

LA-DECK: A Card-Based Learning Analytics Co-Design Tool

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ABSTRACT

Human-centred software design gives all stakeholders an active voice in the design of the systems that they are expected to use. However, this is not yet commonplace in Learning Analytics (LA). Co-design techniques from other domains therefore have much to offer to LA, in principle, but there are few detailed accounts of exactly how such sessions unfold. This paper presents the rationale driving a card-based co-design tool specifically tuned for LA, called LA-DECK. In the context of a pilot study with students, educators, LA researchers and developers, we provide qualitative and quantitative accounts of how participants used the cards. Using three different forms of analysis (transcript-centric design vignettes, card-graphs and time-on-topic), we characterise in what ways the sessions were “participatory” in nature, and argue that the cards succeeded in playing very similar roles to those documented in the literature on successful card-based design tools.

CCS CONCEPTS

• **Information systems** → Data analytics; • **Human-centered computing** → Visualization design and evaluation methods

KEYWORDS

Co-design, cards, learning analytics, participatory design

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1 INTRODUCTION

The development of Learning Analytics (LA) systems requires the careful balancing of data, social and epistemic design components to provide enhanced educational experiences [16]. A critical problem with many LA systems is that their design commonly follows a top-down process where researchers and developers perform most of the tasks and made decisions in behalf of the people who will use the systems (i.e. students and educators). To date, there are few accounts in the literature demonstrating how students, teachers and other stakeholders can have an active voice in the design of LA innovations [4,10]. This can become into a barrier for successful LA adoption both at institutional [12] and classroom levels [21].

The overwhelming evidence from three decades of human-centred design is that bringing stakeholders’ voices into software design increases the chances of successful innovation. A specific strand of work is the discipline of *co-design*, in which researchers and designers tackle the complex task of translating multiple, diverse voices into design requirements using *generative tools* [30]. These provide process scaffolding and representations for diverse stakeholders to express their ideas, experiences and feelings by *telling* (e.g. through storyboards, cards, voting), *making* (e.g. mock-ups, prototypes, models) or *enacting* (e.g. through props, improvisation, role-play) [30].

However, including multiple stakeholders in the design process adds complexity to the development lifecycle [21]. This includes *generic* co-design challenges such as the need to (i) facilitate increased communication, social inclusion and decision making, and (ii) manage asymmetric power relationships. These challenges can deter certain stakeholders (e.g. students) from challenging another group’s ideas (e.g. their teachers) [20]. *Specific* to LA are *data and pedagogical literacies*: the need for non-technical stakeholders to engage in discussions about educational data, and the need for technical stakeholders to build mutual understanding of educational intentions.

The goal of this paper is to propose a novel card-based co-design tool specifically crafted to support inter-stakeholder design of LA innovations. Grounded in key co-design and LA literature, we identify a set of categories aimed at providing stakeholders, bringing different backgrounds, literacies and expertise, with a common language that can facilitate both a space for divergent discussion, balanced with focused deliberation. We illustrate the use of the cards in a series of design sessions in which a course director, teachers, students, researchers, and developers

considered a range of design issues for the social learning analytics component of a system currently in use. We document how the cards supported participants by providing a common LA language, making agreements and disagreements explicit, and providing room for idea generation.

The rest of the paper is structured as follows. The next section briefly summarises the state of the art in LA co-design. Section 3 presents the design rationale for the cards, before Section 4 details a study that illustrates the ways in which they served as resources for inter-stakeholder dialogue in design sessions. Section 5 summarises our findings, and Section 6 discusses implications for future work.

2 PREVIOUS WORK

Human-centred design in LA is emerging as an important topic [3], with co-design/co-creation specifically attracting interest as methods to integrate teacher, student and other stakeholder perspectives. For instance, Dollinger and Lodge [10] argue that co-creation strategies can help to bridge the gap between the tool and the actual educational need, facilitating sensemaking, and ensuring long-term adoption. Martinez-Maldonado et al. [22] propose an applied methodology to engage teachers in iterative prototyping and evaluation cycles before deploying an LA system. Similarly, Rodriguez-Triana et al. [21] proposed an approach to include teachers in *customising* LA solutions and consider other stakeholders (e.g. students) as informants to validate the effectiveness of a LA tool. Moreover, co-design techniques are emerging that are tailored to the design of data-rich educational technologies. For example, Holstein et al. [17] document *replay enactments* to allow teachers to experience different representations of data in order for them to provide early feedback. Prieto et al. [21] propose questionnaires that can be used with different stakeholders (namely teachers, researchers and developers) to interrogate them regarding their particular views on learning, data and technology, and comment on others' perspectives.

Notably, most case studies in the literature involve teachers, researchers or developers, but students have remained conspicuously absent (although for informal accounts, see [31,35]). One exception is our previous 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 [5]. An example of this is the *Learner-Data Journey* [4] used by students to map the activities they perform, with explicit opportunities for *data-informed* reflection.

The concept of using *cards* for stakeholder engagement is a relatively new technique used by designers to provide a structure for ideation [19], 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 [36], and *Tango* cards for designing educational

tangibles [9], but there are many more, collated at Deckaholic library [8] and critically reviewed in [29].

To summarise, the LA community lacks co-design tools tuned specifically to the needs of LA stakeholders to effectively communicate and understand the design components. There are few detailed accounts of how these tools are used by different stakeholders, and with what effect. Our work seeks, therefore, to add to the portfolio of co-design tools available to LA designers, with a practical methodology using a card-based toolkit. This is specifically designed to support design sessions where stakeholders (including students) meet face-to-face to conceive new learning analytics, while satisfying the resource and technical constraints that always bound software design.

3 LA-DECK DESIGN

Inspired by card-based approaches, we have prototyped a *Learning Analytics Design* deck of cards (LA-DECK). The analysis provided in Roy and Warren's review of 155 card-based toolkits [29] showed that an effective card-based approach for design includes carefully defining a scaffolded procedure and rules for operation before designing the visual aspects of the cards. Designing LA-DECK therefore required making choices about the key dimensions for operation that the deck should foreground. The LA literature offers a number of frameworks recommending key considerations for designing and deploying LA innovations, varying depending on the stakeholder groups being targetted, and the framework's purpose [13,25,38]. While there can be no single, correct framework for all purposes, there is clear 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 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*). LA-DECK's *values* are derived from the team's values, as well as from LA frameworks and other literature (e.g. *privacy* is important; since we want to engage educators, we need to talk about *learning objectives*). Table 1 summarises exemplar sources motivating each of the initial dimensions.

Table 1. Sources in LA research motivating the design dimensions expressed in LA-DECK

Dimension	Reference
Data Source, Analytics Type, Developer Tools	[2,6,7,23,26,30]
Testing Site, User Interface	[25, 29]
Privacy and ethics	[27,33]
Analytics Methods	[15,18]
Learning context and objective	[14]

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 [9,36]. Scaffolding the design process into a workable number of dimensions builds on

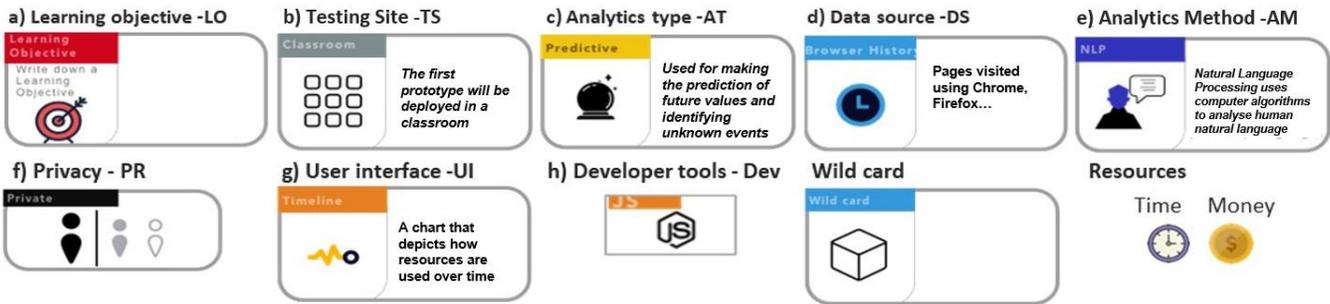


Figure 1: Examples of LA-DECK cards

recommended principles for producing a design plan when working with interdisciplinary teams [24].

3.1 Card themes, suits, and designs

Based on our co-design model, we defined eight ‘suits’ of cards, grouped 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 contains cards following a consistent design including colour, name, icon, and (an optional) description (see Figures 1 and 2). 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 1 for examples). Additionally, two types of Resource tokens are provided for participants to estimate the **time** and **money** required to implement parts of the design.

As discussed earlier, the choice of cards is based partly 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. [37]). We now describe each suit in more detail.

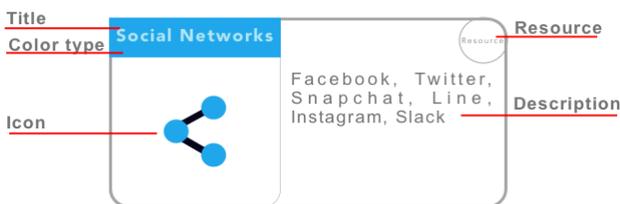


Figure 2: LA-DECK card structure and design

3.2 Context cards

Learning Objective (LO) cards [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 help deliver. Ideally, the point of departure would be the teacher’s explicit learning design, to bridge the gap between the pedagogical intention and LA capability [2], but of course, this

might become the focus for conversation. The cards in this suit were *Subject Learning Outcome*, *Teacher Objective* and *Learning Task*. These provided participants with different options for specificity as the cards are left blank for completion in writing (e.g. see Figure 1a).

Testing Site (TS) cards [grey]: The cards in this suit are 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 not only the design of an LA tool but typically have implications for the wider organisational and technical capabilities that need to be in place to deploy the LA system. Figure 1b shows the grey card corresponding to the *Classroom* level: “*The first prototype will be deployed in a classroom*”.

3.3 Strategy cards

Analytics Type (AT) cards [yellow]: This suit permits participants to choose the type of analytics envisioned to support learning. Based on classic data science literature we provide cards for *Descriptive*, *Prescriptive*, *Diagnostic* and *Predictive* analytics. For example, Figure 1c shows the yellow *Predictive Analytics* card: “*Used for making the prediction of future values and identifying unknown events*”.

Data Source (DS) cards [blue]: This suit provides participants with common examples of data sources, following current practices in the LA field [28]. We provide cards including *blogging activity*, *LMS data*, *chat conversations*, *browser history*, *social network activity* and *marking results*. For example, Figure 1d depicts the blue card corresponding to *browser history*: “*Pages visited using Chrome, Firefox...*”.

Analytics Method (AM) cards [purple]: This suit synthesises common techniques and methods used to analyse data [18]. 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 1e depicts the NLP card: “*Natural Language Processing uses computer algorithms to analyse human natural language*”.

Privacy (PR) cards [black]: This suit provides examples of privacy configurations commonly used in information systems [34]. Cards in this suit include *private*, *public*, *share with group*, *share with friends*, *share with extended network* and *share with specific people*. Figure 1f shows the *private* card accompanied with an icon representing the concept.

3.4 Action cards

User Interface (UI) cards [orange]: This suit includes examples of user interface objects common in LA projects. Envisioning how the interface should look 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 1g we depict the orange *timeline* card: “A chart that depicts how resources are used over time”.

Developer Tools (DEV) cards [orange]: At some point in design practical implementation constraints must be discussed, so this suit provides developers with a way to introduce such considerations, with common technologies such as *JavaScript*, *Python*, *MySQL*, *R*, *PHP*, *Java* and *WordPress*. In Figure 3h we depict the orange *JavaScript* card with the familiar icon.

3.4 Wildcards and resources

Wildcards: Following the familiar gaming device of the wildcard, 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. Figure 1 shows an example wildcard for the *Data Sources* suit.

Resources: Finally, ‘spending’ tokens are provided for participants to negotiate the relative priority of different ideas in terms of where they would assign *Time* and *Money* (Figure 1). Alternatively, participants might choose to use the tokens to show the trade-offs between design options.

4 PILOT STUDY OF LA-DECK IN USE

How do LA co-design sessions unfold when stakeholders are required – literally – to “lay their cards on the table”? Does LA-DECK succeed in supporting stakeholder co-design in the ways that we intended? The study reported next set out to gather qualitative and quantitative evidence to answer this, and provides an account of the extent to which LA-DECK scaffolded the co-design process, which we compare to the roles played in other successful card-based design decks [29].

4.1 Context and participants

This study was conducted in the authentic context of a Master’s course in Data Science & Innovation at the University of Technology Sydney. Students in this program use a blogging platform to share their reflections within the community of students, academics and industry partners, while teachers use it to provide formative feedback, help students improve their writing and communication skills, and demonstrate their learning achievements through reflective writing tasks. Data on student activity, including blog posts and conversations, were aggregated

on a timeline, but there were no other analytics offered to support students. A series of six 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.

A total of 24 stakeholders participated: 5 students (S), 7 teachers (T), 3 developers (Dev), 1 of the two course directors (CD), 7 research data scientists (DS) and 1 facilitator (F). The facilitator was present during the sessions to introduce the task, explain the LA-DECK components, and respond to any questions raised by participants. The duration of each session was scheduled and completed in 60 minutes. Participants attended these sessions as volunteers, and were placed in teams to ensure diversity of perspectives. Students were assured that their contributions would have no bearing on their course grades.

4.2 Task design

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

Sessions were structured by the following the ‘rules of the game’: 1) Each stakeholder started with his/her own complete deck, so they could in principle have a voice in any aspect of the design. 2) Each player was instructed that they could ‘play’ a card whenever seemed appropriate (there were no formal turns), explaining why they were playing it. When a stakeholder played a card, they chose where to position it. 3) Participants were free to start with any card, but we have found that it helped for the facilitator to suggest the thematic sequence of *Context* → *Strategy* → *Action*. 4) Players were shown two example completed maps to illustrate how differently cards could be arranged, with no ‘correct’ layout. 5) Resource allocation (time and money) arose more naturally towards the end once there were multiple options on the table, although it could arise at any point.

Each session resulted in a candidate design represented in the form of the cards placed in different configurations on a large piece of paper. As seen in Figure 3, discussion happened around the table while the cards, and the annotations around them, serve as a representation of the conversation.

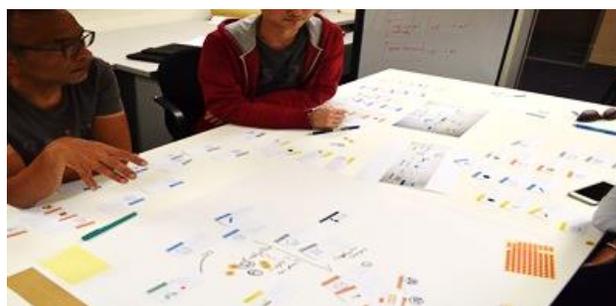


Figure 3: A LADECK co-design session

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's effectiveness compared to other approaches, their interest and willingness to use it in the future, and other feedback.

4.3 Analysis methodology

To validate the claim that LA-DECK supports LA co-design, we sought to 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 [11] of video and audio recordings identified a total of 22 critical incidents around stakeholders interactions with the tool [1], and examples used in the results are a small sample used for illustrative purposes.

Critical incidents were defined as events that "stand out" [1] in some way when using the cards. Additional information about the affordance of the cards, personal opinions and effectiveness were collected through the debriefing interviews.

The findings are organised around the four key roles played by LA-DECK, drawing on Roy & Warren's analysis [29]:

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

We present three kinds of analysis:

1. **Design vignettes:** critical incidents from transcript analysis. We present 2, from a total of 22 incidents identified, illustrating how the cards were used by participants during the design sessions. The remaining 20 other examples are variations of the cards in use, some of which are represented with quotes (given space constraints in this paper). 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, direction of play and connectedness between card suits.
3. **Degree and type of participation:** Cards played in each session, and the time spent discussing in each suit were used as another proxy indicator of participation.

These analyses enable us to attend to what Segalowitz calls the "materiality of the outcome" in participatory design [32], that is, the particular affordances of using paper based cards and pens, in the physical setting described.

5 RESULTS

In this section, we use Roy & Warren's [29] four roles (above) to reflect on LA-DECK's contributions as co-design tool. Roles (1)

and (2) are discussed in Sections 5.1-5.2, while roles (3) and (4) are discussed within them. Section 5.3 discusses LA-DECK's limitations.

5.1 A common basis for communication

The first critical incident is presented as a vignette, in this case around designing for privacy.

Vignette 1: Table 2 shows how two different stakeholders (a teacher and a student) diverged in their views about privacy and surveillance settings for students' blog posts. In session 3, stakeholders were discussing privacy in some depth, with the teacher and the student agreeing on the need for privacy settings, but with differing opinions.

Role of the cards: Different privacy cards were played along with arguments from both participants. In Line 5, the student uses the cards to explore her privacy options and picks the one that best represents what the teacher has said [*Private Card*]. In line 9, the student reflects on 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* and *Shared Specific People* cards. The playing of the Privacy cards thus gives structure to the turn-taking, providing a shared working memory of the options that are on the table, for others to build on.

In a second incident, the developer first introduces his idea in everyday language, then looks for the right card, and plays 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".

LA-DECK cards helped participants make their ideas visible to others by offering cues on what could be used to solve an analytic 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".

Card-based structuring of a session provides the basis for a metric of participation by each stakeholder type. The playing of a card can serve as an index point in the transcript, in which each stakeholder contribution is a new paragraph (as in Table 2). Beyond counting the number and type of cards played, we logged the time that each stakeholder type spent talking about 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.

Table 2. (Vignette 1) Using CardTool for privacy co-design: Facilitator (F), Teacher (TE), Data Scientist (DS), Student ST)

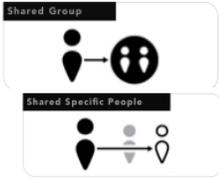
Transcript	Cards played
1. F: Okay, cool. So the default option that we need is this should be public for people in your own group? Private?	
2. TE: Private, or if they're all in DVN (<i>a course</i>) then, you know, or DAM (<i>a course</i>), then the whole class should be able to see. Like, you know, 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 <i>Private</i> [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 <i>Shared Group</i> & <i>Shared Specific People</i> 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...	

Figure 4 shows a barchart 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 Learning Objectives (LO): while participants played more than 20 cards, the conversation remained short in comparison to the three anchor categories.

In Figure 5 we show 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 play 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 data science 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 the Data Scientists.

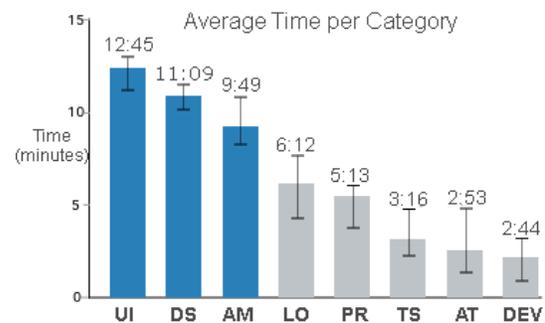


Figure 4: Mean time spent talking about each card suit.

The cards played the least, 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.

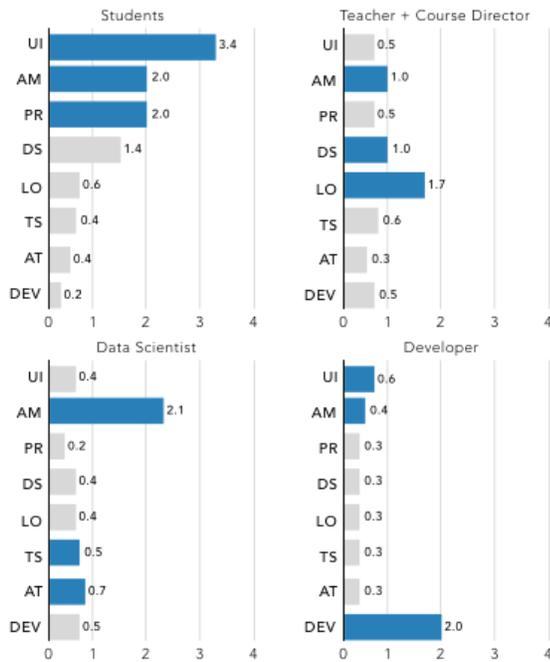


Figure 5: Cards types played by stakeholder role normalise for standard representation

This analysis advances the idea proposed by Segalowitz [32] 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 5). 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 follows: “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, presented next.

5.2 Facilitating creative combinations of information and ideas

Like any representational scheme, whether paper or software, LA-DECK cards capture aspects of an ephemeral conversation as a persistent resource. The semi-structured nature of the cards makes it simpler (than for instance, typical sticky notes or flipcharts) to spot connections between sessions or teams, since it is clearer to see from inspection when the same cards are appearing, and whether opinions differ. For example, two students in two teams disagreed on the default privacy settings for blog posts: “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). Analysing the maps after the sessions, the facilitator was able to see these *Privacy* card disagreements from these stakeholders. If the two teams had been brought together to inspect each others’ card maps, a conversation would then have ensued to understand the differences, which at some point would need resolution.

In another incident, a student played a card, and the data scientist followed this with the same card but in *qualified* agreement, pointing to a potential problem (which was already signalled by another card on the table):

S: (playing the *Sentiment Analysis* card) we can use this to understand peoples’ opinions toward the blog post”

DS: “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”

Both of these examples illustrate how the conversation weaves around the sequence of cards played. As a complementary form of analysis, examining card sequences across multiple groups without the qualitative analysis also revealed some interesting differences and similarities. Figure 6 shows ‘flow charts’ using the corresponding colour codes, starting from Move 1 (M1). It can be seen that groups followed the guidance provided, and initiated their conversation with the red *Learning Objective* card suggested by the facilitator. The blue lines show which cards became “anchors” that were typically built on in subsequent discussion, shown by their greater connectedness. The **anchor cards** in all sessions were *User Interface*, *Data Source* and *Analytics Type*.

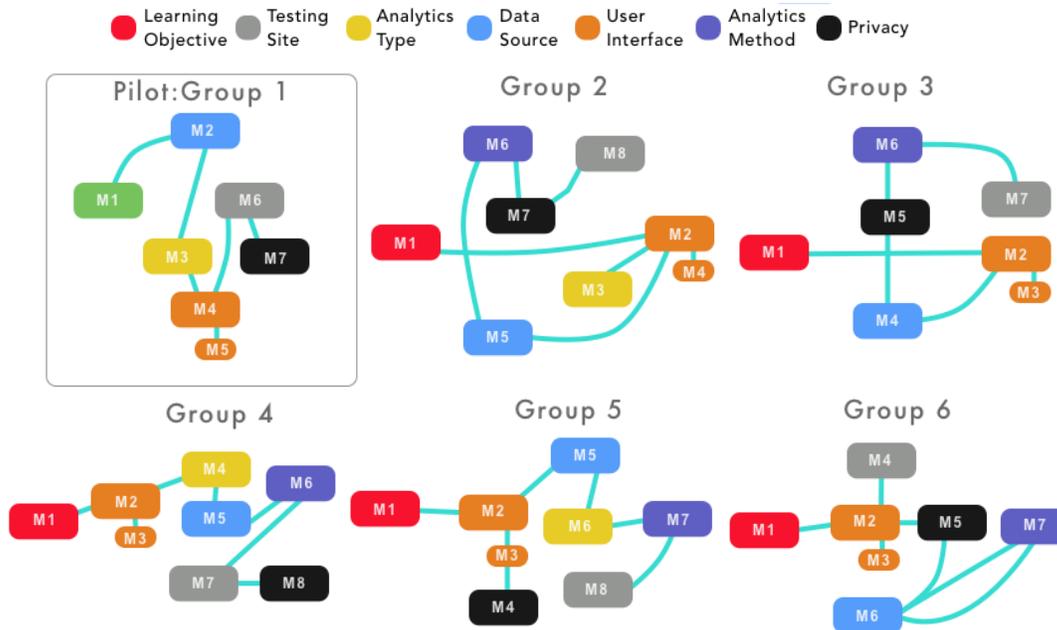


Figure 6: Sequence analysis between groups using LA-DECK (Move, Number)

The cards allowed any form of physical arrangement giving participants the flexibility of forming their own layout. In fact, one team (from a subsequent study) chose not to write on the cards at all, but used them as visual markers for more extensive notes written on the tabletop sheet.

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” [29] – the cards provided a shared memory resource and attentional focus in conversational turn-taking. The sequences in Figure 6 reinforce the idea that the eight 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 next, where stakeholders used two different suits to refine an idea.

Vignette 2: Table 3 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 are 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 uses 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 on the student criteria. This leads to the DS analyzing the cards available and suggesting a Social Network card (Line 4).

Conversation then moves on to consider expanding the data sources (Line 5).

Table 3. (Vignette 2) Combining different suits to form new ideas between Data Scientist and Student.

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

Vignette 1 (Table 2) and Vignette 2 (Table 3) illustrate how LA-DECK “provided convenient summaries of useful information/methods” [29]. The cards operated 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.

5.3 LA-DECK's limitations

The format of using cards as a medium of expression brings limitations already reported in other card sets [29]. LA-DECK aims to give a range of choices for each category. However, for categories like *Analytics Methods*, too many cards overloaded participants attention when formulating an argument. In some cases, participants decided to use the suit as a label but disregard the sub-types of cards, preferring to add their own label. Players were 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 tradeoff is inevitable: we were always mindful that a larger deck takes longer to become familiar, and more effort to manage and search (both physically and cognitively), 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 time-on-topic analysis. When recruiting participants for this to be an authentic pilot study, data science masters' students were the first option since they are early adopters of most data centric products in our university. A co-design session with more conventional stakeholders has been run subsequently with encouraging feedback which will be reported in future work.

6 Conclusion and future work

In this paper we have described the rationale, design and pilot evaluation of LA-DECK, a novel card-based tool, specifically designed to facilitate LA stakeholder co-design. We motivated a 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 in a pilot study.

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 that 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. The effectiveness of the cards can be recommended for early stages in the design process since ideation of high-level features can be formulated without producing a detailed prototype. 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 two vignettes 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. Depending on the design context, the facilitator may also take on additional roles including LA researcher, and subject matter expert.

To conclude, LA-DECK is an evolving co-design tool that will unquestionably benefit from further piloting. We have released a printable copy of the cards for others to adopt and adapt through the LA-DECK website (ladeck.utscie.edu.au), and following our gaming metaphor, we welcome 'expansion packs' that add new suits, and new 'rules' that offer participants alternative ways to structure sessions in engaging ways. Together with related work [4], 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.

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