8th International Conference on Higher Education Advances (HEAd'22)
Universitat Politècnica de València, València, 2022
DOI: http://dx.doi.org/10.4995/HEAd22.2022.14583

Teaching Data-Enabled Design: Student-led Data Collection in Design Education

Renee Noortman[1,2], Peter Lovei[1,2], Mathias Funk[1,3]
[1]Industrial Design, Eindhoven University of Technology, the Netherlands, [2]Philips Experience Design, Eindhoven, the Netherlands, [3]Eindhoven Artificial Intelligence Systems Institute, the Netherlands.

Abstract

As design practice becomes increasingly connected, designers are increasingly engaging with data practices in their day-to-day work. To facilitate this practice, design education needs to embrace data design. In this paper, we introduce a Master-level elective course around the Data-enabled Design methodology. This challenge-based learning activity aims to teach how to use data as a creative material while addressing real-life design challenges from selected industrial partners. In this article, we demonstrate how our master students learn how to prototype, conduct data-enabled interviews, adapt their prototypes, and introduce design interventions via a multi-step approach, leveraging their growing knowledge and skills around contextual data. We share how we use a strong collaboration with our industrial partners and a predefined data infrastructure to help our students use data for sharing valid research findings and presenting experiential interventions.

Keywords: *Data-enabled design; design education; design thinking; data design.*

1. Introduction

Design practice is continuously changing as new technology is being developed and societal challenges change. A design curriculum evolves with emerging technology and needs to address and invoke impact in society. As teachers in design-related education, this means that we create engaging learning activities that fit the open-ended nature of current societal needs and curriculuar learning objectives. Recent trends around big data, smart homes and artificial intelligence have opened up completely new design spaces and design challenges, such as human-AI collaboration, trust between humans and AI and the quantified self movement. Existing approaches to designing with data reach from data-driven design, to data-informed design (King et al, 2017) and data-enabled design (van Kollenburg and Bogers, 2019). To introduce students to Data-enabled Design (DED), the first edition of the DED course was set up in 2019. Currently, three editions of the course have taken place with a total of 91 students spread over three years. In this paper, we wish to share insights into the educational challenge of creating a course where fast-paced, open-ended, student-led data collection can result in valid research findings and experiential interventions. We introduce the course setup and the learning outcomes and analyse student work. Finally, we reflect on educational insights and possible improvements for the course and data design education more generally.

1.1. Data-enabled Design

Data-enabled Design (van Kollenburg and Bogers, 2019) describes a situated design practice aimed at using data as a creative material for designing intelligent ecosystems. Intelligent ecosystems are a dynamic composition of interrelated products, services and people. By collecting data and using artificial intelligence, these systems learn to understand their users and to adapt to them based on their interactions. The term DED describes a design process that consists of a research-oriented contextual step and a design-oriented informed step. The *research-oriented contextual step* draws from modern ethnographic practices and is meant to gain an understanding of the everyday context. In this step, design researchers engage participants to gain contextual insights into the relevant design space. Through building and distributing design probes, objective and subjective data are collected. The design team then uses this data to conduct *data-enabled interviews.* The contextual step typically lasts 3-4 weeks and involves 6-8 participants. Afterwards, using the collected data for the *design-oriented informed step* allows design teams to introduce *interventions* into participants' contexts. This step can be conducted with the same participants as the contextual step, but often a new group of participants is recruited in order to test the assumptions from the contextual step against a fresh pool of participants and their contexts. The informed step is more reactive, not only gathering data but also providing real-time feedback on the data. This step typically lasts 3-4 weeks and involves 10-12 participants. In recent work, we have also explored how to scale up and expand DED for other contexts (Noortman et al, 2022).

1.2. Department of Industrial Design at Eindhoven University of Technology

The educational program at Industrial Design at Eindhoven University of Technology (TU/e) has a strong challenge-based learning character (Johnson et al, 2009), as we strive to create societal relevance for the students' projects and courses from the first year onwards. The focus of the department is on designing and creating intelligent systems, products and related services. Students are educated to actively reflect on their work, as well as their vision on design (Hummels and Frens, 2009). This means that the curriculum is very dynamic and adapts quickly to new societal and technological trends. The students often work with emerging technology and adopt new methodologies and techniques. In response to this continuous innovation, new courses are often set up and courses are rarely taught in the exact same way in consecutive years. To fit into the growing need for designers who fluently engage with data (Lovei et al, 2019), we created a course where students collect, analyse and use data as a creative material for the design process.

2. Data-enabled Design course

In the course, students follow a shortened version of the DED process compared to the drawn-out version that is applied in design practice and industry. In line with challenge-based learning, the course uses examples from design practice as real-life use cases for the students to engage with the methodology. Additionally, the course has a strong focus on collaboration with stakeholders from industry that are active in the development and the application of the methodology (specifically Philips Experience Design and to a lesser extent Novo Nordisk). These partners participated by formulating the design challenges, and by giving guest lectures.

The uniqueness of this course in the program is the engagement with participants early on in the course. The students select one of the challenges provided by the industrial partners, create a prototype for a design probe and deploy it in a participant's context *(research-oriented contextual step)*. This data collection is student-led and open-ended. Students appreciate the high speed and the tools provided to them, including the pre-defined data infrastructure. Throughout the course, students use collected data and conduct data-enabled interviews with participants. They use these findings to select new participants and deploy redesigned prototypes in their context *(design-oriented informed step)*. In the final session of the course, students reflect on their process and present their achievements to the teaching team and industrial partners.

2.1. Course content

The aim of the DED course is to teach students about the role of data in a design process, and how data can be used as a creative material. The content of the course can be divided into

three main topics: designing and prototyping context-specific data trackers, data collection and analysis, and designing a contextual intervention that makes creative use of data. Students receive various tools to help them throughout the course, including a prototyping toolkit with microcontrollers and sensors, access to the OOCSI connectivity middleware (Funk, 2019) and access to a research data management platform to store sensor data and host datasets for analysis.

During the course, we emphasize the need for detailed information about the type of data being collected and gaining informed consent from study participants prior to data collection. Later lectures cover how to analyse the data, with a special focus on how to use the quantitative data as input for the so-called *data-enabled interviews*. By discussing data visualisations with participants in these interviews, students are encouraged to find the deeper qualitative explanation of the quantitative data.

One of the core elements of the DED methodology is to remotely adapt prototypes while they are situated in the target context. This way, the prototyped data collectors can respond to the collected data in real time and allow student teams to carefully craft and deploy interventions. This is a means to try out more and more dynamic design iterations compared to a traditional design process. The informed step means that students are challenged to come up with design interventions that offer a creative response to the findings from the contextual step–using collected data as a creative material in their open-ended design process.

2.2. Course set-up

The DED course is an elective course in the Industrial Design Master program that is open to students from across the TU/e. The course is aimed at teaching knowledge, skills and attitude related to the DED methodology, which is more widely used within Philips Experience Design. The course is hands-on: students follow theoretical lectures alongside a design research group project. Like most Industrial Design elective courses, the course introduces new theory such that the students learn new methods to apply in their semester-long design projects.

There are no prerequisites to register for the course. Nevertheless, students are expected to have prior knowledge of general design research methodology and to be familiar with basic technology prototyping. Students are deliberately mixed in teams to support a broad variety of personal learning goals and styles in the group assignments.

In total, 91 students participated in the course in 2018/2019 (22 students), in 2019/2020 (23 students) and in 2020/2021 (46 students). Slightly different design cases were covered in the different editions of the course. The first two years, the design case was centered around air quality. The third edition offered three different design cases: sugar (focused on diabetes), home environment and mood (mental health).

3. Course outcomes

Due to the open-ended nature of the course, the outcomes are versatile. Students in the course and Master program are encouraged to direct their own development, and thus also encouraged to explore the parts of the DED methodology that fit most naturally with their vision on design and the designers that they want to become. In grading the course, we do not compare outcomes between teams and instead focus on a team's ability to creatively use the collected data for presenting research findings, and to consistently design a final intervention that meaningfully uses data. To discuss the merits of our chosen approach to design education, we present the students' course deliverables and analyse how different teams engaged with data in their projects. We aim to identify how the learning experiences in the course shape the outcomes. Figure 1 shows four representative projects, which is a selection out of a total of 25 projects.

			
"The Knot": Abstract data visualization for co-responsibility of diabetes patients and their social support system	"Air quality dashboard": combining self-reported productivity and air quality in the working-from-home domain	"Not the FBI": A home notification system that communicates about air quality through smart lights	"Bon Voyage": A toolkit for ludic engagement with indoor climate data

Figure 1. Examples of student outcomes in the course

Overall, we see some general themes in the types of projects that students pursue. The largest group of teams (9 projects) focused on data visualization and physicalization, like *The Knot*, where the design challenge is seen as one where data is physically brought into a space to encourage reflection by its users. The main aim of these projects is commonly described as *'raising awareness'* (T18-01, T19-01, T19-05, T19-07, T20-03, T20-04). These projects are product-focused and generally aim to solve contextual issues that the teams identified based on the collected data during the contextual step.

Another large group of teams (7 projects) focused more specifically on facilitating end-user awareness and insights into data, and managing processes associated with that data, such as the *Air quality dashboard*. These projects typically resemble a dashboard and provide users with graphs and numbers, as well as suggestions on actions they might take. In some cases, data that was interpreted as unwanted behavior would result in a detracting intervention (T18-07, T20-07). Generally, these dashboard designs made it easy to *'continuously [develop the solution] further, while it remained in the everyday setting of the participants'* (T18-03).

These projects were system-focussed, and clearly aimed at sense-making, reflection and analysis of collected data.

There were a few projects (4 projects) that took a similar approach to the dashboard teams, but provided an additional layer through contextual automation. After an initial learning phase, their prototypes would provide a practical implementation into everyday routines such as automatically opening windows when the air quality is low (T18-05) or seamlessly embedding notifications about air quality into the home through smart lights (T20-06, *Not the FBI*). What set these projects apart from the previous category are the first steps towards intelligence in the ecosystem, where one element responds to another autonomously and without user intervention.

There were a few teams (3 projects) that took the data they collected in the initial phases as input for new data processes, e.g. to *'promote exploration and help create new connections'* (T19-02, *Bon Voyage*) or to *'[create] conscious awareness of mood over a long period of time through self-reflection'* (T20-09). In these cases, the resulting design would encourage users to engage with data in new ways, and invite researchers to look at contextual data from new perspectives. These designs were more creative explorations of data, with a stronger focus on qualitative data and interpretation, and the teams were research-focussed, ready to push the boundaries of data collection and to use that data creatively.

Finally, there were two teams with an entirely different approach to data. These teams organized focus groups to collect extra data (T20-08) or mainly used the data to improve the data collection process, rather than use it to come to design solutions (T20-10).

4. Discussion

Over the past three editions of the course, we have been impressed by students' achievements. We set out to design a course that helps students to iteratively and creatively engage with collected data in an open-ended, challenge-based design process. We provided a data infrastructure and close collaboration with industry to breach the gap between design education and design practice. At the same time, we took advantage of the flexible course structure to experiment with new technology, introduce diverse design challenges and emphasize different aspects of Data-enabled Design.

4.1. The role of data in the course

Data-enabled design places data at the core of the design process; consequently, learning about data collection and data analysis have a prominent role in the course. The main learning goal is to make sense of data and use it creatively in design, without letting go of design intention and intuition. Students are quickly able to collect and engage with data collected from participants' contexts using the tools provided. They are able to present research

insights based on data visualizations, descriptive statistics and data-enabled interviews. However, moving into hands-on design work towards meaningful contextual design interventions remained a challenge for most of the teams. The teams that were more successful in this regard were those with a balanced distribution of technical and design backgrounds. In the first edition of the course we saw the methodology stay close to its application in industry. In the second and third editions we saw students lean more towards abstract data visualization as a result of an emphasis in the lectures on finding the stories *behind* the data. This approach also opens up the need for a new perspective to the methodology, with more creative exploration of the role of data for design practice.

4.2. Open-ended design cases

The design cases are deliberately kept open to allow students to "follow the data" and adapt to the unfolding challenge rather than a rigid design brief. The open setup was intended to allow for creativity and open interpretation of the data and design context, and consequently, we saw the last two editions strongly lean into topics around the pandemic and working from home. While the shifts in design direction were promising, they were often not congruent with collected data and derived insights. Students would often short-cut promising lines of data-led exploration by following their intuitive assumptions about a familiar context. And the crucial fork in the path only became apparent later when a course correction was no longer possible. Designing in open-endedness needs different educational interventions, often counter-intuitive to growing designers, who strive to converge fast and reduce uncertainty. A second critical aspect of open-ended design education in this course is the overlap between the different design challenges that we offered. Designing in this overlap invites for convergence across cases, mistaking the collected data and insights as similar and indicative of similar phenomena. This warrants more investigation, and preparing cases that are further apart, contributed by more diverse industrial partners.

4.3. Evolution of DED education

Moving forward, we see DED develop into two more specific strands, where one stays close to its current use in industry (focused on ecosystem design), and the other is more focused on the design research outcomes and innovating data collection practices (focused on design probes). Besides teaching the students how to apply the DED methodology, the course also serves as a venue for us as researchers to better understand and further refine and explore the methodology, especially outside of organisations with elaborate resources and infrastructure, such as our industrial partners. Taking the methodology outside of the industrial context allows for deeper exploration of the research possibilities with the methodology. A second aspect of evolving DED education is related to the support infrastructure that we provide, mainly connectivity and data collection technology, technical examples, blueprints, assembled kits and video lectures. Over the course sequence of three years, we have observed

that a good data infrastructure setup is as essential in the educational format as it is in industry. Especially the contextual step requires a fast pace, leaving mere days between kick-off and the first deployment of a working data collector in a target context. This is not something that we can expect students to develop in an entirely self-directed manner. This led to the development of a toolset for students to be used. By creating a stronger overlap between the design challenges and the provided creative technologies, the first encounter that the students have with "their" data is meaningful and naturally leads into the informed step with more intensive design action.

5. Conclusion

In this paper we have presented and reflected on three editions of the Data-enabled Design course. We set out to educate designer Master students on how to creatively use data in a structured process. More than 90 students so far went through their own Data-enabled Design process. We have seen different trends in the student projects, which we use to reflect on the further development of the methodology and the course. Going forward, we see opportunities to further refine the course by introducing more diverse design challenges, and providing a solid infrastructure that allows for even more meaningful interaction and design with data.

References

Bogers, S., Frens, J., Van Kollenburg, J., Deckers, E., & Hummels, C. (2016, June). *Connected baby bottle: A design case study towards a framework for data-enabled design.* In Proceedings of the 2016 ACM DIS conference (pp. 301-311).

Funk, M. (2019, May). OOCSI. Zenodo. http://doi.org/10.5281/zenodo.1321220

Hummels, C. & Frens, J. The reflective transformative design process. *Proc 27th Int Conf Ext Abstr Hum Factors Comput Syst - Chi Ea '09* 2655–2658 (2009)

Johnson, L. F., Smith, R. S., Smythe, J. T., & Varon, R. K. (2009). Challenge-*based learning: An approach for our time* (pp. 1-38). The new Media consortium.

King, R., Churchill, E. F. & Tan, C. (2017). *Designing with Data*. O'Reilly Media.

Van Kollenburg, J., & Bogers, S. J. A. (2019). *Data-enabled design: a situated design approach that uses data as creative material when designing for intelligent ecosystems.*

Lovei, P., Deckers, E., Funk, M., & Wensveen, S. (2020, July). *The Marios and Luigis of Design: Design Plumbers Wanted!*. In Companion Publication of the 2020 ACM Designing Interactive Systems Conference (pp. 197-201).

Noortman, R., Lovei, P., Funk, M. (2022). *Breaking up Data-Enabled Design: Expanding and Scaling up for the Clinical Context.* AI EDAM (in print).