Project-based learning in Human-Computer Interaction: A Service-Dominant Logic approach

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Abstract

Purpose − This study aims to propose a service-dominant logic (S-DL)-informed framework for teaching innovation in the context of human–computer interaction (HCI) education involving large industrial projects.

Design/methodology/approach − The study combines S-DL from the field of marketing with experiential and constructivist learning to enable value co-creation as the primary method of connecting diverse actors within the service ecology. The approach aligns with the current conceptualization of central university activities as a triad of research, education and innovation.

Findings − The teaching framework based on the service-dominant logic enabled ongoing improvements to the course (a project-based, bachelor's-level HCI course in the computer science department), easier management of stakeholders, and learning experiences through students' participation in real-life projects. The framework also helped to provide an understanding of how value co-creation works and brought a new dimension to HCI education.

Originality/value − While HCI has successfully contributed to innovation, HCI education has made only moderate efforts to include innovation as part of the curriculum. The proposed framework considers multiple service ecosystem actors and covers a broader set of co-created values for the involved partners and society than just learning benefits.

Practical implications − The proposed framework and the authors' experience described herein, along with examples of projects, can be helpful to educators designing and improving project-based HCI courses. It can also be useful for partner companies and organizations to realize the potential benefits of collaboration with universities. Decision-makers in industry and academia can benefit from these findings when discussing approaches to addressing sustainability issues.

Keywords HCI education, Innovation, Service-dominant logic, Value co-creation, Research, Higher education, Learning methods, Teaching methods.

1. Introduction

The human–computer interaction (HCI) community has long recognized the need for continuously updated HCI curricula focused on what is a "must" for the curriculum, choosing among diverse theories, frameworks, and exemplars. For example, the association for computing machinery special interest group on computer-human interaction (ACM SIGCHI) Executive Committee sponsored a project (Churchill et al., 2014, 2016) to investigate the present and future of HCI education. The project ran from 2011 to 2014. The findings pointed to the desire among HCI scholars and educators to share and collaborate on the development of course outlines, curricula and teaching materials, calling this the HCI living curricula. However, with fast-changing technologies and the continued rapid expansion of the field, HCI education is particularly sensitive to issues of relevance and balance between theoretical and practical professional knowledge and skills. Thus, what should be taught and how to do it best (Churchill et al., 2013; Culén et al., 2014; St-Cyr et al., 2019) has been difficult to establish.

However, there has been little room in curricula discussions on how to tackle the responsibility of educating future technology innovators and how to address technological innovation that HCI education directly or indirectly shapes. Collingridge (1980) outlined the dilemma by discussing the implications and timing of possible intervention points for technological innovation. He pointed out that the potential consequences of emerging technologies often become visible only after they have been accepted and evolved into sociotechnical systems, which than makes them difficult to change. At the design stage, changes are easy to implement, but the consequences are difficult to imagine. In the meantime, we have become more acutely aware of the impact of technological innovation and design, including interaction design, on both the natural and the human world. Despite the difficulty of assessing the possible impacts of technological innovation, we need to consider ways of educating HCI researchers and practitioners to think about the innovation and design of technology differently and more holistically. In line with van der Duin (2019), we believe that concerns about the future should be tightly coupled with technological developments and linked to social, ethical and environmental conditions. In other words, HCI researchers and practitioners must recognize that framing design activities, which lie at the core of innovation, can no longer rely on the traditional pairing of users with designers and build solely on user-centered approaches to technology design. Instead, approaches that value the full complexity of a design context and stakeholders' diversity in each design situation are recommended (Gray et al., 2019; Irwin, 2018; Rosenberg, 2016). Furthermore, as awareness of the unsustainability issues linked with technology design increases, HCI educators need to consider how to contribute to universities' and society's sustainability goals by making students aware of such issues.

In this paper, which is an extension of the work presented in Karahasanovic and Culén (2021), we explore if and how service-dominant logic (S-DL) (Vargo and Lusch, 2008) might help to include innovation in teaching and learning HCI. In particular, we consider deeper involvement with value co-creation through education for the purpose of social good. Therefore, this paper proposes a framework for teaching HCI based on S-DL that fits the needs for active collaboration with industrial partners and experiential learning when teaching technology-based innovation including social innovation.

The paper is organized as follows. Section 2 provides a brief background on S-DL, its implementation in education and background on constructivist and experiential learning, including the model that captures experiential learning integrated with innovation. Section 3 describes the teaching context and the course. Section 4 proposes an S-DL-based framework for teaching innovation in HCI and describes its main components. Section 5 describes how this framework was used to move our teaching in a more socially responsible direction, respond promptly to changes in the world around us, and bring a new dimension to teaching and learning HCI through value co-creation. We illustrate the approach by providing a few examples, starting with one from the early phases of our teaching towards more recent times. We then discuss the framework and learning in Section 6 and provide concluding remarks in Section 7.

2. Background

Section 2 is divided into two parts. First, we discuss S-DL and previous research concerning the use of S-DL in education. Then, we discuss our approach to teaching and learning innovation in the context of HCI, which is based on constructivist and experiential learning. We also report briefly on previous work in HCI that focused on teaching innovation.

2.1 Service-Dominant Logic

S-DL proposes that service is central to any exchange, whether for business purposes or otherwise (Vargo and Lusch, 2008). In Hollebeek (2019), the authors propose an S-DL-informed model for customer engagement. The model views resource integration as a required antecedent of customer engagement and co-

creation as its key outcome. Furthermore, other research, e.g. Hollebeek and Andreassen (2018), Lusch and Nambisan (2015), Ordanini and Parasuraman (2011), explicitly uses S-DL to frame service innovation and highlights the importance of exploring the integrative interfaces that support customer engagement and service innovation. According to these views, innovation is a result of resource-integrating activities that create new resource configurations, thus, paving the way for innovation. In line with S-DL, the main components of this perspective include the following:

- Service platforms: Structures of tangible and intangible resources that facilitate interactions between the involved actors (Breidbach et al., 2014).

- Value co-creation: The extraction of actor-perceived value from focal service innovation-related interactions (e.g., customer–firm, employee–firm).

- Service ecosystems: Networked actors connected through service exchanges that serve as the environment in which service innovation occurs. While some ecosystem actors may make direct innovation-related contributions, others may make indirect ones (e.g., by virtue of their connections to other actors).

Service-dominant logic has also been previously applied to understand higher education as a customer experience, where the core service is a co-created learning experience with value that is emergent, unstructured, interactive, uncertain and with a hedonic dimension (Ng and Forbes, 2009). In their paper (Díaz-Méndez et al., 2019), the authors argue that higher education institutions represent a complex system where many actors interact to co-create value and that S-DL is a good approach to managing such institutions. Other authors, e.g., Jarvis (2014), apply S-DL to conceptualize engagement in large, flipped classroom courses. They provide an S-DL-based framework implemented in undergraduate marketing teaching contexts and show that this approach fosters co-creation and enhances the learning experience and outcomes, even in very large classes.

While our work bears similarities to the above-mentioned research in that it focuses on the co-creation of value and desire to create an engaging and positive learning environment, it also offers a different perspective. The most significant difference is the inclusion of multiple actors, including those external to higher education. In addition to universities and students, industrial partners and possibly their customers contribute to the co-creation of value through joint innovation efforts and experiential learning in design teams.

2.2 Constructivist and Experiential Learning and Innovation in HCI

Constructivist theory has a long history and builds on the work of many great educators, such as Dewey (2017), Vygotsky (1978) and Piaget (1973). Constructivist theories explain the process of knowledge acquisition and not a specific pedagogy, although implications for education are clearly important. Constructivist theory suggests that humans create knowledge and meaning by constructing mental models based on their experiences and prior knowledge (Brooks and Brooks, 2001; Dewey, 2017; Jonassen, 1999; Vygotsky, 1978), continually evaluating and evolving these models with every new input. The notion that learning is constructed and that new knowledge is founded on pre-existing knowledge sharply contrasts the view that learning is a passive activity, characterized by the one-way transmission of information (e.g., from teacher to student). The reception of such information creates inert knowledge that is often difficult to apply, especially in complex settings. On the one hand, learning paradigms, such as constructivist and experiential, which build on self- efficacy and collaboration, make the application of gained knowledge easier (Ruben, 1999). On the other hand, such learning is affected by individual learner's characteristics to a higher degree than passive transfer of knowledge. To reduce the impact of individual characteristics of learners on learning, Vygotsky (Vygotsky, 1978) suggested the concept of the zone of proximal development, which can be interpreted as the distance between what a learner can do without help compared to what they can achieve with the support of a knowledgeable adult or in collaboration with more knowledgeable peers. Thus, to promote meaningful and memorable learning, it is necessary to create learning environments that directly expose the learner to the study material and ensure that active co-learning takes place.

The dimensions of constructivist learning that were particularly important and evident

from the way we organized learning as real-life projects, with ongoing reflection on pedagogy, methods and learning processes included:

- the relevance of learning to real-life and society at large;
- reflection on pedagogical plans and proximal development (support for learners) as well as learning methods if important for learning processes;
- ensuring the design and management of learning activities, assessment criteria and social norms in the classroom are co-shaped; and
- providing opportunities to explain, justify and test the viability of students' ideas, e.g. (Collis, 1998; Culén, 2015; Ioannou et al., 2015; Karahasanovic and Culén, 2014; Schultz and Christensen, 2004).

We adopted Beckman and Barry's experiential learning and innovation model described in Beckman and Barry (2007), see Figure 1. The model utilizes Kolb's experiential learning model (Kolb, 1983), based on the dichotomies between action and reflection, abstract and concrete, and different thinking styles. It integrates the phases of innovation processes and incorporates contextual understanding, insights, ideation, and solution-finding.

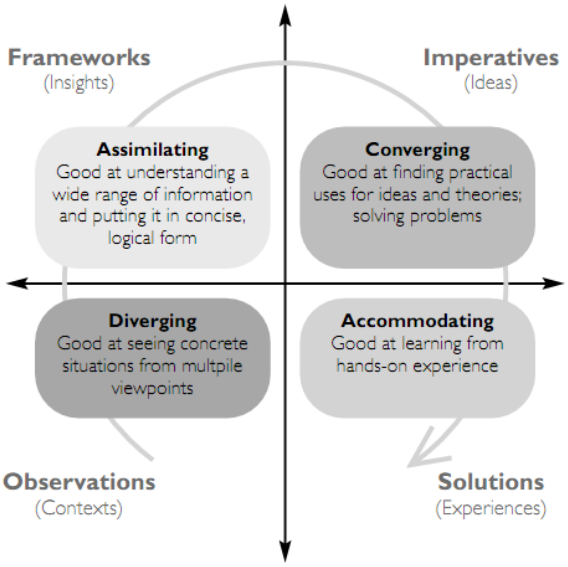

Figure 1: Beckman and Barry's integrated innovation-based learning model (Beckman and Barry, 2007).

The HCI theories, approaches, and frameworks taught on the course, needed to be applied and experienced through real-life projects. Designing the learning materials implied creating trajectories that align knowledge construction, experiential learning, and innovation.

The multi-disciplinary nature of HCI and how to teach the subject has attracted much attention within the educational community. The learning challenges, described by Sas (Sas, 2006) about fifteen years ago (e.g., the nature of design and creativity, processes, tensions between clarity and ambiguity, appropriate feedback, assessment of designed outcomes), remain difficult to address. Focusing on responsibility and innovation in HCI education is even more complex. Although shaping novel solutions has always been central to the field, there are few examples of good learning approaches concerning the socio-cultural impacts of new technologies, environmental impacts, or innovation and possible new business models as part of HCI (Chilana et al., 2015; Frohlich and Sarvas, 2011).

Critical thinking, creativity, collaboration (both within the field and across disciplines), and advanced communication skills have long been recognized as important in HCI education. As a recent SIGCHI initiative (Xie et al., 2019) indicates, the HCI community at the ACM Conference on Human Factors in Computing

Systems (CHI) is actively engaged in learning. It suggests areas of focus, and how to study and evaluate learning. It is also worth mentioning that many large HCI conferences offer workshops dedicated to education, such as HCIed[1] that is committed to discussing challenges for HCI education in this time of radical educational change. Furthermore, many papers suggest real-life project-based learning in HCI; for example, working with particular user groups (Roldan et al., 2020), providing pedagogical strategies suitable for project-based learning (Roldan et al., 2021), and focusing on real-life community needs through education innovation (Mulder, 2015).

Our approach to teaching innovation on our HCI course in collaboration with external partners recognizes the complexity of design situations and the need to expand the HCI toolbox for dealing with these situations (Gray et al., 2019). It is worth pointing out that innovation is not only about producing novel ideas; rather it is also concerned with the ability to recognize the innovation potential of existing ideas and realizing the potential of these ideas for the common good in collaboration with others. For students, this implies understanding established HCI theories and methods, appropriating them, and applying them to real-life settings, to produce new knowledge, designs, and values.

3. Teaching context

We have been teaching a project-based HCI course in a university computer science department since 2011. In 2018, the course was re-designed and divided into two new courses. One of these courses has continued to provide instruction under the same premises as discussed in this paper but with more direct involvement with sustainability, social responsibility, and other aspects of innovation in HCI. Meanwhile, the other course utilizes lecture-based teaching and focuses on theoretical grounding in research methods in HCI (based on the book Research Methods in HCI (Lazar et al., 2010)). We are no longer involved in the teaching of the latter course. From 2011–2017, the course was obligatory on our bachelor's program Interaction, Use, and Design. It was the third course focusing on interaction design, following the introductory course based on the book Interaction Design: Beyond Human-Computer Interaction (Preece et al., 2015) and the course on use-oriented design. After re-design, it is now an elective course, with the research methods element as a prerequisite. This implies that while the students taking the course at present have a more solid theoretical background, fewer students choose to take it, which provides us with better opportunities to supervise the projects. Although the course is designed to be taught in person, the pandemic has forced us to offer the course online for the past two years.

Our original motivation was to provide our students with real-life and meaningful project experiences. Thus, before the start of the course each year, we discussed and identified a set of relevant problems. Once we decided on the potential topics, we recruited organizations (public and private), startups, and/or research organizations participating in large EU or Norwegian Research Council-financed research projects with related and relevant themes. Due to the large number of students enrolled in the course prior to 2017, we needed to recruit at least ten external collaborators per year, who were encouraged to provide two distinct project opportunities each. Thus, each year, we could offer new topics and collaborators, engaging more than 30 organizations over time. The students typically worked in teams of four people, in line with the established optimum for experiential team-based learning (Kayes et al., 2005). The student teams collaborated further with the external organizations and the instructional team to complete the projects.

In Section 4, we focus on the opportunities that S-DL-inspired thinking offered to better understand value co-creation and how this allowed the transformation of the course toward a deeper awareness of values, their visibility and meaning in the context of such a cross- sectional collaborative project.

[1] https://hcied.adalsimeone.me/

4. S-DL-based framework for teaching innovation in HCI

After several years of working with this course, we needed an analytical tool to help us continuously improve the course and adapt it to social and educational changes in a structural way. We thus developed a conceptual framework for teaching innovation in HCI based on Service-Dominant Logic.

Table 1. SLE-based framework for teaching innovation in HCI

Component	Definition	Main issues
Service Ecosystem	A relatively self-adjusting system of industrial and educational actors and beneficiaries of services connected by shared interest in innovation and mutual value co-creation through the development of new technologies and exchange of services.	(1) The service ecosystem needs to consider diverse actors, such as the university, instructors, individual students, student teams, companies/organizations that own the problem, regulatory bodies (NSD), and end-users of proposed solutions as well as the broader society and the environment as parts of the system. (2) The actors need to understand the service ecology. (3) The actors need to understand the situated context of each project. (4) The need to develop a shared system of value expectations and understandings among actors.
Service Platforms	Structures facilitating actors' interactions with resources and/or other factors.	(1) The need to provide structured and efficient approaches for interactions (shared work platforms, blogs, emails, calendars, etc.). (2) The ability to adapt interaction to online-only communication. (3) The need to define clear rules for exchanges (confidentiality and intellectual property agreements among universities, companies, and students), the frequency and content of the supervision provided by companies, and ethics/privacy in contact with end-users and deliveries in the project (the platform for uploading the deliveries and informing the students). (4) Learn to communicate effectively. (5) Learn to relate concrete experiences to more abstract levels of knowledge and the converse. (6) Inclusion, trust, and safety need to be addressed. (7) The need to learn and develop professional conduct.
Value Co-creation	Jointly creating value through interactivity (within a student team, between the team and project stakeholders, and other actors in the ecology).	(1) Define key roles in the project (including roles within the team) and the nature of value co-creation. (2) The need to clearly communicate values and expectations among the involved actors. (3) Use diverse learning pedagogies, including peer-to-peer learning. (4) Assign tasks to different team members according to their skills or learning needs. (5) Discuss the purpose (identify benefits) of the project. (6) Utilize differences and diversity of perspectives and knowledge among design team members. (7) Engage with instructional staff to support design and new knowledge creation. (8) Teams take charge of the process.

Our concern was not about a specific curriculum, but how to use the described key components of S-DL to design a course that reflected the values that we wanted to impart. Inspired by (Hollebeek and Andreassen, 2018; Lusch and Nambisan, 2015; Vargo and Lusch, 2008), using teaching goals for the course and experiences gained from the previous runs of the course, we adapted the S-DL framework to our context. This led to the following three components: service ecosystem (including a broader network of participants than stakeholders e.g., the university strategy makers and social groups), service platforms (representing the set of technologies and platforms used), and value co-creation (covering a broader set of values than just the learning benefits for the students and the potential value of the project outcomes for partner organizations). This is summarized in Table 1. While the framework can be used for other courses, such as project-based engineering courses, we believe that it fits the complexity of the ecosystem needed for teaching innovation to HCI students particularly well.

5. Situating the framework and project examples

The S-DL-based framework was used as a tool to systematically evaluate and improve the course. It was used to gain a comprehensive overview of the entire ecosystem and assess the strengths and weaknesses of our approach to project-based teaching. Each year, at the end of the semester and exams, we collected feedback from the students, partners and other teaching-related staff (teaching assistants and supervisors) on the processes that unfolded in the work on the projects. We also served as supervisors for some of the projects directly related to our own research, which gave us the opportunity to observe students directly in action and note any challenging points that might require improvement. In particular years, we also felt that we needed to make deeper inquiries to better understand how the teams worked with value co-creation and how different actors collaborated and used the service platforms. For example, in 2015, we interviewed 8 of our industrial and research partners and surveyed all 18 student teams.

In 2021, we conducted interviews with partners and students (four groups and three individual interviews: 13 students and 3 partners in total). The interviews were conducted in Norwegian or English (depending on the students' preference). The qualitative data, including notes, observations and interviews, were analyzed by the authors of the papers using a simple coding schema matching the framework elements. It should be noted that this evaluation was carried out in addition to the regular course evaluation completed by an independent student body at the end of each semester. As this standard evaluation targets students only, it cannot reveal the views of other stakeholders, such as industrial and research partners, which are central to the success of such a project-based course.

In the Section 5.1, we relate the three components of the framework to our course. We then explain how the framework helped us identify the strengths and points of improvement in the course design.

5.1 The service ecosystem

Our course and the projects included actors such as the university with its teachers and other helpers, administrators, and students (individuals and teams) as well as other actors, such as participating research and industry partners, the Norwegian Data Protection Service (NSD), those people who might benefit from the outcomes of these projects, and, for some projects, others with governance knowledge, law, or expertise. The project beneficiaries represented diverse social groups. Some projects involved children, while others included people with special needs (e.g., patients and such users needed to be met with special care and perhaps additional consents or permits). Similar to findings in (Roldan et al., 2020), our students needed to learn how to work with these user groups in real life settings. In addition to the literature, we have provided them with lessons learned from similar student projects or our own research and practical advice when challenges

appeared. This was of, course very time consuming due to diversity of user groups. There were also those who were difficult to recruit for participation for project work due to their busy schedules, such as air traffic controllers, police, oil-engineers, or firemen. This posed additional challenges for design teams and often departed from students' expectations of having situations prearranged for them. Additionally, student teams often had to master new and rather complex domain knowledge, both to support their design processes and to be able to communicate efficiently with field experts. This often resulted in additional workloads for instructors, internal supervisors, and contact persons in participating organizations. However, we did not find any evidence that students preferred projects in domains that were easier to understand or where the users were more accessible.

Almost always (with a couple of exceptions among 125 projects), the actors in service ecology gained a good understanding of the context for collaboration. Still, for some actors, it was more difficult to respond to the needs of some projects. For example, the regulatory body (NSD) could not change its routines to accommodate student projects, even understanding the project needs. Normally, it takes about four weeks from the submission of the notification form (for projects that require the processing of personal data) to its approval, which is too long for projects where students had only five weeks to deliver the first prototypes or solution sketches. This is an example of a challenge that we could not solve. It was addressed by workarounds—by either avoiding the collection of personal data altogether (for example, taking notes instead of audio recording interviews) or by postponing data collection that involved sensitive data.

5.2 Service platforms

Apart from the possibilities for face-to-face meetings with instructional staff, students could share their project-related processes with the instructional staff as well as the industrial partners, using blog posts to share their progress regularly. Finding an adequate platform was left up to the students. Many teams preferred simple blogging platforms, such as Tumblr for external communications and Google Docs for internal work. Various scheduling tools, such as Doodle, were frequently used. E-mail was still one of the primary communication channels with partner organizations.

During the pandemic, the communication moved to Zoom and Teams. Figma (the collaborative interface design tool) and Miro (online whiteboard tool) were used for prototyping and sharing ideas. As the first lockdown in Norway began in the middle of the spring semester (March 2020), the students as well as the teachers, partners, and user groups had one week to completely change their project plans. The workshops and focus groups that had already been prepared were replaced with online studies. The students were generally satisfied with online communication tools and appreciated immediate response of their group members, supervisors or partners. They said that "it worked fine as all are Yes people". However, students also reported Zoom-fatigue as during Spring 2021 they had up to 4 hours daily of Zoom lectures and meetings in different courses.

Students often thought of partner organizations as clients and themselves as design consultants. Many students remarked that it was motivational to think that way and that it helped them to develop a professional attitude as well as to take the extra mile to learn. For example, they were willing to learn how to use sophisticated platforms that their clients carried out their work on, even if they required extra time and effort, and even if they were not likely to use these programs after the project is over. This was often the case for large organizations with proprietary platforms and specialized work tools.

5.3 Value co-creation and examples

Value creation and later value co-creation was the most central focus of our efforts when shaping the course. At the start, our goal was to design a course that would benefit students (to create value for students primarily)

by providing real-life experiential learning that granted self-efficacy and self-management while providing a good safety network should one be needed. However, through iterative improvements in the course design and framework formulation, we started to note more clearly the potential benefits of collaboration for diverse organizations. This enabled us to be more precise and more convincing in getting organizations to partner with us and to build and expand networks of potential project contributors actively, for example, by sharing success stories from previous projects and pointing out their impact. The main motivational factor for the organizations to engage in this collaboration was exploring students' innovative and "fresh" ideas or engaging students with existing ideas that the organizations could not work on due to time or resource constraints.

However, when asked about the benefits of working with students after experiencing the collaboration, the organizations frequently highlighted the importance of students' creativity and the value of their activities for the organization. Many organizations became repeat participants, emphasizing that the projects generated significant value to the organization. The importance of the outcomes of collaborations for organizations could be classified as:

- significant experimental and conceptual explorations;
- directly or indirectly generated larger research collaborations; and
- outcomes that were interesting in their own right, either as usable products or experiences.

With time, it became clear that beyond creating value for the students and learning only, we could actually talk about the co-creation of values for actors within the ecology, including the public and the university at large. Addressing the latter, every one of the participating organizations said that they would recommend such collaboration with the university to others.

To make the impact of the projects and co-created value more visible, for the benefit of all involved actors, we turned the final course presentations into a competition, where, as mentioned, a jury of experts evaluated the projects by novelty, impact, user engagement, and the ability to clearly communicate the central challenges and outcomes of the projects. The competition was followed by a social event, enabling students to meet diverse industrial partners, experts, faculty, and other guests. In this context, we would like to point out that this was also a way to network and identify potential openings for employment (something that happened on several occasions). Trying out a different opportunity regarding the same goal, we organized an open seminar featuring student innovators. Alongside their talks, the seminar included talks by organizations that participated in student projects, startups (some launched by our former students), and the Norwegian Business Association. For the cohorts with smaller numbers of groups (2020 and 2021), instead of having a competition, we invited all the external partners as well as guests from another European university teaching transition design to the presentations of the students' projects at the end of the semester.

To illustrate how the values that were cocreated for diverse actors within the service ecology and how they intended to provide values for social groups or the society at large we give several examples of success stories. The projects are presented in the chronological order and selected to show the diversity of the involved actors and technologies.

5.3.1 Project with a telecom company

This project was one of the first projects in this course. In 2011, a group of students collaborated with a major international telecom provider and a research institute on a project aiming to reduce workload of their customer service and technical support departments. After exploring several options, the students implemented an Augmented Reality (AR) app helping the customers with installation of broadband modems, Figure 2. The application should empower customers by providing a way to set up a modem that is more efficient, useful, and fun than contacting the customer service or reading user manuals.

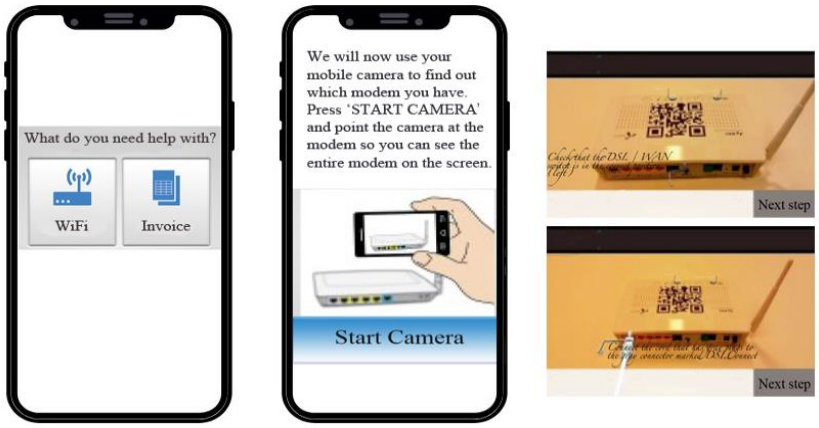

Figure 2. The images are based on the repost by the student team (Berghaust et al., 2011). The images on the left and middle show a part of the initial prototype; the images on the right show how the AR app guides the customer through the router installation process by indicating which switches to turn-on (top image) and where to plug in the cables (bottom right).

At the end of the semester, the students presented their prototypes and the evaluation of the results to a large group of company experts and managers. The feedback was very positive. Based on the students' results, the manager group initiated a follow-up internal development project to further explore the use of AR to support customers. The co-created value for the University was mostly related to the company gaining a better understanding of the teaching provided by our department After seeing the potential of such projects, the company wished to further strengthen the University's user experience education and funded student projects in this area (not limited to the telecom domain) through a new collaboration agreement between the company and the department. The students emphasized the usefulness of their experiences of working with this major telecom company and addressing real-life problems. This project contributed to strengthening the collaboration between the company and the research institute, which resulted in several further research and innovation projects.

5.3.2 Project on healthcare for elderly

This project explored how technology can be used to support the elderly in their everyday lives. It was carried out in collaboration with a research institute. The students developed a prototype of a robot that reminds elderly people about the medicines they need to take (should they forget), reminds them to drink water if they are dehydrated, and contacts the emergency services and family in case of an emergency (see Figure 3). Design and evaluation activities were conducted with elderly participants and the employees of a residential care home. For the students, the project raised their awareness of the ethical issues and methodological challenges of working with the elderly. Further, they learned how to collaborate within a multidisciplinary team. Two team members were design students, and one was a student of robotics and intelligent systems. The project was awarded first prize at the end-of-semester competition. The external jury praised the project's user involvement and potentially high impact. For the research institute, the results were useful as a part of the material for a research project proposal and recruitment purposes.

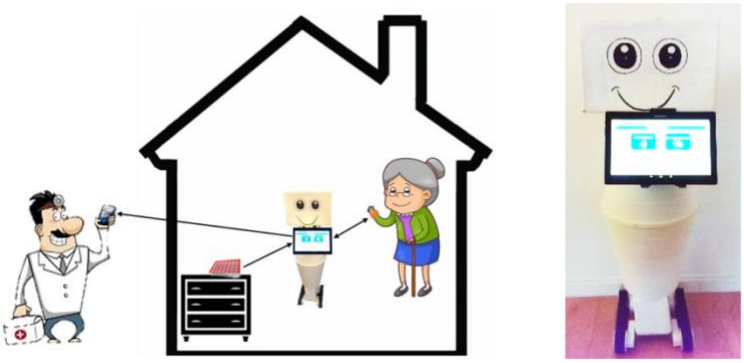

Figure 3. The robot for the elderly (Nejad et al., 2015). The pictures present the ecosystem of the robot (left side) and the prototype (right side). A video showing the robot in action is available on You Tube (*LUDVIG the Robot*, 2015).

5.3.3 Project with the national health directorate

This project aimed to improve the specialist approval process for medical doctors wishing to specialize in a particular field; it was carried out in collaboration with the national health directorate. It formed part of the ongoing digital transformation of the healthcare sector. The primary goal was to improve the efficiency of the approval process. Being accepted for a specialization typically takes five years; it requires doctors to document that they have fulfilled numerous requirements, such as performing the required surgical operations, courses, and clinical tasks. There are 44 different specializations. University hospitals are responsible for doctors' education and the health directorate is responsible for providing approval. Figure 4 shows how the students worked with doctors and created a large map of the interconnections between different stakeholders in this complex area.

The possibility of making a real change and contributing to improvements within the health sector was very motivating for students. They reported that working on this project was both challenging and rewarding. The students highly appreciated the opportunity to learn how complex systems (such as a health directorate) work and consider the system from different perspectives. Working with a group of professionals that have very busy schedules forced the students to learn about alternative methods they can apply. During their work, the client (the health directorate) reported that it was unhappy with some of the findings (specifically, the criticisms of the existing process) and the students were forced to learn how to deal with this issue. For the health directorate, the main added values were the new insights into the end users' experience of the existing process and the new authorization process the students proposed.

Figure 4. Medical doctors in specialization participate in a focus group to discuss the problems with the existing process and suggest their 'dream process' (Bergli et al., 2017).

5.3.4 Project on sustainability in rural areas

This project addressed the needs of people living in rural, scarcely populated areas for sustainable, convenient, and low-cost transport. It was a part of ongoing research and innovation projects funded by the National Research Council. The partners are a municipality, a county's transport section, a hospital, a service provider in the transport sector, and a research institute. Figure 5 provides an example of the project's results.

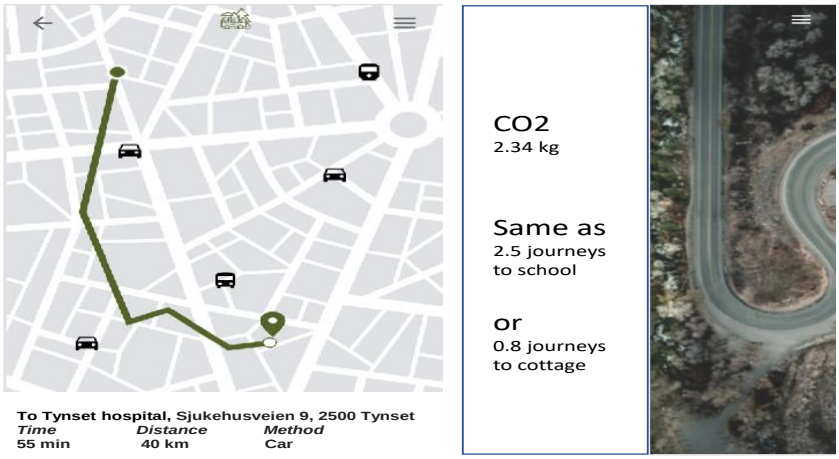

Figure 5. The picture on the left presents the neighbor function of the app. All available cars within a 1-km radius are shown on the map. The picture on the right shows the environmental impact of the selected journey (Justnæs et al., 2020).

The overall aim of the project was to investigate the potential benefits of the Mobility-as-a-Service (MaaS) concept in rural areas. MaaS is a type of service enabling users to plan, book, and pay for different mobility services through a single digital platform. A MaaS app tailored to the transport needs specific to rural areas was developed (see Figure 5). This app provided an environmentally friendly transport alternative for people who usually drive their own car when commuting, taking children to kindergarten, or activities such as shopping, and so on. The app uses an optimization tool that calculates possible journeys from point A to point B and the impact of the journey on the environment. The transport service users can then select their journeys based on different criteria, such as waiting time, travel time, or CO_2 emissions. One of the findings was the importance of environmentally friendly solutions that easily fit in with the often very busy everyday lives of families.

In their design of the app, the student team considered both the environmental impact and the impact on the local communities. The students were motivated by the opportunity to contribute to reducing the environmental costs related to transport and improving users' experience of transport in rural areas. At the end of the project, the students presented their results to the project steering board, where further development of their prototypes was discussed. The work done by students provided the participating public-sector actors with valuable insights into the transport needs of residents in rural areas. Importantly, they had prototypes addressing these needs to support these insights and offer concrete opportunities for further development. For the students, the work on the project raised their awareness of the broad spectrum of tools for dealing with sustainability ranging from the United Nations Sustainable Development Goals to visualizations of environmental impact. The opportunity to work with professionals from the public and private sectors was highly valued by the students.

For the research institute, the students' work contributed by exploring concepts and ideas that could not be explored due to limited resources. While the main funded research project focused on the optimization

algorithms and the interaction with the operators planning the traffic, the students' focused on the passengers and their needs, supporting the main project in a significant way.

While the core of the course has remained the same for many years, service ecosystem actors, service platforms, and value co-creation have changed over time to reflect technological and societal changes. As a result, the focus of the project shifted from a client-designer relationship toward design for the common good and the intent to contribute to solving significant societal challenges. These trends have also been addressed by others. For example, Mulder (Mulder, 2015) described a framework for collaboration with urban stakeholders in the context of HCI education; however, this framework differs from ours as it features a self-organized network including collaborations not initiated by university course leaders. Similar to our findings, (Mulder, 2015) reported positive experiences and the engagement of both students and the involved stakeholders, as well as a shift in focus from solving a particular problem to solving wicked problems and considering a system of systems.

6 Findings and reflections

This section is divided into three parts, where the first two identify strengths and weaknesses of the framework, and the third part is a reflection on the constructivist and experiential learning approach used.

6.1 Use of the framework to identify strengths of the course design

The framework clearly leveraged value as a tool to evaluate and identify possible pathways to the co-creation of values through different partnerships with external actors. It also helped to compare the expected and actual outcomes of the co-creation. Students, the instructional team, and the industrial partners shared positive feedback on the significance of the projects and, specifically, on the opportunity to co-create values. For example, in a survey conducted in 2015, we asked each student team if it was valuable to collaborate with an industrial partner. The majority of teams found it to be valuable (MED 1; AVG 2.3 on the scale of 1 [totally agree] to 7 [totally disagree]; N = 18 groups). A corresponding question posed to eight partner organizations was answered affirmatively by all. In the interviews conducted in 2021, the students emphasized that a main value from the course, both for them and for the partners, was a gained understanding of how designers can make a real change toward a sustainable future and take the first steps toward such a change. The project results (different prototypes and tools developed in the projects) were of great value to both the students and the partners.

On a smaller scale, the framework allowed us to re-evaluate the course requirements and platforms (e.g., time investments for various actors) and outline how changes that we made affected the course (e.g., one year, we specified that the blog was an obligatory communication platform but found out that while this worked well for some teams, it did not work for others, resulting in just a recommendation to blog the year after). Paying attention to interactions among different actors within the ecology helped us gain insight into the amount of work and time needed by different actors to support the projects effectively (e.g., how many hours for teaching assistants, internal supervisors, etc.). It also enabled us to make clear agreements on working conditions and to attempt to make the conditions equal for all projects.

Among individual elements, the purpose of the project, learning from teammates, and the openness of many on the project, allowing for creative solutions, were most appreciated. In their post-course surveys, post-exam surveys, and the conducted interviews, the students stated that the diversity of skills, knowledge, and experiences within the team created additional value for them and increased both creativity and learning. They found teamwork in real-life settings to be both motivating and fun. One team described their teamwork experiences as follows: "We have a group of different people with different ways of thinking, stirred together in a creative pot, it's awesome!" Another said, "Working in a group has been a good learning experience and really helped us to explore the different ways to design." Still another team found that "It [teamwork] really

helps. Quite often you have some ideas, but you need help to be able to explain them. So, in our group we really understood how each other was thinking, and we could really help each other describe and realize our ideas and creativity." The students also emphasized the importance of safe teamwork guidelines and "not killing each other's ideas."

The survey, the course evaluations completed by an independent student body, and interviews with participating organizations all showed that it is precisely the co-creating value that was the most productive aspect of this form of learning. When the projects were successful, students felt a sense of pride and that they were actually contributing to society. In some instances, the student projects have been recognized as innovations and have motivated companies to research, seek grants, or develop products in collaborations across the service ecology. Notably, at the moment, the framework and the iterative approach to making a course allowed us to align with our institute's and university's strategies to scaffold active collaborations between academia and the industry to provide timely, relevant, and responsible contributions to mounting social challenges. As an analytical tool, the framework helped us to iteratively improve the course and adapt it to different challenges in a structured way. For example, it helped us to identify and address the need to shift the focus toward sustainable innovation and the need to quickly adapt work and communication platforms due to the pandemic.

6.2 Use of the framework to identify points of improvement

The framework helped to elucidate that both diversity (of knowledge, skills, thinking styles) in teams and diversity in projects were appreciated and important for value co-creation. However, diversity in projects had additional time costs. The ecosystems included many actors, leading to an increased workload for the instructional team related to project management. Due to the diversity of the projects, methodologies, eagerness, and skills of the teams, among other factors, the workload grew for students and partners, which we tried to compensate for by providing extra supervision. This added further hours for the instructional team, students, and sometimes the partner organizations as well. In terms of the workload among student teams, those who had the highest motivation and the best results often ended up using a lot more time than expected. The expected workload in the course was 13.5 hours per week, including lectures, work on assignments, readings, and projects. The actual self-reported average workload was as expected (MED: 40 hours per week for all group members [3-4]; MIN: 6; MAX: 70), but for those highly motivated students, the average of 70 hours was too high. The workload became a clear point of improvement, and this is one of the reasons for splitting the course in 2018 and scaling it down. The second reason for the split also emerged clearly from working with our S-DL-based framework—we felt that the situation in the world and in the field of HCI is changing—calling for responsible innovation and teaching of innovation (Bates et al., 2019). Thus, the re-designed course strengthened focus on social values and sustainability and on pathways to implement positive changes in real social contexts.

We also decided that the new course would have all the projects dedicated to the same overall topic. For example, the topic in 2020 was 'Artificial Intelligence for Sustainability'. Our partners were invited to come with project proposals addressing this topic in different ways, ranging from healthcare chatbots to AI agents, enabling smart transport in rural areas or waste management. In 2021, the topic was 'Grassroot changes – Makerspaces and DiY as opportunity for change'. With these more complex projects, the issues of how to teach and learn about responsible innovation come to the forefront. Another point of improvement that emerged was related to first-time partners. It was difficult for us to know exactly how they would work, even when we communicated well about the course and saw great potential for value co-creation. The student feedback on some first-time partners was often somewhat lower, with the main complaint that they sometimes did not dedicate enough time to projects.

On the other hand, some partners also had suggestions for improvement. They expressed a desire to be better informed (by us) about students' abilities regarding their programming experience, design experience,

HCI methods, and other skills. While we recognized the importance and potential challenges that the lack of such information might cause, we could not provide this information in a timely fashion at the start of the course. Massification and mobility in education certainly had an impact on this, as we often had students from other institutions as well as international students. Although we asked all students to describe relevant experiences, skills, and knowledge when selecting a project to work on, their self-assessments did not always match the reality. Also, they sometimes did not have the skills that we expected (e.g., even though everyone had to have a programming course, not everyone was actually able to program). One of the partners, for example, told us that their team had no programming skills whatsoever, though they expected informatics students to be able to do well with programming. The students, however, were quite creative and delivered a range of ideas and explorations that were highly appreciated. If the partner had possessed this insight, they informed us that they would have written a very different brief to start with. Our master's students had especially varied educational backgrounds (e.g., bachelor's in education, music, art, design, and/or psychology), sometimes to the great benefit of teamwork. However, this made it difficult in terms of course planning in two ways: how to best connect the experiential learning path with a more theoretical and methodological one and how to determine how much work the extra supervision would take.

6.3. Constructivist and experiential learning

The examples of projects presented in Section 5 illustrate how the framework supported the dimensions of constructive learning mentioned in Section 2 (Beckman and Barry, 2007; Kolb, 1983; Roldan et al., 2021): the projects dealt with real-life problems and solutions featured, at the time, genuinely innovative proposals. Thus, through sharing problems and projects' approaches to solve them, the students could clearly see the relevance of their work for the society at large. For example, in 2011, there were no AR apps in use to help telecommunication customers. Therefore, the project with AR in collaboration with the telecom organization inspired further research on the opportunities of AR- apps in the telecommunication industry. Similarly, with the robot companion. Furthermore, the issue of medical professionals' certification is a systemic problem. To map the problem and suggest possible improvements requires the understanding of the context and adoption of new methods. This can only be achieved by learning from system insiders and proximal learning (Vygotsky, 1978). Similarly, to deal with the rural traffic problem students needed a range of new sustainability based, future oriented methods. Their processes had to involve concrete actions when involved in the design practice, and more abstract thinking when considering what methods might work best, or how to understand results from diverse design explorations, thus using the Bachmann and Barry's model, shown in Figure 1, as a natural part of their processes that unfolded between accommodation (of concrete experiences), assimilation (abstract thinking) and divergent-convergent thinking that supports contextual understanding, ideation and focus on possible solutions. Since each project was unique, the involved actors had to co-constitute collaboration jointly and decide on how to manage their project and processes. Thus, learning and design processes were co-shaped by participating actors for each project. Finally, opportunities were created to reflect, explain, share and justify student ideas, both in the classroom and through online presence of projects. Using the elements of the flipped classroom pedagogy and focus on critical thinking, students reported that they felt empowered and more confident in the skills they gained through the course and, most importantly, through the project work.

7. Conclusion

We believe that the proposed framework fits well with HCI education in this era of global change. While the core description of the course and its learning goals remained the same for many years, actors in the service ecosystem, service platforms, and value co-creation changed over time to reflect the changes in technology and society. As a result, the focus of various projects shifted from a client-designer relationship toward design intended for the common good. The problems presented by project contributors also grew in complexity, from

common interaction problems to solving increasingly complex ones. S-DL has helped us to manage this growing complexity appropriately. First, the framework's focus on the co-creation of value has helped create an engaging and positive learning environment. Second, our framework allows for multiple perspectives and positions on learning. For example, in some projects, particular user groups could also contribute to value co-creation through joint innovation efforts and help construct knowledge—taking the end-user involvement approach. Other projects produced new knowledge without user engagement; for example, some used self-learning, while others preferred to learn from experts. Third, the framework enabled better management of the course, providing a straightforward overview of the structure and what might require changing to make further improvements to the course. Fourth, a rich service ecology and collaboration with industrial partners brings a current and relevant industry focus to HCI education in concrete and experiential ways, centered on what is of growing importance: co-creating values for all—students, partners, the University, and the public—through education. We believe that our framework has helped our students to become better prepared for their future professional practice.

In terms of the limitations of the work, the main one is that we can only report on our subjective experiences with the proposed framework. This limitation also frames opportunities for future work. We hope to be able to observe others using the same framework in their courses to gain a more objective assessment of its usefulness.

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