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| **Institution:** University of Leicester | | |
| **Unit of Assessment:** 11 | | |
| **Title of case study:** Enhancing Usability and User Experience of Online STEM Education Worldwide: the Impact of Participatory Design | | |
| **Period when the underpinning research was undertaken:** 2007–December 2019 | | |
| **Details of staff conducting the underpinning research from the submitting unit:** | | |
| **Name(s):** | **Role(s) (e.g. job title):** | **Period(s) employed by submitting HEI:** |
| Effie L-C. Law | Professor in Human-Computer Interaction | 2005–Present |
| Matthias Heintz | Post-Doctoral Research Associate | 2017–2019 |
| Robert Edlin-White | Post-Doctoral Research Associate | 2014–2016 |
| **Period when the claimed impact occurred:** August 2013–2019 | | |
| **Is this case study continued from a case study submitted in 2014?** N | | |

## 1. Summary of the impact

The Human-Computer Interaction (HCI) group at the University of Leicester has improved online STEM education worldwide through their novel Participatory Design (PD) research, conducted as an integral part of the Go-Lab and Next-Lab projects. The creation of the tool PDot led to enriched user interaction at the development stage, which facilitated the integration of stakeholders' needs in the final products. By gathering timely, relevant inputs from end-user perspectives throughout the software development lifecycle and enabling developers to implement them meaningfully, their research has enhanced the quality of online learning resources, contributing to very high user adoption and satisfaction. Over 90,000 students and 31,000 teachers across 45 countries have already benefitted from the resulting software solutions. This has been of significant benefit to educators and parents for home schooling through Covid-19.

## 2. Underpinning research

The University of Leicester's Human-Computer Interaction (HCI) team, led by Professor Effie Law, have established a strong track record in their research on usability and user experience (UX) methodologies and Participatory Design (PD) approaches. Law has contributed significantly to the evolution of UX research on an international level **[R1]**, which was built upon her earlier work on usability **[R2, R6]**.

Law chaired the two European Cooperation of Science and Technology Actions, MAUSE and TwinTide (2005-2013), bringing together HCI researchers from > 20 countries to analyse and synergise the then-scattered work of usability and UX in Europe. Insights thus gained have been applied to several projects in the area of Technology-Enhanced Learning (TEL), including ROLE (2009-2013) on personalised learning environments **[R3]**, 80Days (2008-2010) on digital educational games **[R4]**, and Go-Lab/Next-Lab (2012-2019) on interactive online resources for STEM education **[R5]**. In each of these projects, Law was a work package leader on usability, UX or PD.

The impact of the Leicester-led PD work in Go-Lab/Next-Lab is particularly salient as it has leveraged a deeper theoretical grounding for UX frameworks, based on the experience and expertise accumulated during the previous projects, and systematic PD approaches and a dedicated PD tool **[R5]**. By enabling end-users (teachers, students) to voice their needs and preferences and translating them into technical (or practical) recommendations for the developers, the Leicester HCI team played a critical role in ensuring that user feedback was taken into serious account throughout the development process. Consequently, the enhancement of the quality of online resources (e.g. labs, learning apps) could be implemented effectively and efficiently, enabling their diverse usages in real-life contexts to address various educational goals.

The Leicester HCI team has overcome the challenges for PD approaches when working in distributed international locationss. A typical scenario involved the Leicester team conducting PD activities in the UK while the development teams were located elsewhere, such as Switzerland, Netherlands, Estonia, and Spain in the case of Go-Lab/Next-Lab. This characteristic of locational dispersal exposed the shortcomings of traditional paper-based PD approaches and thus stimulated the creation of PDot (Participatory Design online tool) **[R5]**, which was grounded in the usability/UX frameworks **[R1, R2]**. With paper-based methods, a typical issue is that the distribution of physical props to participants to provide feedback and to developers to analyse and respond to the feedback can be time consuming and expensive. A software tool can overcome the physical limitations through digital data collection and online access to the results **[R5]**.

PDot therefore comprises two main components – PDotCapturer and PDotAnalyser **[R5]**. The former facilitates sharing of feedback by end-users, the latter enables extraction of requirements from PD raw data and supports collaboration between HCI specialists and developers.

Apart from gathering feedback directly from end users, the Leicester HCI team applied Heuristic Evaluation, with the process enhanced based on Law's usability research **[R6]**, to evaluate the quality of prototypes of the Go-Lab/Next-Lab resources under development. The ensuing results proved useful to the developers enabling rapid, iterative improvement of the design of Go-Lab online resources.

## 3. References to the research


**Publications**

**R1. Law, E. L-C**., Roto, R., Hassenzahl, M., Vermeeren, A. POS, and Kort, J. (2009). "Understanding, scoping and defining user experience: a survey approach". *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'09)*, pp. 719-728. ACM.

**R2. Law, E. L-C**., Hvannberg, E.T., and Cockton, G. (2008). *Maturing usability: Quality in software, interaction and value*. Springer.

**R3. Law, E. L. C**., Schmitz, H. C., Wolpers, M., Klamma, R., Berthold, M., & Albert, D. (2012). "Responsive and Open Learning Environments (ROLE): Requirements, Evaluation and Reflection". *Journal of Interaction Design and Architectures (IxD&A)*, 15, 87-101.

**R4. Law, E. L-C**., and Sun, X. (2012). "Evaluating user experience of adaptive digital educational games with Activity Theory". *International Journal of Human-Computer Studies*, 70(7),478-497.

**R5. Heintz, M. and Law, E. L-C.** (2018). "Pdotcapturer and Pdotanalyser: participatory design online tools for asynchronous idea capturing and analysis". *Proceedings of the 10th Nordic Conference on Human-Computer Interaction (NordiCHI)*, pp. 622-633. ACM.

**R6.** Hvannberg, E. T., **Law, E. L. C**., & Lárusdóttir, M. K. (2007). "Heuristic evaluation: Comparing ways of finding and reporting usability problems". *Interacting with Computers*, 19(2), 225-240.



**G1: Go-Lab** (Global Online Science Labs for Inquiry Learning at School)
Coordinator: Ton de Jong, University of Twente, the Netherlands: PI (Leicester): Effie Law
Funder: EU FP7; Grant number: 317601
Period: November 2012- October 2016. EUR9,700,000 (Leicester: EUR713,000).

**G2**: **Next-Lab** (Next Generation Stakeholders and Next Level Ecosystem for Collaborative Science Education with Online Labs). Coordinator: Ton de Jong, University of Twente, the Netherlands: PI (Leicester): Effie Law. Funder: Horizon 2020; Grant number: 731685
Period: January 2017- December 2019. EUR4,000,000 (Leicester: EUR290,000).

## 4. Details of the impact

Two projects – **Go-Lab [G1]** and its follow-on, **Next-Lab [G2]** – enhanced STEM education across Europe on a large scale. Go-Lab/Next-Lab offer a unique, extensive collection of interactive online (virtual and remote) laboratories that can be efficiently combined with dedicated support tools (inquiry learning apps) and multimedia material, which forms open, cloud-based, shareable educational resources with an embedded pedagogical structure **[E4, E5]**. To ensure longevity, the target groups included students in secondary and primary schools and in-service and pre-service teachers in Europe, Africa, Asia, and Latin America. In Go-Lab/Next-Lab, the design of digital artefacts relies on **co-creation with users**, in combination with rapid development and testing cycles.

Go-Lab created a pedagogical framework for online learning with online labs and inquiry learning scaffolds for large-scale use in school STEM education. Using the Authoring platform, teachers create their inquiry learning spaces (ILS) to share with students in class. The Go-Lab Authoring platform **[E1]** enables the easy creation of ILSs, including, labs, apps, and other multimedia materials that are organised in an inquiry cycle. Teachers can configure the apps directly and provide students with (partially) pre-filled apps. The background infrastructure for enabling the learning analytics facilities (based on artefacts and activities) has also been put into place. In Go-Lab, Leicester was the leader of the work package Participatory Design (PD) to plan and implement research activities to gather end-user inputs for developing online STEM learning resources, ensuring their usability, usefulness, and desirability. The PD activities in Go-Lab enriched the implementation work of the development partners and supported positive user experiences for students and teachers when interacting with Go-Lab resources **[E1, E3]**. Thus, Leicester was invited to continue their PD work in Next-Lab. The impact of Leicester-led PD work is summarised along three dimensions:

### (1) Improving STEM education worldwide

The goal of the Leicester PD activities is to enable end-users of Go-Lab online resources to meet their needs with high effectiveness, high efficiency, and positive user experience. According to the established User-centred Design (UCD) approaches (to which PD is closely related), and to scientific publications on PD, incorporating end-users' feedback into iterative development lifecycles is one of the critical success factors for the high uptake of final products and services by their target users. While other factors could contribute to the success of the Go-Lab online resources, the Leicester PD activities are credited. Testimonials from students and teachers show that they benefited from the Go-Lab resources in various ways. Students appreciated the independent learning afforded by the platform **[E6b]** and teachers reported that *"the use of this platform has had a positive impact on teaching, learning and evaluation process[es]"*; and, *"The Go-Lab impact has been present in our school since 2014 as we still use the platform… [it] gives us flexible tools…"* **[E6b]**. The design and functionality of these tools were shaped by the Leicester PD work.

The Go-Lab platform includes >600 labs, 41 apps and ~1,000 Inquiry Learning Spaces (ILS) published by teachers. These resources are used each month by over 18,000 people in >45 countries. A further 31,000 users have been registered to the Authoring Platform, enabling them to create and share their own teaching resources **[E6a]**. Between 2017 and 2019, over 16,000 teachers have created ILSs, implemented in >1,200 classrooms to ~90,000 students **[E6]**. This usage pattern has visibly changed since March 2020, as the Go-Lab platform plays a role in mitigating the undesirable effect of school closure as a global measure against COVID 19. During the pandemic peak, the number of Go-Lab users has doubled, increasing to 40,000 ILS per month with 50,000 teachers registered with the platform **[E7]**. Both teacher remote-coaching and parent home-schooling rely on online resources that must be highly usable and appealing to engage students in the unusual situation **[E3]**. The impact of the Leicester PD work is even more salient in this context.

### (2) Awareness, understanding and appreciation of the PD effort

The dedicated software tool PDot has been created and other PD approaches have been adapted to address the contextual constraints of the projects. Awareness about PD effort was raised by constantly giving the design and development partners access to the user voice, so that they got direct and immediate formative feedback from their target group throughout the development process—rather than only at the end. By understanding how PD can mitigate the negative consequences of not listening to the needs of the users, the project's designers and developers learned to appreciate PD. The online tool developed for capturing and analysing end-user feedback, PDoT, was highly valued by designers and developers, as can be seen from quantitative (usability and UX measurements presented in **[R5]**) and qualitative responses **[E2, E8]**.

The Leicester team adapted PD methods to gather feedback within the project's constraints. Many of the suggested changes were implemented and proved useful **[E2]**. The Go-Lab platform was perceived positively and even novice teachers had no major problems with its use **[E9]**.

**3) Procedural Changes**

The increased appreciation of the PD effort led to procedural changes in the activities of the consortium partners responsible for design and development of Go-Lab online resources. As a consequence of the positive impact developers witnessed in their initial apps, they were convinced to ask for and include user feedback earlier and more often in the development of their apps: *"The feedback and co-creation improved the usage of the Go-Lab artefacts for teachers, students as well as researchers"* **[E2c]**. The project's developers and partners have aligned their work plans accordingly **[E2]**. For instance, the lead developers of inquiry learning apps have adapted their practice by requesting the Leicester PD team to evaluate early prototypes from the usability and UX perspective to identify areas of improvement. The high uptake of recommendations and return to the Leicester team for support attests to the value of the PD work. Developers at the University of Tartu, Estonia highlight that *"This feedback enabled us to incorporate user feedback as part of our development process . . . It has enabled us to achieve the improvement of our lab in a simple and intuitive way which would not have been possible without the Leicester team's work"* **[E2a]**.

The team at the University of Twente, Netherlands, attest to the usefulness of PDot and PD design methods. They stated that, as a result of their improved understanding of how PD methods can improve user experience, they began to actively seek out feedback from Leicester to incorporate into their development: *"Many of their suggestions were incorporated in their apps and labs, resulting in significant improvements"* **[E2e]**. The PD methodology influenced the design and functionality of the Go-Lab authoring platform, Graasp, from the start and throughout, as confirmed by members of the Interaction Systems Group (REACT) at the École Polytechnique Fédérale de Lausanne, Switzerland: *"[O]ngoing general data collection initiatives were conducted during both the Go-Lab and Next-Lab projects, with users interacting with the platform and providing feedback. The outcomes of these interventions shaped the design and functionality of the platform"* **[E2d]**. The latter is highlighted by the head of the REACT group stating: *"The Leicester team's work has supported us to create and improve the Go-Lab Authoring and Learning platform in a simple and intuitive way"* **[E2d]**.
Software developers, Information Multimedia Communications AG (IMC) (Saarland University spin-out), found that *"Targeted PD activities that were aimed at the integration of scenarios in the platform, revealed some issues with this particular area, which were addressed to improve the process to create scenario-based online lessons"*. Benefits of the PD method are listed as including **[E2f]**:

- improved user engagement;
- increased repeat uses of the platform;
- increased relevance of the platform and its content for the target group of teachers;
- improved speed and ease of use;
- better user experience when interacting with the platform;
- simplification of processes.

**5. Sources to corroborate the impact**

**E1.** Extracts from Go-Lab Project Deliverables; and website, http://graasp.eu/.
**E2.** Developer Testimonials:
(a) Senior Researcher of Educational Technology, University of Tartu, Estonia.
(b) School of Digital Technologies, University of Tallinn, Estonia.
(c) Institut du Management de l'information, Université de Neuchâtel, Switzerland.
(d) Three testimonials, REACT Group at the École Ploythechnique Fédérale de Lausanne, Switzerland.
(e) Two testimonials: University of Twente, the Netherlands.
(f) Information Multimedia Communications (imc AG), Germany.
**E3.** Teacher Testimonials: https://premium.golabz.eu/about/schools-and-teachers
**E4.** Go-Lab Deliverable Report D8.4.
**E5.** Summary of Go-Lab Deliverable Report D8.4 (Document D8.5).
**E6.** Evidence of Go-Lab reach and uptake.
(a) Google Analytics Data in Email from co-ordinator.
(b) "Understanding teacher design practices for digital inquiry-based science learning: the case of Go-Lab (in print)". *Educational Technology Research and Development* (Journal), Springer.
**E7.** Go-Lab COVID 19 update (websites): https://support.golabz.eu/news/go-lab-offers-free-teaching-tools-for-schools-affected-by-covid-19
**E8.** *Think aloud* notes from PDotAnalyser evaluation.
**E9**. Next-Lab Deliverable Report D4.6.