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Working Together in Learning Analytics Towards the Co-Creation of Value

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Abstract

The value of technology lies not only with the service or functionality of the tool, but also with its subsequent value to the people who use it. New learning analytics (LA) software and platforms for capturing data and improving student learning are frequently introduced; however, they suffer from issues of adoption and continued usage by stakeholders. Scholars have previously suggested that it is not enough to introduce stakeholders (e.g., teachers and students) to LA technologies; they must also be a part of the LA creation and design process. In this paper, we will continue the ongoing work to clarify and compare different approaches of human-centred design through an overview of participatory frameworks in LA (co-design, co-creation). We will also present a case study using an LA tool used and developed within several Australian universities that was utilized over six years as an example of how LA designers can co-create dynamic platforms with teachers. Implications of participatory design frameworks in LA will also be presented through a discussion of the costs, challenges, and benefits of adopting human-centred design.

Notes for Practice

- There are key differences between various terms used to describe collaboration with stakeholders in learning analytics, including user-centred design, human-centred design, participatory design, and co-creation.
- The framework of communication, usage, and service encounters is a practical lens through which to consider engagement with participatory design partners. Through this framework, practitioners can symmetrically design, implement, and evaluate interactions with users that generate value.
- Flexible LA tools — such as the Student Relationship Engagement System discussed here — allow teachers to co-create LA and develop expertise, thereby allowing them to contribute in a more meaningful way to participatory design and co-creation of LA in the future.
- Approaching participatory design in LA as co-creation of a dynamic set of actions, supported through a platform to co-create the teachers' practice, may alleviate issues surrounding technical knowledge and expertise.

Keywords

Learning analytics, co-creation, co-design, participatory design

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1. Introduction

Learning analytics could be described as a concoction of business analytics, computational modelling, educational technology, and learning design. As a field, it is at an intersection where many researchers and designers from unique disciplines and backgrounds can add value and integrate their ideas (Siemens, 2013). However, despite learning analytics' historical roots as a multidisciplinary field, there is less detectable collaboration between researchers and teachers, or researchers and students

(Lodge, Alhadad, Lewis, & Gašević, 2017; Dollinger & Lodge, 2018). This gulf between researchers and users subsequently curbs the translation of value between design and use.

To illustrate, previous studies have reflected upon the distinct contexts of LA interventions, the specific institutional/school culture, teacher and student concepts of LA, and/or the accessibility of platforms as important, yet too often under-considered, elements in research designs (e.g., Corrin & de Barba, 2015; Macfadyen & Dawson, 2012). In other words, these factors are often not given enough prior consideration before implementation or adoption of processes begin. This recognition has led many scholars in the LA field to call for more user/and or human-centred design (HCD) practices (Ferguson et al., 2014; Gibson & de Freitas, 2016; Knight, Brozina, & Novoselich, 2016; Siemens & Baker, 2012) and positioned HCD as an important mechanism to support large-scale adoption (Ferguson et al., 2014). Benefits of HCD could aid large-scale adoption through several underlying functions, such as reduced need for training and support, improved acceptance across stakeholders, and enhanced reputation (Maguire, 2001). However, while there is a growing consensus across LA communities of scholars and practitioners on the need to integrate HCD, there remains confusion over terms and approaches on how to do so.

As well as differentiating between terms, HCD in LA could also be aided through greater articulation and discussion on why specific approaches and/or stakeholders were chosen to collaborate (Maguire, 2001). Interventions can benefit from the initial consideration of "who are the stakeholders?" and thus use contextual reflections to inform subsequent decision-making of approaches (e.g., storyboarding, brainstorming; see Maguire, 2001). While these are not the only critical questions or considerations across HCD, the "who" and "what" aspects of design are often considered as the first critical questions in HCD and can later inform additional questions (e.g., when, why). As highlighted by Giacomin's (2014) HCD pyramid, the human factors (who) and activities, tasks, and functions (what) often lay the foundation for increasingly complex HCD design questions such as interactivity, semiotics, communication, and discourse (how), and meaning (why).

In this article, therefore, we will provide an overview of HCD in LA literature through the ongoing integration of participatory design frameworks and delineate between frequently used terms such as co-design and co-creation as well as identify two common barriers. In this, we hope to distill the plethora of terms to aid future adoption and summarize a clear need for HCD in LA. Secondly, we will consider two of Giacomin's (2014) design questions for HCD of who can and should participate, and how they will participate. Finally, we will discuss these questions through the introduction of a case study that highlights the advantages and struggles of collaborating with users. Ultimately, the contribution of this article will be a consolidation of the current literature on participatory design in LA as well as findings from a case study on how co-creation can play out in practice.

2. Human-Centred Design and Related Terms

To begin, the difference between user-centred and human-centred design may appear slight, yet is impactful. HCD is rooted in psychological and social justice discourses on the need to provide humans with products that support their needs (Krippendorff, 2004). Buchanan (2001) wrote that while HCD researchers often overlook these historical roots, the driving principle that guides HCD is the affirmation of human dignity and an "ongoing search for what can be done to support and strengthen the dignity of human beings as they act out their lives…" (p. 37). Comparatively, user-centred design (UCD) is narrower in scope and focused explicitly on designing for the intended users of the product and/or service (see Norman & Draper, 1986) and is defined by Abras, Maloney-Krichmar, and Preece (2004) as "a broad term to describe design process in which end-users influence how a design takes shape" (p. 445). Therefore, when researchers choose to situate their perspective and research design lens in either HCD or UCD they are taking a significant stance on whether their goal is to provide for the target audience or tackle design issues on a far greater scale.

However, whether a researcher has chosen to undertake HCD or UCD, they are likely to draw upon participatory design to enact the intended collaboration with stakeholders. Participatory design is a series of actions, including investigation, reflection, development, and support, towards mutual learning between multiple and unique participants (Schön, 1983). Participatory design has been likened to the "democratization of innovation" as the process facilitates new voices (non-producers, users) into the design process (Von Hippel, 2005). Thus, there are several epistemological and axiological underpinnings that drive participatory design, as well as traverse from HCD and UCD perspectives. These include the belief that designers should share their design-making power with users (Bratteteig & Wagner, 2012) and that both users and designers should engage in reciprocal learning from one another through participatory design (Carroll, 1996; Sangiorgi, 2012). Yet while these guiding beliefs often situate the decision to implement participatory design, the ways these beliefs manifest in action may vary, depending on the context and other case-specific considerations. For example, participatory design may occur between researchers and designers, but may not always include students or teachers (or vice-versa; e.g., Dimitriadis & Goodyear, 2013; Marjanovic, 2014).

The current gap in the literature relating to participatory design in LA is not the lack of interventions, but rather the transparency of the researchers' perspectives, values, and goals underpinning their decision-making. For example, Verbert et al. (2014) report that many of the current LA platforms allow for participatory design elements, such as user feedback and ideas. In their review, outcomes of participatory design are discussed (i.e., benefits) and include automatic tracking of learning activities, learner and teacher access to dashboards, and visualizations of social media activity. However, the authors do not discuss in detail how the processes or actions to guide participatory design approaches were chosen or may have impacted the outcomes. This oversight renders the positive outcomes from participatory design difficult to understand or mimic, as only the benefits were made clear to the readers. Conole and Culver (2010) have also used participatory design in the platform Cloudworks. They met with potential stakeholders prior to design to help create a prototype. However, in this example, student stakeholders were not included, and the authors did not explain this decision. Similarly, in an effort to ramp up engagement of Massive Open Online Courses (MOOCs) a team from Indiana University additionally trialled Big Open Online Courses (BOOCs) using "wikifolios" to allow learners and teachers to see and be able to comment on a myriad of resources (Hickey, Kelley, & Shen, 2014). Yet again, details on the collaboration steps and processes are not discussed and it is unclear how the participants of the participatory design intervention perceived the activity and if they believed it added value. Thus, while these interventions undoubtedly have important lessons to be derived for future researchers, the lack of transparency on what drove their choices makes it difficult for readers to derive.

Echoing, and likely stemming from a lack of transparency, seems also to create confusion in the field over the differences between forms and/or outcomes of participatory design. Thus, frequent calls from scholars to integrate more co-design or co-creation approaches in LA (Chai, Koh, Lim, & Tsai, 2014; Heath, 2014; Martinez-Maldonado et al., 2016; Buckingham Shum & Ferguson, 2012; Vatrapu, Reimann, & Hussain, 2012) may benefit from further distinction between these terms. For example, as Sanders and Stappers (2008) distinguish, co-design is one of many forms that facilitate co-creation and/or co-production. To them, co-design is just one process of collaborative design, with other popular forms of collaboration with stakeholders as co-evaluation, co-reflection, or co-governance. Thus, while all these forms are examples of participatory design, they differ on how they choose to collaborate with users and may be more or less appropriate depending on the context and specific intervention goal.

Following this, the chosen form of participatory design (co-design, co-evaluation) can result in two different outcomes, either co-production or co-creation. Co-production can be defined as the outcome of two or more stakeholders interacting, sharing access, and sharing knowledge towards a process and/or product (Ranjan & Read, 2016). For example, students could give feedback into the user interface of a dashboard, resulting in a co-produced (between designers and students) dashboard. Comparatively, if the value extends beyond the chain of production (which it often does) these less measurable forms of value creation (e.g., experiences, relationships, personalization), plus the value already created in co-production, are what constitute co-creation (Dollinger, Lodge, & Coates, 2018; Ranjan & Read, 2016). To give an example, LA software can be co-produced by teachers, but unless teachers subsequently use the platform to inform their teaching (and further create value) it is not co-created.

Recent literature on these collaborative processes highlight the variety of ways these processes have spurred research (please note, terms here are from researchers' chosen language, not the authors of this article). Sclater (2016) used a co-design process for developing a code of practice for LA that included the formation of an advisory group. Liu, Froissard, Richards, and Atif (2015) collaborated with teachers and support staff in design-based research to enhance an existing LA plugin for Moodle, using an iterative consultation process. Rienties and Toetenel (2016) further used collaborative design when exploring the link between learning design and learning behaviours, which included giving academics the opportunity to comment on datasets and discuss how it linked to their intended pedagogy. Other researchers have explored how intelligent tutoring systems (ITSs) and wearable cognitive augmentation can be co-designed with teachers to ensure technology supports teacher needs and expectations (Holstein, Hong, Tegene, McLaren, & Aleven, 2018; Holstein, McLaren, & Aleven, 2017). Another team of researchers used a co-design process called Co-operative Inquiry to co-design social media with children, allowing all members (students and parents) to collaborate equally, make decisions and evaluate designs (Yip et al., 2014). Further still, some researchers have noted that, as students or users bring their own resources and actions to learning environments or platforms, the processes are continually co-created (Thompson, 2013). However, consistent across this research are the remarks of the difficulty integrating collaboration into interventions. In the next section below, we thus provide a brief overview of some of the key challenges (and subsequent considerations) to participatory design in LA.

3. Challenges to Participatory Design

There are numerous challenges and obstacles to facilitating participatory design in LA. Kujala (2003) through a literature review of UCD interventions, found that common obstacles included time, consensus, users lacking information, too many

user groups, user lack of confidence, and users unaware of implementation constraints. In fact, a frequent challenge stated across literature is users' lack of technical knowledge and/or expertise, which subsequently curbs their ability to provide useful ideas and/or suggestions (see Kujala 2003 for a list). This obstacle further relates to another commonly discussed challenge in participatory design, that of supporting genuine partnership with stakeholders (especially regarding ethics and privacy; see Robertson & Simonsen, 2012). While this issue is less functional than the first, its significance is heightened by the overarching premise to distribute power and decision-making through participatory design (Buchanan, 2001). While these two do not span the wide spectrum of challenges that can occur, we chose to focus on them here as they are both common and include one functional challenge and one value-based challenge.

3.1 Technical Knowledge and Expertise

When employing participatory design frameworks with users and stakeholders, the task is made simpler if the users already have a working knowledge of the service, product, or platform (Zwass, 2010). For example, some of the earliest industry examples of participatory design had users co-design sneakers or provide ideas to LEGO or Starbucks (Ramaswamy & Ozcan, 2014). While all these examples could be highly technical, depending on which particular dimension is discussed, they all also have negotiated points where users can offer feedback without needing a baseline of expertise (e.g., how comfortable are these shoes?). However, within the discipline of LA, finding negotiated points where users, either students or teachers, can offer feedback, guidance, and ideas can be more challenging.

To illustrate, Elias (2011) compares several LA frameworks and models to map the common data lifecycle. While there is clear overlap between several of the models, we can use their five steps of analytics — capture, report, predict, act, and refine — as a baseline to discuss how participatory design (i.e., joint decision-making, reciprocal learning) can take place. To begin, the first step in most LA interventions or projects is to capture data. Capturing data, however, is often limited by what data can be captured. For example, many learning management systems (LMS) now allow for several types of data to be collected, such as log-in, assignment submission, and forum posting. There are also data that teachers (or systems) can collect such as attendance and marks. Lastly, there is perception-based data, which one could obtain from a student survey, for example, "Was this week's content helpful?" Barring a substantial innovation in data capture, these are the baseline types of data available. By applying participatory design elements, students and teachers can help advise on data capture (for example, see Macfadyen & Dawson, 2012) even if it may be difficult for them to co-design or co-create additional forms of data capture. Thus, the challenge of participatory design regarding data capture is less of a technical hurdle, but rather an indicator perhaps of a lack of communication between stakeholders (Dyckhoff, Zielke, Bültmann, Chatti, & Schroeder, 2012).

Reporting and predicting data are further tasks often left to technical experts, rather than students or teachers. And yet, while it is perhaps unrealistic to assume that teachers and students could help co-design a predictive model for student retention, they may be able to advise and offer feedback. Further, in the fourth step of the data lifecycle, act, participants have a significant ability to contribute. Teachers and students may be helpful in making inferences from data and ensuring that findings are valid (Arthars et al., 2019). The last step, refine, may also benefit from participatory design as stakeholders offer suggestions and ideas for future iterations. Therefore, even though the technical nature of LA is a challenge to participatory design, it is not an absolute barrier.

3.2 Privacy and Ethics

While expertise provides a functions-based challenge for participatory design, the challenges of privacy and ethics relate back to values instilled in conceptualization of participatory design and/or HCD (see Buchanan, 2001). Frequently discussed already in LA literature, questions over how stakeholders feel about the use of their data, and ethical implications resulting in that use, often result in some wariness in users (Prinsloo & Slade, 2015; Tsai & Gašević, 2017). One survey of educational practitioners and researchers found that trust in LA algorithms and concerns over breaches of privacy loomed as large issues for the LA community to consider (Drachsler & Greller, 2012). These sentiments may prove a hindrance for getting stakeholders (e.g., teachers, students) involved in participatory design. Responses to privacy and ethics concerns have included de-identification (Khalil & Ebner, 2016), policies on the ethical use of student data (Open University, 2014), and more ethical approaches to decision-making (West, Heath, & Huijser, 2016). Additionally, scholars have begun to reflect on how supporting student agency and/or ownership of data through participatory design can be a means to empowerment and engagement (Prinsloo & Slade, 2017). Further, the provision of rigorous and well-designed privacy features that align with ethical codes of conduct may, in turn, help improve stakeholder engagement and usage of LA platforms. Application of participatory design in this area therefore can both highlight and address the need to revisit power imbalances and related issues of privacy and ethics in LA interventions.

4. Key Questions For Human-Centred Design

As stated previously, there have been calls for more integration of HCD within LA. However, there are numerous iterations and types of participatory design and, depending on which type of stakeholder participation is desired, the approach is likely to change. Therefore, two key design questions are prerequisites to consider before integrating participatory design. Important to note is that these are not the only two critical design questions (see Maguire, 2001 for a comprehensive overview of design considerations). However, as Giacomin (2014) notes, the questions of "who" and "what" often subsequently impact other questions such as "when" and "why" and thus are good first steps for newcomers in participatory design to consider.

4.1 Who Can and Should Participate?

Numerous participatory design scholars have noted that planning the participatory design process is critical (e.g., Brandt, 2006; Schuler & Namioka, 1993). However, while literature on participatory design has often included debate over the location and activities of the design process (e.g., Brandt, 2006) there is less discussion about deciding who can and should participate. As Giacomin (2014) illustrates through the HCD pyramid, the question of who participates should be the first question in the design process. Rather than being an LA-specific question, other research areas integrating participatory design, such as environmental assessment, similarly highlight a lack of description of participants or stakeholders (Glucker, Driessen, Kolhoff, & Runhaar, 2013). Glucker et al. (2013) suggested that "public" or potential stakeholders can refer to those affected. In the case of LA, therefore, stakeholders who could be affected by LA interventions include LA designers, researchers, university administrators, staff, and academics (and other teaching staff), and students. But how does one know whom to involve in an intervention?

To decide who should participate, one must first reflect on the motives and goals for participatory design (Giacomin, 2014). Bergvall-Kåreborn and Ståhlbrost (2008) clustered motives for participatory design into three groups, ethical (democracy), curiosity (theoretical), and economic (pragmatic). These clusters work in a variety of contexts, including LA. To illustrate, in the example of Sclater (2016), participatory design was driven by ethical motivations as they were drafting ethical and privacy rights of students in LA. In the case of Rienties and Toetenel (2016), who sought to link learning behaviours to instructional design, the motivation was likely theoretical or curiosity-driven. Lastly, in cases where LA seeks to provide a predictive model for at-risk students (i.e., to improve retention) the motivation is likely economic (for the institution) and pragmatic (to help the student; e.g., Liu et al., 2015). Depending on the justification for collaboration with stakeholders, the sought-after sample (e.g., who should participate?) will vary. For example, for studies motivated by economic or pragmatic concerns, it is likely to be a convenience sample or snowball sample method of whichever population with which they are trying to improve engagement (e.g., at-risk students).

Yet alongside the question of who *should* participate is also the question of who *can* participate? An ability to contribute within participatory design often requires time and energy on the part of participants and flexibility in the design process to align with potential participants' schedules, interests, and concepts of power (i.e., decision-making; Bratteteig & Wagner, 2012; Bergvall-Kåreborn & Ståhlbrost, 2008). This capacity is critical, as often only highly engaged students and staff participate in extra activities. However, these voices do not represent all the diversity required or suggested by the question "who should participate?" Literature on student partnership in higher education has highlighted the difficulty in attracting underrepresented groups or disengaged students into participatory design-type activities (Cook-Sather, 2017; Dollinger, 2018). Therefore, it is critical to consider how the participatory activities will be promoted, how access to all groups will be supported, and how the design process and corresponding requirements of participants align to stakeholders' lifestyles and interests. In a study of participatory design in Cambodia, Hussain, Sanders, and Steinert (2012) found that barriers to attract and maintain participants included the following: 1) human aspects (the designers' relationships to the participants); 2) social, cultural, and religious aspects (consideration for group dynamics and power balances); 3) financial aspects and project timeframe (funding and time); and 4) organizational aspects (well thought-out design). In a review of ten participatory design projects Clement and Van den Besselaar (1993) further noted three basic requirements to facilitate participation: 1) access to relevant information; 2) the possibility of taking an independent position on the problem; and 3) participation in decision-making.

4.2 How Can Stakeholders Contribute?

Moving one step higher in Giacomin's (2014) HCD pyramid is the question of what or how can stakeholders contribute? There are various ways one can design and implement how stakeholders can contribute in LA. While LA is a digital space, tangible techniques to elicit stakeholder feedback such as 2-D collages (e.g., of dashboards) or 3-D mock-ups (e.g., of data collection in a learning environment) could help designers understand stakeholders' mental models (Sanders, Brandt, & Binder, 2010). Additionally, diaries or cards may help express stakeholders' feelings towards using LA as well as their expectations. Researchers have also suggested techniques that could be used, even for digital spaces, include improvisation or acting out skits and plays of moments or pain points (Sanders et al., 2010). Frow, Nenonen, Payne, and Storbacka (2015) also note that

stakeholders can contribute outside of product/service design through helping with co-promotion.

Perhaps more relevant than listing the numerous techniques of participatory design is instead outlining the basic ideas that should underpin whichever technique is selected. Norman and Draper (1986) argue that there are more important factors in user-centred design than the selected technique. These include assuring that it is easy to determine what actions are possible, making all aspects visible to all stakeholders, making it easy to evaluate the design and outcomes, and following the natural mappings between intentions and required actions. Thus, even if the intervention uses more UCD techniques (rather than HCD) such as interviews, focus groups, observations, and usability testing, what matters most is clear delineation of purpose and goals and a description of decision-making processes (Abras et al., 2004).

5. Case Study Background

In this section, we situate our preceding discussion in an authentic context by presenting a case study of participatory design in LA. Using the delineations between terms relating to collaboration in LA, the researchers in this case adopted an HCD approach (based on the belief that products/services should serve the needs of people, and that this is how value is created), to drive participatory design. They further adopted co-design and co-evaluation to collaborate with stakeholders as their goal was to develop the LA platform through an iterative process with users. Finally, the goal or outcome of the case was found to align with co-creation, rather than co-production, as the researchers sought not only to co-produce the functions of the software to help enhance the platform itself, but to help teachers inform and reflect on their teaching practices (i.e., extend value creation past the chain of production). Design questions focusing on who and how to participate further grounded the intervention. In this case, the question of "who participates" was a case of collaboration between teachers and designers, as designers wanted to design a tool that would support teacher reflection. Further, the "how" of participation was supported through ongoing communication with teachers through various means (detailed below).

In an example of idea co-conception (Frow et al., 2015), the Student Relationship Engagement System (SRES) was initially an amalgamation of two isolated but convergent teaching needs: 1) the inefficiencies of tracking student attendance in class; and 2) the inadequacy of student communications and connections with staff in large courses. Neither of these had directly to do with LA, although both were important as data points and actions, respectively, for LA. These needs arose from (non-LA) faculty academics struggling with large student cohorts, and initially in 2012 SRES had the simple function of being a web-based platform where teaching assistants could scan student barcodes on their own mobile phones, and course coordinators could track this attendance data and send personalized emails to absent students. These needs were identified through informal discussions between teachers, who subsequently worked together to build prototypes that were rapidly piloted in their own and other teachers' courses. In conversation with pilot teachers, other needs were quickly identified. These included the desire to import custom data from spreadsheets and also to collect richer data (apart from an attendance timestamp) in situ. These requirements were then built into the platform in an approach reminiscent of agile software development.

In its early years, participatory design of SRES was conducted in an unsystematic manner; however, the philosophy underlying the ongoing design of the platform remained constant. The SRES team have consistently applied a simple set of triage and design philosophies in developing ideas for enhancements in iteration with users. These included urgency (e.g., is it a critical bug?), impact (e.g., how many users could benefit?), pedagogical meaningfulness (e.g., will it benefit learning and teaching substantively, or is it just an administrative improvement?), ease (e.g., how programmatically complex is it?), and fit with design philosophies (e.g., how flexible and scalable is the idea, does it put teachers in control, is it human-centred as opposed to machine-driven, is it actionable, and is it transparent, ethical, and secure?; Liu, Bartimote-Aufflick, Pardo, & Bridgeman, 2017).

Over the intervening years, users (faculty and staff) were closely involved in co-designing SRES together with the teachers who developed it, leading to the development of a centralized SRES team in 2016 and the introduction of more advanced functionality, including text messaging, personalized web portals, automated teacher alerts, machine learning, visualizations and dashboards, offline data collection, and LMS data synchronization. The SRES, as it currently stands, brings together all aspects of the student data lifecycle (Arthars et al., 2019) into one web-based platform, controlled by teachers. It provides teachers with the capability to design responsive online and offline interfaces to capture a range of data directly from teachers (e.g., class participation, feedback, grades) and students (e.g., interests, background, trajectory, feedback, reflections), and curate these with data from other sources (e.g., engagement and performance metrics from the LMS, or simple spreadsheets). This teacher-driven data curation is matched with equivalently teacher-driven analysis afforded by the platform (e.g., in-place calculations and other data transformations, visualizations and dashboarding, machine learning). Following this, teachers design actions stemming from these data (e.g., highly tailored messages to students delivered via email, text messaging, or available through online portals), and then receive live feedback about how students are engaging with these to afford their own evaluation and reflection of these teaching approaches. In this way, the SRES platform extends far beyond a register and

mark book with a mail merge engine, instead being used by teachers to augment their teaching approaches and provide highly personalized engagement, learning support, and feedback for students (Blumenstein, Liu, Richards, Leichtweis, & Stephens, 2018; Arthars et al., 2019).

The uniqueness of this teacher-driven platform has had interesting implications for two key elements already described: 1) the value-based challenge of ethics and privacy, and 2) the involvement of student stakeholders. One of the key relative advantages of SRES was that it augmented teacher abilities (e.g., more efficient and selective curation of, and action upon, academic engagement and performance data), but did not provide access to data that would otherwise be unavailable to their roles that are often used in other LA approaches (e.g., Wi-Fi access, library use, demographics). This meant that privacy and ethics issues were mostly related to extant teaching practices, as the platform worked to streamline and scale these (Liu et al., 2017). Amplifying teachers in this way also meant that SRES was intentionally invisible to students; they should see the outputs of SRES as personalized engagement directly to and from their teachers, with SRES being merely an enabling intermediary. Asking "how can students contribute?" meant that students were not involved in participatory design of the platform itself, but rather provided feedback on learning and teaching processes that were (ostensibly invisibly) enhanced by SRES.

The SRES is now in use at five Australian universities. At its originating institution, it is used by over 1,500 faculty and staff in courses that cover almost two-thirds of the entire 60,000-student cohort. This case study provides an example of the power of participatory design for creating LA-based tools that can achieve substantial real-world impact.

6. Method

6.1 Participant Selection

From 2017 onwards, all current, past, or future users of SRES at its originating institution have been identified through review of SRES user accounts and invited by email campaigns, sent every six months, to participate in semi-structured interviews. The purpose of these interviews is twofold: 1) to obtain feedback through which to refine SRES in line with UCD principles, and 2) to collect qualitative data as part of a larger research project (approval number 2017/018).

Of the 40 users who agreed to participate in 2017 and 2018, interviews were conducted with 20 participants from a range of faculties and roles at the University of Sydney. SRES users interviewed ranged from those who had only used the platform in one course for one semester, to others who had been using it across multiple courses for multiple semesters, including staff who had used the platform since it was initially developed in 2012. Table 1 outlines the characteristics of interview participants, with the level of participation from each faculty being representative of the proportion of staff users from each.

Table 1. Characteristics of Interview Participants

	Science	Medicine & Health	Business	Arts & Social Science	Engineering & IT	Health Sciences	Other
Course/Laboratory Director	2	–	–	–	–	1	–
Unit Coordinator	3	1	–	3	1	1	–
Tutor/Lecturer	2	–	1	1	–	–	–
Technical Officer	1	–	–	–	–	–	–
Teaching Support Staff	1	1	–	–	–	–	1
Total	**9**	**2**	**1**	**4**	**1**	**2**	**1**

6.2 Data Collection and Analysis

The semi-structured interview guide contained 12 questions focused on the following areas: use of SRES; plans for future use and associated needs, benefits, and challenges; and support mechanisms utilized. Twenty interviews were conducted from 2017 to 2018, ranging from between 35 minutes to 80 minutes in length. Interviews were digitally recorded and transcribed.

For the purposes of this paper, transcripts were analyzed to identify and code instances where users had engaged in prior participatory design (61 references coded). These were subsequently grouped according to three broad types as per Payne, Storbacka, and Frow's (2008) framework (outlined below): communication encounters (8 references), usage encounters (36 references), and service encounters (17 references). The references identified were reviewed by the second and third author to refine, merge, and identify prominent sub-types of encounters. This iterative process resulted in a total of 11 themes: communication encounters (3 themes), usage encounters (5 themes), and service encounters (3 themes). Each of these themes were further analyzed in order to identify associated challenges and benefits.

7. Results

7.1 Instances of Co-Creation

Payne and colleagues (2008) provide a powerful framework for modelling how value for both producers and users (i.e., "suppliers" and "customers") is created during touchpoints or "encounters" that they have with each other. In this case, users were the faculty and staff who used the tool, while the producers were SRES team who created the tool. In their framework, there were three types of encounters that enabled co-creation with users: communication encounters, usage encounters and service encounters (Payne et al., 2008). We have observed all three in our case.

7.1.1. Communication encounters

Communication encounters were primarily instantiated by the SRES team for the purposes of reaching out to users to catalyze dialogue. These encounters fell under three themes: email newsletters, masterclasses, and interviews. Email newsletters were sent by the SRES team to users about new features, reminders of useful functionality, and links to articles or examples of innovative applications by other users. The latter was supported by occasional articles on the institutional learning and teaching blog showcasing exemplary uses of SRES to personalize learning. These typically had a few hundred readers and have triggered teachers to seek out more information about SRES in what Rogers (2003) conceptualizes as "[c]hange agents [creating] needs among their clients by pointing out the existence of desirable new ideas. Thus, knowledge of the existence of an innovation can create a motivation to learn more about it and, ultimately, to adopt it." (p. 172).

Since 2016, SRES users have been invited to attend twice-yearly "masterclass" sessions, where existing and experienced users from across the university meet to share their practices with SRES and upskill. These sessions have been invaluable encounters for co-creation because they achieve two things: 1) provided users with more "how-to knowledge" (see Rogers, 2003) to better use the innovation and, more importantly, increased "principles-knowledge" to better understand the underlying concepts of using student data to personalize learning; and 2) provided a collegial environment for rapid ideation of improvements between users and the SRES team. Attendees consistently attested to the benefits of 1 and appreciated the transparent nature of 2. Additionally, for the SRES team, they provided insights into the needs and use cases of LA in diverse contexts.

The interviews themselves were also classified as a communication encounter. The authors identified that a number of the suggestions for enhancements to SRES provided during interviews had since been considered and successfully implemented. Moreover, during one interview, it became apparent to the interviewer and interviewee that their discussion had generated research questions related to the interviewee's use of SRES that they wished to pursue.

Despite the existence of an institutional social media (Yammer) group, established by a user, which has twice as many members as the equivalent group for the institutional LMS, this was not identified in any of the interviews as a support mechanism or communication channel. This channel is, however, a place through which other users share experiences, ask questions of each other, and where the SRES team posts minor updates and announcements.

7.1.2. Usage encounters

Usage encounters occur when users use the product and create "value-in-use" (Payne et al., 2008, p. 86), the presence of which also elevates the co-design process from co-production to co-creation (see above section). To illustrate, through the platform, users not only co-produced the functionality of the tool, but also used this product (SRES) to create their own customized LA-enriched learning experiences for their students, where the outcomes were additional enhancements in their teaching (i.e., co-creation of value).

In level 1 usage encounters, users were typically involved at the levels of co-conception (e.g., suggesting new features), co-design (e.g., suggesting enhancements or tweaking the software to their individual needs), co-maintenance (e.g., providing ad hoc support and training to colleagues), and co-promotion (e.g., sharing SRES practices and success stories with colleagues). In fact, the latter two aspects have been the primary reasons for the substantial uptake of SRES across the originating university and to other universities, when early adopters have shared the benefits of the software for their contexts (Vigentini et al., 2017). As one interviewee stated, "[Teacher name] used SRES and I think [another teacher's name] as well and had a massive bump in [student course evaluation] scores. So when we were advertising SRES those were the two [course] results that we sent round to people, showed them, like 'this is what engaging with the system can do' you know 'students really appreciate it' and lots of people cared and lots of people turned up."

In level 2 usage encounters, users would leverage the flexibility of SRES and its range of functionality to co-produce LA that impacted their teaching and their students. This is arguably the richest avenue for value creation. For example, teachers proposed an enhancement that allowed students to enter their own data into SRES (level 1), and then used this to collect relevant background, interest, and trajectory data directly from students, combined it with LMS and other data, and reported this to teaching assistants at the point of contact with students in classrooms, all within SRES (level 2). In this way, the product

acted as a service that allowed users to create their own experiences, expanding the value proposition of the product to be greater than the features of the product itself (Payne et al., 2008).

7.1.3. Service encounters

Service encounters are typically initiated by the user to receive support in using the product. This was also a rich avenue for value creation since support and training requests were usually driven by unmet needs (Maguire, 2001). In the first few years of SRES as adoption was increasing, this was primarily ad hoc and provided by the initial developer and, in an example of co-maintenance, by early-adopter academics to interested colleagues.

Service encounters from the SRES team included half-yearly whole-university introductory workshops (each typically attended by 30–40 faculty and staff), and a number of bespoke sessions for faculty (typically attended by 5–15) that were run on request. Although these were not overtly co-creative, the SRES team (and the product itself) did benefit from observations of new users and their interactions with the software, leading to various UI and UX enhancements. Through introductory training, the SRES team were also able to subtly influence the support and feedback practices (level 2 usage encounters) of teachers, providing suggestions for richer engagement afforded by the software. This was reflected in two of the interviews and is illustrated by the following comment: "[Trainer's name] was speaking last year at the training day of not using SRES to punish students but support them and help them with engaging with lecturers. I really want to do that. I don't want to be the person who's saying according to this database you have failed. I want them to see the database as something to help them and help me."

Finally, technical support and troubleshooting requests were an opportunity for users to discuss pain points, allowing the SRES team to consider design changes to alleviate these issues, and also to gain insight into the diversity of use cases from around the university. Moreover, for users, these were ad hoc opportunities to upskill in the software's functionality. On a number of occasions, these encounters would also lead to a negotiated enhancement to SRES based on the aforementioned triage and design philosophies.

Critical to note, the academic context of universities adds additional layers to the communication, usage, and service encounters. As Buckingham Shum and McKay (2018) suggest, faculty academics typically have a much deeper understanding of pedagogy and learning and teaching needs, are more closely connected with academic colleagues who may serve as early adopters in pilot studies, and can provide rigorous approaches to research and evaluation.

7.2 Benefits of Co-Creation

From the three processes to support co-creation (i.e., communication, usage, and service encounters) there were several beneficial results, including ongoing usage of the platform, an expanding user base, and modifications and/or additions to its functionality. In this section, we will discuss the benefits of co-creation uncovered in this case.

The first result from enacting a process that led to co-creation was ongoing usage of the platform from users. Users often encounter issues when trialling new platforms and these can lead to the decision to stop using them. Rogers (2003) terms this process discontinuance, which can occur when users find a better alternative or become dissatisfied with an innovation. The latter can be due to users not seeing a relative advantage compared to existing or other approaches but could also be due to misuse of an innovation that would have otherwise been beneficial. Although interviews with users who were early adopters revealed a range of issues such as data accuracy being encountered, the fact that they were able to contact the design/development team and co-design solutions have largely resulted in continued use and the development of a more refined and user-friendly platform for all users. In a positive feedback loop, such co-creation of SRES with teachers has had a positive impact on its widespread adoption, which has led to increased uptake due to co-promotional activities. As one teacher commented, "for me, the biggest selling point about SRES is that it's made by a teacher. […] I can trust that it will do what I want it to do because a teacher built it and a teacher would think the way that I think."

Another result from the co-creation with teachers was an expanding user base. In the biological sense, co-evolution occurs when two species cause changes in each other's evolutionary pathways. While often used to describe predator–prey relationships, mutualistic interactions can also be co-evolving. For example, a flowering plant that is pollinated by one species of insect may evolve morphological features that benefit that insect species, while the insect species may evolve behavioural traits that make it more dependent upon that flowering plant species. In software engineering, co-evolution has been described in the context of user-centric design as "metadesign," where "software developers are needed to perform substantial system and solution-space modifications [and] end-users must also participate because only they can judge what solutions are useful and what structures will serve their work practices" (Fischer, Nakakoji, & Ye, 2009, p. 39). These authors describe a process that is concurrent with participatory design, where elements of social infrastructure are established so that users can collaboratively shape software. In this co-evolutionary sense, the users of SRES have evolved alongside SRES itself (Figure 1): users, as domain experts in teaching and student support, have caused (co-created) structural changes in SRES, which has led to their own behavioural (workflow, pedagogy) changes. As these changes occur, users have become more comfortable

with both SRES itself but also more demanding of actions around student data, which have consequently led to further evolution in SRES through co-creative processes.

The third benefit that arose from supporting co-creation within the platform was the modifications and additions implemented based on user feedback and suggestions. For example, from early on in SRES's development, personalized and targeted messaging was a key priority. However, teachers yearned for the ability to evaluate the efficacy of these messages. As a result, the widely used marketing approaches of email read tracking and link click tracking were implemented, alongside a teacher-facing interface that reported these statistics as well as returning the email open count back into teachers' bespoke databases. The SRES team went a step further and designed in a vote-based evaluation feature, which automatically injected a short prompt to students at the bottom of every message asking whether the message was helpful, and then inviting their comments. Teachers could opt out of this feature if they did not want to use it. This feedback was also surfaced to teachers through a reporting interface in SRES so that they could evaluate and reflect on their data-driven actions. Later, through service encounters, the SRES team discovered that some teachers were unaware of this reporting interface, leading to the development of another feature, which directly emailed teachers whenever a student left a feedback comment.

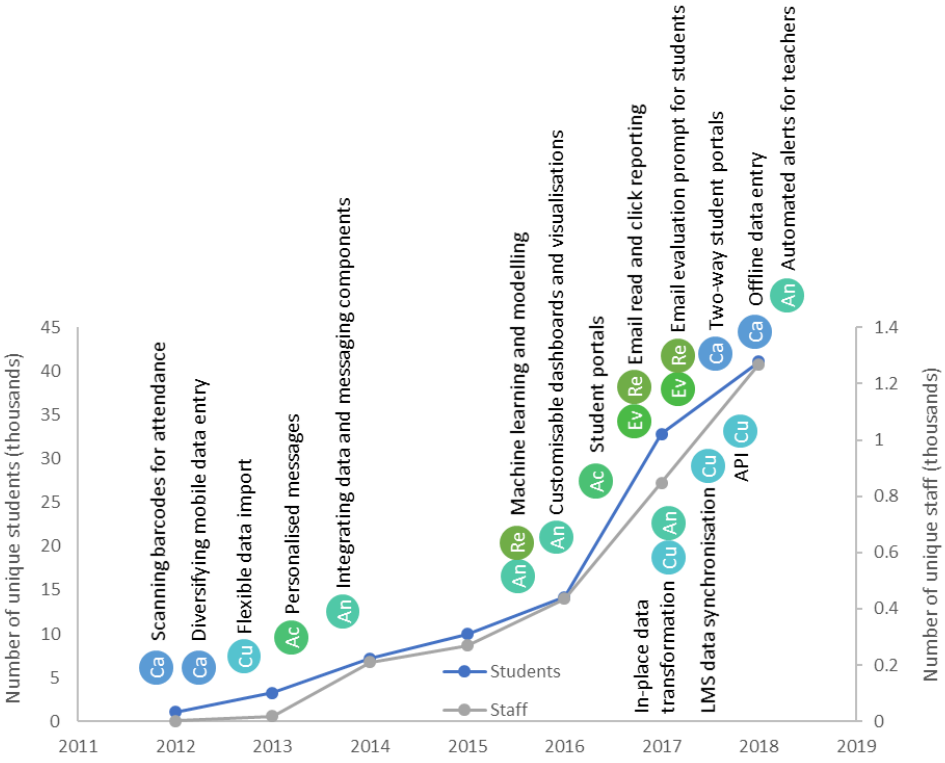

Figure 1. Timeline of Key Innovations: selected features in SRES co-created with users, against the growth in user numbers and coverage of students at its originating university. The features are categorized by stage(s) in the data lifecycle: collate, curate, analyze, act on, evaluate, and reflect. Placement of features on the timeline are stylized and not to exact scale. Secondary axis displays the number of unique staff.

Further, teachers often lamented that students rarely check emails, so personalized messages may not even reach their intended audience. Because teachers expected students to access their course's LMS site regularly, they wanted students to receive personalized suggestions there. This led to the development of "student portals" within SRES, which initially allowed teachers to customize a web page that conditionally showed any text, or data held by SRES, to students. But because of an expanded need to collect relevant data directly from students, SRES was adapted to enable teachers to design portals where students could be shown, and allowed to enter, personalized data — turning portals into a bidirectional data exchange interface. The use of student portals has increased as they afforded fully teacher-customized dashboarding that could be embedded within an LMS. More recently, early adopters during masterclass communication encounters have asked for usage statistics; this is being built into SRES.

Additionally, the "roll view" in SRES has become one of the main mechanisms through which teaching teams capture data from in situ teaching environments. This itself was a result of a service encounter where an educational designer asked whether

an interface similar to a paper roll (fundamentally, a list of names and an area for data entry) was available. The SRES team worked with them to develop the idea such that it was more flexible and adaptable to more diverse contexts, and this was subsequently built into the system. In another example of bidirectional data flow, this also allowed teachers to not only enter data about students but also customize the information shown about each student; for example, instead of a static roll that only displayed names, SRES could show a student's avatar, their study preferences (entered by students through a portal), last week's quiz grade (from the LMS), and other tutors' feedback. As its use increased, teachers in areas with poor internet reception complained that a fully online system could not tolerate connectivity issues and that unexpected data loss was an understandably significant issue. Coupled with other departments' needs to replace existing clinical examination approaches, an "offline mode" was co-created to enable these workflows.

SRES has had several analytical elements built in response to user needs. In addition to teacher-driven machine learning (where teachers actively instantiate and interact with simple machine learning processes; Liu, Taylor, Bridgeman, Bartimote-Aufflick, & Pardo, 2016), a more accessible approach to both analyzing and acting on data has been to alert teachers when certain data conditions are met. These "teacher insight alerts" were co-created with educational designers and academics who were managing large student cohorts and teaching teams and needed a way to harness automated reporting to teachers based on customizable rules. Since this functionality is new to SRES, only some early adopters are taking advantage of it, mainly to automatically identify attendance or performance issues in their classes. However, as we have seen with the personalized messages, the student portals, and the lists/columns themselves, although teachers often start using these for more simplistic purposes, their usage rapidly co-evolves as they move through various level 2 usage encounters.

From these findings, it can be seen that the benefits of co-creation were varied and included user buy-in, a deeper understanding of user requirements, and adaptivity to the changing needs of users. Kensing and Blomberg (1998) note that participatory design "helps[s] ensure a better fit between technology and the ways people (want to) perform their work" (p. 168). In the context of LA, participatory design can assist with understanding the needs of teachers across different disciplines, which allows for a design that is contextualized (and flexible) to meet these various needs. As Friesen (2013) notes however, "students' needs and their learning preferences are complex and vary over time" (p. 10). This means that both teachers and LA platforms need to be agile and adaptable to the dynamic needs of students. Knight, Brozina, Stauffer, Frisina, and Abel (2015) report on the benefits of designing LA with students and engaging them throughout, including sustainability of the LA tool and identifying necessary features that would enhance interest and engagement with it. Developing a deeper understanding of teacher and student needs may therefore assist with designing an LA tool that is adaptable and sustainable.

Organizational change literature discusses the importance of including employees in organizational design efforts, as this can ease resistance to change while simultaneously engaging employees as agents of change (Jabri, 2017). Likewise, including teachers in the participatory design of SRES has resulted in increased buy-in and support for the platform. Perhaps more importantly, SRES has benefitted from having teachers leading the design and providing ongoing support to users. Having a point of contact that could explain SRES was important, with one user noting "I was lucky I suppose because I could watch what the teacher was doing as he created it. And he could explain it to me in words with one syllable." While the teachers we interviewed were supportive of SRES, they also displayed a strong awareness of the challenges and barriers to widespread adoption of the platform. Perhaps more interestingly, they provided a range of ideas during interviews on how these challenges and barriers could be overcome. For example, ongoing use of SRES within individual courses was a concern, particularly when responsibility for coordinating courses often changed. One course coordinator emphasized this issue, suggesting "with a bit of guidance, with the sort of little guidebooks and things like that we can get a system where it's seen as normal. Just the same way that you pass on tutors' notes, if you pass on the guide to using SRES on this [course]." Development of guidebooks and templates that teachers can use, build upon, and share have also been suggested by users as a way to encourage more widespread adoption of SRES. This lends support to extending participatory design beyond design of the LA platform to design of its implementation and promotion.

7.3 Challenges or "Costs" of Co-Creation

While there were numerous benefits from co-creation, however, there were also several challenges or costs. The main cost of all participatory design approaches is the time involved, both on the part of designers and participants, such as teachers and students. Teachers already manage a number of competing demands in academia, such as the need to conduct and publish research as well as teaching and supporting large cohorts of students. The participation of teachers in the original design of SRES was sparked by the potential to reduce the time spent on the administrative task of recording student attendance. In this original context, the cost of dedicating time to participatory design was offset by the benefit of time saved in the future on recording attendance. After this initial co-conception, participatory design has continued, with teachers providing feedback and suggestions on other features that have the potential to save teachers time. More interestingly, the time saved by using SRES has allowed teachers to expand their use to engage in additional activities that support and encourage student learning.

As one teacher noted:

> *We go from a situation where we've got this whopping great spreadsheet to manually filling in data [...] to SRES now being able to consolidate up and bang, there it is, entered at once. So, for most of the teaching staff, it has significantly reduced their input. If they take that base level approach. So, I guess it depends on personal teaching style. Do you want to go out of your way and help the students? Do you want that personal engagement? Or are you happy to just stand and deliver? If you're happy to just stand and deliver, then it doesn't make a lot of difference. If you actually want to engage with your students, then it gives you that opportunity to do so.*

This means that while it is widely recognized that teachers have busy workloads and competing demands on their time, they may be willing to engage in participatory design if they can see the long-term benefits that an LA platform may bring to them and their students. Additionally, if the use of an existing LA platform results in time savings for teachers, they may be more willing to expand their use of the platform to engage in other activities aimed at providing additional support to students.

There may also be a cost involved in engaging teachers in participatory design and not utilizing their design ideas. Decisions about which suggestions to incorporate into the ongoing iterative design of SRES are based on a multitude of factors, including urgency, impact, pedagogical meaningfulness, ease, and fit with the overall design philosophy. This means that although many ideas for additions or changes to SRES have emerged via participatory design, not all have, or will, be implemented. The impact on a teacher's willingness to engage in future participatory design when their ideas are not utilized is unknown and is a potential area for future research.

8. Discussion

Historically, teachers have always used data about students to understand and improve learning, from adapting instruction to student responses on Socratic questioning, to a teacher marking attendance on a sheet of paper and matching this with test scores to triage support. The modern (digital) data environment has not changed this fundamental aspect of a teacher-driven "data lifecycle." Teachers capture and curate data that they consider meaningful, analyze it (perhaps mentally, perhaps on paper), act on it, and then change their practices based on the outcomes of this. LA-centric lifecycles, however, now typically involve the steps of "prediction" and "reporting" (e.g., Elias, 2011), while reducing the touchpoints that teachers have with it. An alternative, more human-centric lifecycle has been proposed by Arthars et al. (2019), outlining a teacher-centric (as opposed to data- or analytics-centric) model: 1) data capture, at the point of student contact; 2) data curation, wholly determined by teachers; 3) data manipulation and analysis in a transparent fashion; 4) actions enabled by the presence of data, focusing on students; 5) evaluation of actions; and 6) reflection for iterative enhancement (see Figure 2).

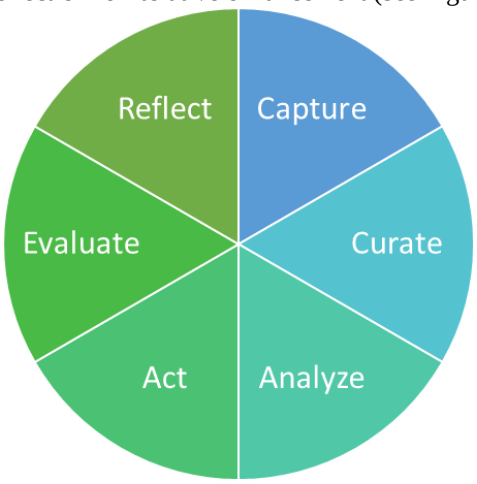

Figure 2. A teacher-centric student data lifecycle (adapted from Arthars et al., 2019).

Through this lens, we may reconceptualize the goal of participatory design, particularly in the context of tools such as SRES, from enhancing a specific artefact (e.g., software) to reflection and an ongoing process (e.g., teaching approach). If, as we have argued in the introduction, stakeholders need some appropriate technical knowledge and expertise of the service, product, or platform, then ultimately, in the context of LA, the service or product is teaching itself. The software is merely a support for this enterprise. Co-creation in this instance is not co-creation of software but rather a dynamic set of actions

supported through a platform, to co-create the teaching approach and practice with teachers. Viewing participatory design of SRES through this perspective may also explain why the issues of lack of technical knowledge (Kujala, 2003) and ethics and privacy (Robertson & Simonsen, 2012) were not present in our findings as would be expected.

9. Conclusion and Recommendations

From our research, we offer several key recommendations for those interested in integrated HCD in projects that relate to LA. Our recommendations include the following:

- Transparent and clear documentation of the initial motivations, processes, and outcomes of any approach to adopt participatory design that builds upon existing knowledge
- Consideration of the knowledge(s) that participants could potentially bring and clear pathways that allow them to collaborate and contribute their specific expertise across all aspects of the data lifecycle
- Reflection on the varying design options, including whether participation should be online, face-to-face, or a mixture; who to participate and how they will be able to participate
- Greater discussion of the benefits that participatory design approaches can bring to LA, specifically in relation to ongoing issues with large-scale adoption and continued usage

Experience in other contexts suggests that participatory design processes might bring great benefits to the implementation of LA-based innovations, despite the challenges we have outlined here. The example provided by SRES shows how much of an impact can be achieved when a system is built in full collaboration with those who will (and do) use it. Therefore, the value created through participatory design can impact not only tool modifications, but also user knowledge, experiences, and subsequent behaviours.

While there is a growing interest in involving stakeholders in the design, development, and implementation of LA-based innovations, there are few examples of mature and transparent collaboration with stakeholders in the literature to date. As we have discussed, there are often perceived barriers to the participation of the full range of stakeholders. In particular, the technical expertise required to develop LA systems is seen as a critical limitation on the capacity of user groups to meaningfully contribute to LA implementations. The case of SRES, however, provides a key example of the critical input that can be provided outside the technical and research expertise voices that have dominated the LA community. As with a growing number of industries, participatory design will increasingly be seen as a vehicle for ensuring that future LA innovations will be fit for purpose and meet the needs of the users for whom the tools and systems are ultimately designed to benefit.

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