.

Session 3 invited 3 nursing students to build a lo-fi prototype using the collaborative sketch tool (section 5.3.5). The prototype contained their expectations in terms of data visualizations and preferred interaction styles. Once they finished with the collaborative sketch, the facilitator used the outcome to discuss privacy setting and limits when sharing their data.

Vignette 1: focus group and collaborative sketch with students

The conversation started with the facilitator asking students about sharing their data with other students (line 1). Students hesitated and explained their concerns over sharing identifiable information even between people in the same class (line 2 -3). The facilitator requested them to clarify what constitutes as identifiable data using face recognition as an example (line 4). ST1 elaborates that even conversations can be used to identify them, hinting that mistakes should delete any of those details (line 5). ST2 further elaborated that mistakes create a bad image of themselves and it should not be shared with other teams (line 6). ST1 reflects on the positive side of comparing yourself with other students even when the results are not as good as expected (line 7). The facilitator finished the conversation by asking how they would like to receive this information (line 9); ST2 responded with an unspecified comment stating that this depends on the teammates (line 9)

Table 45: Vignette 1 including the practitioner actions, the transcription with students' perspectives on sharing their data and the interactions with the focus group

Practitioner		Transcription	Co-design Tool
[KAF] ***Action***			
[Sensemaking] ***Inquire***	1	**Facilitator**: what if we want to share this information (Shown in the side image) with other students? Would you find that acceptable with your data? (Action – *The facilitator points at the collaborative sketch result from the past activity)*	
	2	**ST3**: Not too sure, maybe as a collective group. Maybe they can say, last year had more stress with this, probably not specific classes or anything like that.	
	3	**ST1**: I think it would just be the visuals and the voice recording that might be less inclined for people to want to… But any other interactions… I guess, identifiable things.	
[Sensemaking] ***Exemplify***	4	**Facilitator**: Like your face?	
	5	**ST1**: Yes, face and the conversation, unless it's a wonderful example. Yes, then maybe, yes, a consent thing. But I guess, it's people that might be able to be identified by voice and it's a really bad thing and then	
	6	**ST2**: As long as it's not identified. Say I did really bad, and I don't want the whole year to know I did so bad.	
	7	**ST1**: The thing is, it's one of those things that… You get an exam result and it's not good, you don't feel good about it. But if it's something that's throughout the course that you can then improve from… In the end it might not feel good finding out that you're bottom of the class, but at the same time	

		you then have the opportunity to actually improve on it rather than thinking that you're doing okay.	
[Sensemaking] ***Exemplify***	8	**Facilitator**: You can do both. After a session, like a summary of your actions. Would you like to see your laptop at a personal level, or would you like to share with your team?	
	9	**ST2**: Depends who the teammates are. It's true, some teammates don't care; it's really frustrating.	

Vignette Commentary

The challenge

Participants hesitation to discuss data privacy practices leads to an unclear path of action for the co-design practitioner. Most of the unclear comments from learners can be attributed to their short understanding of what can be track and analysed for academic purposes. The purpose was to establish those limits, but the conversation turned into personal preferences towards teammates getting access to their data.

The role of the practitioner

The co-design practitioner/researcher acted as a facilitator. This required for the facilitator to *Inquire* learners into communicating their preference towards sharing their data. Once the topic is being discussed, the facilitator realised that learners struggle to understand what constitutes personal data and proceeds to *exemplify* using common language and relatable scenarios.

Effectiveness of the co-design tool (collaborative sketch)

The collaborative sketch helped the facilitator to use a visual object to represent how data would be used by the LA tool. Giving examples using the post-its proved to be easier than giving pure definitions of privacy concepts. The practitioner ended up writing on the post-its and learners used this to preview their requests as functional features.

Teaching and learning expertise TL2 – Example 2

Case study: Automated Feedback tool for nurse students

Co-design tool: Learner/Data Journey

Design Cycle: Iteration 1 Session 1 & Iteration 2 Session 5

Critical Incident: Students determine tracking stress is a non-relevant feature. Teacher disagrees and elaborates on the role of stress when performing.

In this example, differences emerged between students' perceptions of stress data, and other useful feedback, and the teacher's experience. These were found when contrasting two sessions (session 1 & session 5) which were part of the first iteration of the case study focused on designing an automated feedback tool for nursing students.

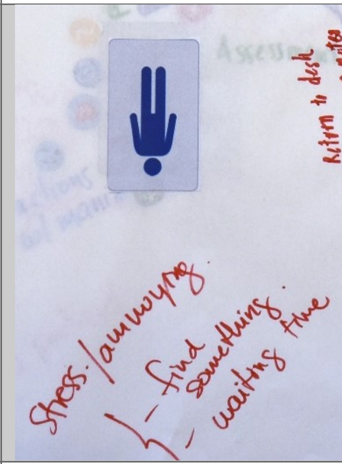
Session 1 included 3 students using the Learner/Data Journey tool (See section 5.3.8) to explore the usefulness of recommended feedback by the design team. The feedback proposed included critical incidents, information about mistakes, manikin data, communication and stress readings. Session 5 invited a teacher to visually inspect student's comments on preferences using the digital version of the Learner/Data Journey and provide commentary.

The critical moment shows students' disinterest in tracking their stress levels during the simulations.

Vignette 1: focus group with students

The conversation starts with the facilitator asking about tracking stress levels during the simulation (line 1). The facilitator then used the Learner/Data Journey map to capture keywords in annotations of students' views (line 2). ST 2 is not sure if it's important information to track (line 4). ST3 agreed and elaborated that stress is pretty simple to identify (without sensors) making this unnecessary (line 5). ST1 then explains that the structure of the simulation makes impossible for students to feel stressed (line 6).

Table 46: Vignette 1 Students representing their preferences in terms of receiving automated feedback using the Learner/Data Journey tool

Practitioner		Transcription	Co-design Tool
[KAF] ***Action***		[Session 1: Students]	
[Sensemaking] ***Inquire***	1	**Facilitator**: Let’s say that we can measure your stress level; would you like to see that, or it’s not important?	
[Improvisation] ***Draft***	2	**Facilitator: (**Action-*The facilitator writes keywords to situate the comment around the bedside)* The figure at the right shows the resulting image produced in iteration 1 session 1.	
	3	**ST2**: I don’t know how important it is.	
	4	**ST3**: I would know my stress, because I’m stressed, so I don’t really need the feedback.	
	5	**ST1**: I don’t think you can feel stressed while doing this in the sim room.	

Learning Design LD1 – Example 1

Case study: Automated Feedback tool for nurse students

Co-design tool: Learner/Data Journey

Design Cycle: Iteration 1 Session 1 & Iteration 1 Session 5

Critical Incident: Students and teacher disagree on how the automated feedback tool to display data during the debrief section and diverge the conversation into a learning design discussion.

This example illustrates an instance where the initial conversation between students and teacher regarding the automated feedback tool diverge into a learning design discussion. Some tension between these two was found when contrasting two sessions (session 1 & session 5) which were part of the first iteration of the case study focused on designing an automated feedback tool for nursing students.

Session 1 included 3 students using the Learner/Data Journey tool (Section 5.3.8) to explore the multiple ways that automated feedback could be delivered to students. At this point the conversation covered students feedback expectations and issues with the current simulation practice. Session 5 invited a teacher to visually inspect student's comments on preferences using the digital version of the Learner/Data Journey and provide commentary.

The critical moment mentioned above is shown as a vignette in the following section. The vignette includes actions performed by the co-design practitioner (playing a facilitator role), the partial transcript of the dialogues that emerged during the sessions, and the interactions with the co-design tool.

Vignette 1: Learner/Data Journey with students

The following transcription starts with the facilitator asking students how the automated feedback tool should display their results (line 1). After this, ST3 explained that feedback should be part of the debrief section and should only show if the procedures are right (line 2). ST3 proceeded to use the Learner/Data Journey map to point at the bedside (line 3). Based on this comment, ST1 elaborates that the best way for them to receive this feedback is by marking their mistakes with red colour and percentage (line 4). ST3 disagrees with the percentage idea but agrees with the correct/incorrect approach (line 5).

Table 47: Vignette 1 Students representing their preferences in terms of receiving automated feedback using the Learner/Data Journey tool

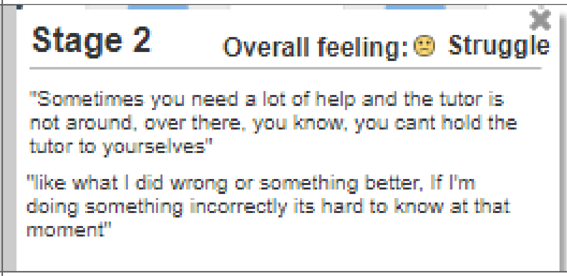
Practitioner		Transcription	Co-design Tool
[KAF] ***Action***		[Session 1: learners]	
[Sensemaking] ***Inquire***	1	**Facilitator:** How would you like to receive this data?	
	2	**ST3:** I think in my head I think the most useful would be having the playback and then seeing where we're going with our conversations and then having what the mannequins respond to. If we're doing the procedures right, if we're hitting the right points that we need to look at. This should be part of the debrief. Even like stress level on the side would be pretty funny, I reckon.	
	3	**ST3** (Action-*The student (ST3) uses the Learner/Data Journey map to point at the bedside.*	
	4	**ST1:** Yes, I'd like the individual thing to be in red or highlighted that was missed or done incorrectly. Because generally, you think you're doing the correct thing, so if it was just 70% correct, you wouldn't know what part of the procedure you did incorrect if it wasn't specified.	

	5	**ST3:** I don't think a percentage would do anything to me.	

Vignette 2: co-design session with a teacher

During session 5, the conversation started with the facilitator asking the teacher to review students' comments on feedback and the debrief structure (line 1). The teacher reviewed students' comments through the digital version of the Learner/Data Journey (line 2). TE then responded by explaining that feedback is just not about telling students if they did right or wrong. TE further elaborated that teachers need to help students to reflect on their practice to make the process focused on students and enrich the debrief section (line 3-4).

Table 48: Vignette 1 Students representing their preferences in terms of receiving automated feedback using the Learner/Data Journey tool

Practitioner		Transcription	Co-design Tool
[KAF] ***Action***		[Session 5: teacher]	
[Narrative] ***Inquire***	1	**Facilitator:** What do you think about the tool showing data results as described by students?	
	2	**TE:** (Action – *Teacher clicks on the Learner/Data Journey map to see what students think about data and feedback)*	
	3	**TE:** So it's not just about: how do you feel? It's about: how did you feel? So let me explore that a little bit; let's talk about those feelings. What made you feel like that? At what point did you feel like that? Let's talk about the task you were doing. Did you feel comfortable in that task? Tell me a little bit about it. So you were struggling; can someone else help here? What do you know about that task? Let's talk about how we can help each other. Let's unpack the task and the skill so that we can help each other learn.	
	4	**TE:** So it's not: I'm going to tell you what to do; it's: I'm going to pull it out of you, because I've given you appropriate pre-work; it's there somewhere. It's about pulling it out of the student and making it a real student-led experience rather than teacher-led. And then if there are real problems, then you have to jump in and give appropriate feedback where required. But, generally, you're facilitating group learning; you're not doing the teaching, so to speak. Does that make sense?	

Vignette Commentary

The challenge

In session 1, students described their needs in terms of receiving feedback through the tool. At the same time, they developed their opinion towards the current issues with the debrief section part of the learning design (session 1 line 2-4). This suggestion goes against teachers' recommendations over not changing the intended learning design for the purpose of exclusive scenarios (session 5). Students suggested that getting a visualization with their mistakes and success rates is the most useful thing they could get. However, the teacher commented that the problem is not the learning design, but the way current teachers unpack the required feedback. If the design team follows students' recommendations, the debrief structure (which is part of the learning design) will have to change to fit the tool display features. The challenge of working with a section related to the learning design structure is that students and the teacher turned the conversation into discussing the effectiveness of the debrief section, rather than discussing the expected features for the tool. This fits the description given in section N when explaining that the tool co-design process may evolve into a learning design debate leading to unproductive conversations for the design team.

The role of the practitioner

The structure followed in both sessions required for the co-design practitioner to assume the role of facilitator. Understanding [Sensemaking] students' expectations towards delivering results through the tool required for the facilitator to initiate with a specific question (*Inquire* line 1 session 1*)*. The facilitator expected for students to give a straight answer citing examples but turned into a discussion about changing the debrief section to fit the tool results. The facilitator must wait for students to finish their argument and see if the comments provided an answer to the intended question. In session 5, the facilitator initiated by asking the teacher to comment on students' perspectives about feedback delivery and the debrief integration. The *inquire* action is considered as part of the [Narrative] since the intention is to follow the same idea established through the learner-data journey map previously produced.

Effectiveness of the co-design tool (Learner/Data Journey)

In session 1 the Learner/Data Journey tool helped students to support their argument by pointing at specific parts of the map. Line 3 shows a piece of the map used as a reference by ST3 to represent a specific place without further verbal clarification. The students understood how the map could be used to present ideas without repeating an argument. In session 5, the facilitator uses the digital version of the Learner/Data Journey tool to summarise students' arguments from all sessions. The summary then is used in line 2 by the teacher to understand students' perceptions on feedback delivery and his place in the current debrief structure. The digital version allowed the teacher to save a lot by breaking full-transcriptions into useful quotes. This also facilitated the data analysis allowing the teacher to focus on specific parts of the problem.

Learning Design LD2 – Example 2

Case study: Automated Feedback tool for nurse students

Co-design tool/technique: Collaborative sketch.

Design Cycle: Iteration 1 Session 2

Critical incident: Students suggest that results should be used to shape the following sessions and learning design.

The example shown here illustrates an incident where students took advantage of the design activity to talk about changing the current learning design. During session 2, participants use the collaborative sketch results to communicate their need for improvement when teachers plan their learning design in simulations.

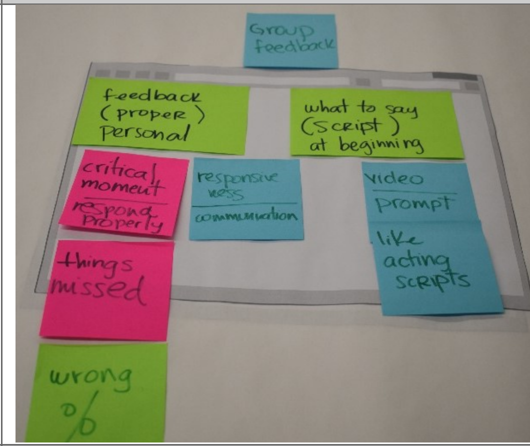
The participants invited to session 2 included 2 students (ST) explaining how data delivered by the tool can be used by teachers. This conversation was supported by the collaborative sketch tool (Section 5.3.5) guided by the facilitator.

The section shown below presents details of the critical incident using a vignette. This vignette includes actions enacted by the co-design practitioner (acting as a facilitator), the partial transcript from the conversation, and the interaction with the collaborative sketch tool.

Vignette 1: Learner/Data Journey with students

The short transcription below started with the facilitator using the collaborative sketch result to ask students about teachers getting access to the data (line 1). ST1 responded with details of how teachers should use this information to improve their future simulations (line 2). ST2 agrees (line 3) and continued saying how data should inform instructions followed (part of the learning design) and be implemented in all session similar to the one used as an example.

Table 49: Vignette 1 Students representing their preferences in terms of receiving automated feedback using the Learner/Data Journey tool

Practitioner		Transcription	Co-design Tool
[KAF] ***Action***		Iteration 1 Session 2	
[Narrative] ***Inquire***	1	**Facilitator**: Lets continue with how to use this data, Do you think the same data should be shown to teachers? (Action- *Facilitator pointed at the "critical moment" and "Things missed" pink colour post-its)*	
	2	**ST1**: I think it would actually be good feedback for the teachers and course organisers if they have everyone's data. Because if everybody is missing the same steps or everybody is not pressing hard enough on compressions, it's something that they can even redress in the next lesson. Or, certainly in future classes, that this is something that the other students missed out.	
	3	**ST2**: Yes.	
	4	**ST2**: Use this (Data) to change the instructions for all simulations like this one.	

Vignette Commentary

The challenge

While engaging with the co-design sketch tool, students suggested that feedback should be used by teachers to re-shape the following sessions (line 2-4). The implication of making changes to the plan goes against the learning design used for all the session during the semester. According to teachers and the course director, feedback is intended to be provided at the end of the session, this allows students to solve any issues with their practice within the same session. Time is very limited, and the following sessions are designed to address new topics. As a result, students' suggestions are compressive enough, but the application would have a bigger impact on the simulation structure and the intended objective for the automated feedback tool.

The role of the practitioner

The co-design practitioner assumed the role of facilitator to engage with students. The facilitator had the responsibility of further *Inquire* students about using their data beyond their working group. This action is intended to support the [Narrative] of getting enough details about the interface after students' comments using the collaborative sketch. However, the *Inquire* action led to unexpected arguments about changing future sessions. The facilitator had to make a conscious decision and drive the conversation back to the tool design avoiding a complex conversation of proper learning design.

Effectiveness of the co-design tool (Collaborative sketch tool)

The collaborative sketch tool used in this session helped the facilitator to open the conversation about data outcomes after students' proposals. In line 1, the facilitator opened the conversation using the sketch results to remind students about two interesting features ("Critical incidents" and "things missed "). Features are listed as post-its and the colour was used to identify each student. The pink post-its used in this discussion (shown in line 1) were proposed by ST1, this drove the student to lead the conversation and expanding their contribution towards changing the learning design of future sessions.

Learning Design LD3 – Example 3

Case study: Automated Feedback tool for nurse students

Co-design tool/technique: Learner/Data journey

Design Cycle: Iteration 1 Session 1

Critical Incident: Students diverge from the original idea and want to replace the teacher with highly responsive manikins.

This example illustrates an instance where the students' comments diverged from the original idea of building an automated feedback tool into updating the current manikins. This incident was found in session 1 when the facilitator guided participants intro design related question about data visualizations.

Session 1 invited 3 nursing students (ST) to a co-design activity using the focus group technique (Section 5.3.1). The objective of this section is to understand students' expectations when receiving their data through the automated feedback tool.

The critical moment mentioned above is shown as a vignette in the following section. The vignette includes actions performed by the co-design practitioner (playing a facilitator role), the partial transcript of the dialogues that emerged during the session, and the interactions with the co-design tool.

Vignette 1: Learner/Data Journey with students

In the following vignette, the conversations started with the facilitator asking students about other interesting data to explore (line1). Following this, ST2 diverge the conversation into having pre-programmed manikin acting as a real patient (line 2). The response from ST3 and ST1 shows agreement and introduced the problem of requiring acting skills when following the current learning design (line 3-5). The conversation ended when ST2 makes the comment that the current interaction with the manikins makes them feel "like a dummy" (line 6).

Table 50: Vignette 1 Students representing their preferences in terms of receiving automated feedback using the Learner/Data Journey tool

Practitioner		Transcription	Co-design Tool
[KAF] ***Action***		[Session 1]	
[Sensemaking] Inquire	1	**Facilitator:** What other data would you like to find in the tool?	*Reads the script written for the Focus group*
	2	**ST2**: Actually, I just thought of something. If, instead of having a teacher or someone that responds, there could be a programmed written to give appropriate responses. You say something and then the machine will give a series of pre-programmed responses to that, that would also help to make it a little bit more realistic.	
	3	**ST3**: Because it's like acting.	
	4	**ST1**: Yes.	
	5	**ST3**: Pretend. We're doing an acting degree.	
	6	**ST2**: Actually, I find that talking to a dummy makes me feel like a dummy.	

Vignette Commentary

The challenge

The conversation following the focus group protocol deviated from the intended design objective into generating a whole new tool using the manikins. Students participants in the session proposed that instead of having an automated feedback tool (line 1), the better solution should be replacing the teacher as a way of having feedback straight from the manikins (lines 2-5). These new manikins should be capable of giving realistic answers so it's not necessary to have a teacher present. Giving that other participants agreed with this, the conversations turned into making changes to the current learning design. This change in the conversation becomes an issue for the co-design session since participants started to lose their focus on the tool design. Also, it brings conflict to the original objective of supporting teachers instead of replacing them.

The role of the practitioner

The co-design practitioner acted as the facilitator giving the objective of the session. During this part of the process, the facilitator wanted to know about details when presenting students' results. The facilitator started the conversation asking (*Inquire* action*)* participants to specify data they would like to get from the tool (line 1). This was intended to get specific answers like chart types, interface details and notifications. However, participants decided to turn the conversation into a non-related topic regarding current manikins and their experience when interacting with them.

Effectiveness of the co-design tool (focus group)

In this part of the session, the focus group allowed the facilitator to post questions about the expected data delivery using a pre-defined script. Giving the details explained before, this example showed some limitations when having pre-defined questions and students want to discuss other topics. Free exploration is supported by the focus group structure but participants may use this space to talk about other issues and personal ideas that may not be useful for the research team.

Surveillance and privacy SP4 – Example 1

Case study: Developing graduate attributes with MDSI Students

Co-design tool/technique: Learner/Data journey

Design Cycle: Iteration 1 Session 1 & 2

Critical incidents: Students are overly suspicious of university tracking practices.

The critical incident described in in this section illustrates the challenge of surveillance and privacy concerns when MDSI students collaborate in design. During the collaborative persona and focus group activity, participants comments on being tracked for the purpose of providing accurate information that reflects their progress were exchange from an overly suspicious stance.

Session 1 and 2 invited 10 students (ST) from the MDSI program to discuss expectations when using their data to build a learning analytics tool. The setting of the focus groups led to honest conversations about privacy and the value of their data according to their knowledge in the field.

The following vignettes present the transcriptions and interactions between participants during session 1 & 2. We separated the two session into two vignettes to allow comparison between groups and additional annotations on the practitioner actions.

Vignette 1: Focus group with students

The following transcriptions illustrates the negative stance towards data tracking practices for academic purposes. In line 1, the facilitator starts with an open question to participants about tracking their data. ST 2 and ST 3 elaborate that regardless of the question UTS may be tracking their data already (line 2-3). In line 4 and 5 students explain that there are no other options since they understand how data ownerships works when you are a student.

Table 51: Students explaining the position towards being tracked regardless of their concent.

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***		[Session 1]	
[Sensemaking] Inquire	1	**Facilitator:** Would you allow us to track your data for academic purposes?	*Read script for the focus groups.*
	2	**ST2**: I have a feeling I've been tracking it all the time, because I've been using UTS like this. I might already be tracked.	
	3	**ST3:** But I don't switch on location on my phone, so [overtalking]. I know like this… I'm a bit of a paranoid person, at this day and age I could just be overthinking. But location, yes? I don't know. I…	
	4	**ST4:** I'm already being tracked, so I can't say yes or no.	
	5	**ST5:** I'd be comfortable, I understand your concerns, intellectually, but I don't understand your concerns… I mean, I'd be more concerned about an unknown third party tracking me, which is again much more likely given my browsing habits. But if it was for specifically for the university, I wouldn't have a problem.	

Vignette 2: Focus group with students

In this example, the facilitator starts the conversation citing examples of tracking their data from different sources (line 1). ST 3 and ST5 answer with a simple agreement towards giving their data including browser history (line 2-3). ST 4 has a different stance about this and explains in line 4 the concept of negotiation setting a laptop as a proper exchange for his data.

Table 52: Students introduce the concept of negotiation in exchange for their personal data.

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***		[Session 2]	
[Sensemaking] Inquire	1	**Facilitator:** All right, what about your browser histories and kind of material?	
	2	**ST3:** I don't mind that.	
	3	**ST5:** I think, no.	

	4	**ST4:** No. Not unless you're giving me a computer which is specifically for work, free for university. Giving me a computer for free with 16 gigabytes of ram, that stuff can be fair. And you can track me [inaudible], otherwise no way	

Vignette Commentary

The challenge

Participants relationship with data practices in this session became relevant when their position towards being actively tracked comes from a perspective of expecting the worst from the institution. The arguments reflect an already negative position on not being able to negotiate their data privacy since they find the current practices intrusive. This brought a problem to the design process since the topic couldn't be discussed enough between participants, leaving details behind based on the premise that the institutions will disregard their preferences as usual.

The arguments expressed by participants in group 1 shows 3 different students with similar stances using their negative experiences as the point of comparison for this new analytics tool. On the other hand, the second group showed less elaborated answers but ST3 introduces the concept of negotiation when allowing access to their data, some that can be considered as putting a price to their information.

The role of the practitioner

The practitioner acted as a facilitator and introduced the premise of privacy and surveillance expecting for participants to communicate their perspectives. The *inquire action* leads the conversation and gives space for every student to give an answer.

Effectiveness of the co-design tool (Focus group)

The settings of the focus group allowed the facilitator to introduce the topic without expecting a positive answer. Students used this space to talk about their concerns without pressure. As a result, the answer shown in the vignettes were considered honest since participant understood how the focus group was not used to assess their knowledge on the topic but rather as a guided conversation around learning analytics design.

Surveillance and privacy SP5 – Example 2

Case study: Developing graduate attributes with MDSI Students

Co-design tool/technique: LA-DECK

Design Cycle: Iteration 2 Group 1

Critical incident: Participants discuss temporary privacy settings to focus on other components.

The following incident illustrates the challenge of privacy as a topic in learning analytics design. Participants tried to avoid going into details about privacy and surveillance for the sake of focusing on other components.

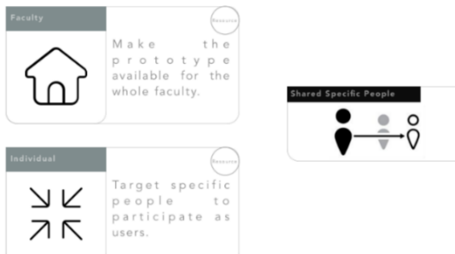
Session 1 part of iteration 2 invited a course director, a developer and a teacher to use the LA-DECK cards to design a learning analytics tool to support writing in CICAround. while engaging with the LA-DECK design session,

The following vignette illustrates the conversation between participants and their interaction with the LA-DECK tool during the session.

Vignette: LA-DECK with the course director, developer and teacher.

The conversation analysis shows the main arguments from participants marked in bold letters when a particular stance is taken. In line 1 the facilitator asked participants about the importance of discussing privacy during the design process. The Course Director (CD) opens the conversations by letting know other participants that the subject is too complex for it to be resolved during the 60-minute activity (Line 2). In line 3 the CD uses a privacy card [Shared with extended people] to illustrate his argument. Answers from the Teacher (TE) and Developer (DEV) shows agreement but contribute to at least provide examples like not having any privacy is a normal thing inside the course as a teacher (Line 5-8). This exchange leads the CD to do the same and set the minimum working settings for the tool to work as expected. The other evidence used to mark this critical event can be seen when analysing the card played during the activity. The developer finished the conversation by explaining the possibility of anonymising data to avoid controversies (line 12).

Table 53:Participants discussing how complex privacy can be and the need for further sessions focused on this topic.

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***		[Session 1]	
[Sensemaking] Inquire	1	**Facilitator:** Do you think privacy should be discussed at this point?	
	2	**CD:** Possibly yes. So that is to be determined. For me that's… It's just to flag that there are privacy issues there and that you'll have to… It's something that has to be discussed. I think if you start going down that rabbit hole you'll get stuck in there a long time.	
	3	**CD:** (Action- *Plays a privacy card)*	
	4	**CD:** Yes, so you would need data from Review, but there is privacy issues around that. So I think you had some of your privacy flags and stuff.	
	5	**TE:** Privacy. I don't have it.	
	6	**CD:** There's also… That's also quite sensitive information so it's probably, you know, the dashboard has to have security designed around that as well, which is, you know.	
	7	**TE:** Should be again only for the teacher.	

	8	**CD:** Yes, and even maybe not all teachers.	
	9	**TE:** Not all teachers?	
	10	**CD:** Maybe. I don't know. I don't know. It depends. Would you give it to teachers, would you give it to, you know.	
	11	**TE:** Yes that's true.	
	12	**DEV:** Or maybe you want to anonymize it before you give it to people.	

Vignette Commentary

The challenge

During this part of the session, the course director acknowledges that privacy is an important component, but this may require a whole other session for them to give a definitive answer. Other participants support this instance but suggest using temporary preferences as a starting point for the analytics tool to be functional. The discussion became a trade of arguments stating the need for agreement before moving to discuss a different component. Privacy proved to be a sensitive topic for some participants that required further discussion beyond the use of the cards.

The role of the practitioner

The practitioner acted as a facilitator using an *inquire action* to guide the conversation towards privacy. The facilitator understands the cards and incites participants to use them to build an argument without overthinking.

Effectiveness of the co-design tool (LA-DECK)

The cards helped participants to kickstart their argument about privacy concerns. In line 3, the CD looked at the cards and decide that there is no right answer that can include all the aspects relevant for privacy settings. However, the card played invited other participants to elaborate on the minimum things that can be discussed without extending the conversation beyond the allocated time. The developer used the card to support his argument that data can be anonymised and move on to the next topic on using students' data.

Surveillance and privacy SP7 – Example 4

Case study: Developing graduate attributes with MDSI Students

Co-design tool/technique: LA-DECK

Design Cycle: Iteration 2 Session 3

Context: Developing graduate attributes with MDSI Students

Key: CICAround mentioned as the blogging tool used by students. MDSI Master of Data Science and Innovation

Critical Incident: Teacher and student disagree on over what constitutes as private information when it comes to personal blog posts.

Figure 9-1: Student using the map to explain his position on privacy as a counterargument for the data scientist comment.

The example shown below describes a situation where the teacher/data expert and the student engaged in a debate over what constitutes as private information when it comes to personal blog posts. This example can be found in session 3 during the second iteration of the LA project to develop graduate attributes with MDSI Students.

Session 3 invited 1 expert in data science (DS) and 1 student (ST) currently enrolled in the MDSI course. The purpose of this session is to define the design components of the current CICAround blogging system using the LA-DECK cards to support their conversation.

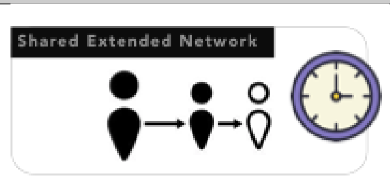
The critical incident mentioned before is presented below as a vignette including the partial transcription of the dialogue, the actions followed by the co-design practitioner and participants' interaction with the co-design tool.

Vignette: Using the LA-DECK with a student and one data science expert

The following extract starts with the facilitator guiding participates towards privacy options (Line 1). Before giving an example, the data scientist expert (DS) starts an argument over private blog post as the default option giving a posture of keeping everything as private (Line 4). Following this, ST1 comments seem to agree but request clarification over what constitutes as private (Line 5). Once the DS clarifies his position, ST1 express a change of mind and includes the concept of public available for the class as limited access to his blogging information (L 14). Since the following comment do not show any sort of agreement, ST1 proceeds to pick a *Shared Extended Network* card and place it on the table.

Table 54: Vignette 1 includes the conversation between the facilitator, data expert and the student analysing the limits when sharing blogposts.

Practitioner		Transcription	Co-design Tool
[KAF] ***Action***	1		
[Narrative] ***Inquire***	2	**Facilitator**: What do you think about the surveillance and privacy for your blogpost?	
	3	**ST1**: Default option?	
	4	**Facilitator**: Yes.	
	5	**DS**: Private. I would go for private.	
	6	**ST1**: Yes, full private. Yes. Does private mean it's inside CIC Around?	
	7	**DS**: No, it's yourself.	
	8	**Facilitator**: No, it's only for you.	
	9	**ST1**: [Students explores the privacy cards]. I don't know. In my opinion, it should be public to everyone in CIC, at least internally.	
[Sensemaking] ***Inquire***	10	**Facilitator**: So, friends or your close group like people in the same year or people in MDSI?	
	11	**ST1**: In MDSI, yes. Which I think is the current configuration, current setup. If you publish something there, everyone can see it	
	12	**DS**: Your class.	

	13	**ST1**: In CIC Around can see.	
[Sensemaking] ***Explain***	14	**Facilitator**: I don’t know why. It’s something that happens. So, we will cut all the privilege and go to one by default.	
	15	**ST1**: Private? I don’t know. But in my opinion, it should be to everyone that has access to MDSI because it already is a closed system. I don’t know. I don’t see much sense of being private just to yourself and maybe a professor. I don’t know. It’s...	
	16	**ST1** (Action - *plays a card* [*Shared Extended Network*])	

Vignette Commentary

The challenge

This example shows a scenario where the challenge of privacy and surveillance emerges when two different stakeholders collaborate. The student (ST1) disagreed with the data science expert (DS) comment on privacy settings and this evolved into a short argument before reaching a common agreement. The DS provided a recommendation from a data security position and recommended keeping everything as private (Line 4). This goes against the purpose of receiving feedback from peers. ST1 understand this issue and used his personal experience to create a counter-argument. ST1 used the cards to better understand his options but further clarification is required for both parties to reflect on how limited settings have an impact on students' access to information (Line 14). After further reflection, the DS misunderstood the learning objective behind writing blog posts. This led to the challenge over what should be done in theory against what is needed from the student perspective.

The role of the practitioner

In this session, the practitioner became the facilitator. The facilitator starts the conversation by asking participants about privacy and focus on this topic for the following minutes. This *Inquire* action (Line 1) guides the conversation and keeps the [Narrative] connected with the following activity on privacy. Even though *Inquire* is used to support the design [Narrative], the same action was used to prompt ST1 into explaining [Sensemaking] more in detail about his definition of a closed group (Line 9). After this, the facilitator responds (*Explain* action*)* to ST1 questions on current settings before reaching a partial agreement. This helped ST1 to make a conscious decision [Sensemaking] based on the information available.

Effectiveness of the tool (LA-DECK)

In this scenario, the cards worked as a reminder of the possibilities when it comes to privacy settings before making an argument. First, in Line 4 the data science expert does not use the cards and gives a straight answer. However, In Line 8 the student takes some time to look at the privacy cards and think a response to what the data science expert is saying. After looking for clarification in Line 9-14, the student decides that making the blogpost completely available for everyone as public would be too much access. The student is not sure about what option fits the best and settles for the [Shared Extended Network card] while explaining how it can be applied.

Learning Design LD8 – Example 8

Case study: Developing graduate attributes with MDSI Students

Co-design tool/technique: Collaborative sketch.

Design Cycle: Iteration 1 Group 2

Critical incident: Students response to personal results become a debate over the benchmark used for assessment.

This critical incident illustrates an instance where students engage in a learning design discussion against the design objective of the session.

Session 2 invited 5 students to discuss the expected features when designing a new LA tool using the collaborative sketch to support their conversation. At this point, participants already discussed how the tool interface should look like and engaged in a conversation about data showed by the tool.

The following vignette illustrates the conversation between students and the facilitator while using the tool and engaging with the design activity.

Vignette: Using the collaborative sketch with students.

The conversation shown in the following transcript shows two students from Group 2 providing a different answer to what is required to fulfil the design task. The facilitator opens the conversations by asking if the visualization part of the tool interface should only show personal results (line 1). ST3 (line 2-3) starts answering with an opposite example of using other student's results as a benchmark for everyone. ST4 continues by reflecting on the nature of being assessed implying some sort of comparison (Line 4). The conclusion becomes more about being benchmarked than deciding if showing personal results should be included as a visualization in the learning analytics tool.

Table 55: Students debating comparison as a benchmark result for the learning analytics tool interaface.

Practitioner	Line	Transcription	Co-design Tool
[KAF] ***Action***		[Session 2]	
[Sensemaking] Inquire	1	**Facilitator:** Would you like the tool to show only personal results?	
	2	**ST3**: Actually I was thinking the other way round. Like, for this master course, it's more about the benchmark of what is… Like, it's not amongst us. The benchmark is more about, like, for example, we're all going to write this essay about how to identify opportunities and the impact of the a [inaudible] industry, in terms of data, usage and things like that. I guess if all of us do really well, we can all get HDs, but it doesn't mean that…	
	3	**ST3:** We're not normalised. It's not like if one [overtalking]. Yes, so if ten people do really, really well, they want us to say, I'm sorry, I can't. I can only have two high Ds, and two Ds and two credits. I think…	
	4	**ST4:** Sure, but in a way, your work is still being assessed as being very good. That's still, even if everybody in the course is deemed to be very good, on the population average then everyone in the course is… In a way, it's still [overtalking].	
	5	**ST3:** Yes, I agree with you. It's benchmarked, but it's not benchmarked with the rest of us. It's benchmarked at the absolute value of… Whether it is well done or just so-so [overtalking].	

Vignette Commentary

The challenge

While building a lo-fi prototype using the collaborative sketch technique, students disagree with the proposed solutions of having only personal results shown by the tool. The argument for their disagreement is unclear since participants described a combination between comparison within the same group and a personal score using others as the benchmark. The challenge lays on students diverging the conversation into a learning design topic behind group assessment and not completing the design task of formalizing a chart visualization.

The role of the practitioner

The practitioner acted as a facilitator when asking students to pick between personal results or comparison with their peers. The intention of the *inquire action* is to keep the conversation flowing into details without asking for technical language.

Effectiveness of the co-design tool (Collaborative sketch tool)

The tool allowed participants to set the context of the conversation in the function of the interface design. Even when the conversation deviates into a learning design topic, the information became useful for the designers to understand their needs towards the LA tool.