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Selection and framing of briefs for educational circular design projects

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Abstract

Purpose – This paper aims to present key characteristics of educational design briefs for the circular economy (CE) through the analysis of 11 design briefs focussing on real-life challenges related to sustainability and the CE, developed with collaborating industry partners for four consecutive circular design internships conducted in Ireland, Catalunya, The Netherlands and Sweden.

Design/methodology/approach – These four internships were conducted between September 2017 and June 2019 and each internship lasted three to four months. The supervisors for each internship collaborated with local industry partners genuinely interested in adopting sustainable business practices to develop design briefs focussing on real-life challenges they face. The briefs for each internship were developed further according to the feedback of the interns, industry partners and supervisors of previous internships.

Findings – Five steps of brief making for circular design were identified as reviewing the existing resources, emphasizing the importance of systems thinking, emphasizing the importance of collaboration for the CE, focussing on circularity and communicating expectations. The paper outlines how design briefs changed throughout the consecutive internships according to the different curricula and the characteristics of an educational circular design brief.

Originality/value – For design educators and researchers, the value of this paper lies in presenting the steps for the brief making of educational circular design projects. Additionally, the characteristics of circular design briefs are outlined, discussing their focus and content to act as a guide for design educators.

Keywords Product design, Design education, Circular economy, Industry collaboration, Design brief, Internship programme

Paper type Research paper

1. Introduction

Design and engineering education has evolved to tackle environmental problems for decades now, leading to many studies exploring the educational aspects of overcoming these problems and achieving sustainability and giving rise to journals on the topic such as this one. Many researchers/educators suggested ways of incorporating sustainability and circular economy (CE) as inherent aspects of higher education and explored the competencies needed to solve sustainability issues (Brundiers and Wiek, 2011; Svanström *et al.*, 2008; Warburton, 2003; Wright, 2002, 2003). The UN Decade of Education for Sustainable Development (2005–2014) highlighted many challenges persevering and the final report calls for more transdisciplinary, collaborative approaches amongst and beyond higher education institutions (HEIs) (UNESCO, 2014). This paper, however, is more focussed on design education in HEIs and concerns itself with the competency building for real-world challenges of sustainability and especially the CE. Design briefs are an integral part of design education, especially for project-based modules, outlining the purposes of the educational design projects, constituting a starting point for the educational tasks and hinting at the learning outcomes for novice designers (Paton and Dorst, 2011; Read and Bohemia, 2012). For a fruitful collaboration between industry partners and HEIs in the area of design for sustainability and CE, the development of the design briefs requires an integrated approach, considering the varying requirements of collaborating partners and the wide scope of sustainability and CE theories and challenges (Dewulf, 2013; Parkman and Malkewitz, 2019). While there are studies on integrating concerns of sustainability into design briefs (Dewulf *et al.*, 2012; Petala *et al.*, 2010), there are not many studies about educational design projects.

This paper presents the development of design briefs for four consecutive Circular Design Internships facilitated in Ireland, Catalunya, The Netherlands and Sweden. This internship programme was developed as part of the circular design as follows: learning for innovative design for sustainability (L4IDS) Erasmus+ Knowledge Alliance project, with four European institutions with design departments [i.e. University of Limerick (UL) in Ireland, Universitat Politècnica de Catalunya (UPC) in Catalunya, NHL University of Applied Sciences (NHL) in The Netherlands and Linköping University (LiU) in Sweden] along with four design-led small to medium enterprises and three national design agencies. One of the purposes of L4IDS project is to develop an exchange training programme for circular design with an adaptable schedule conforming to the structures of these schools. The programme aimed to promote a culturally diverse, interdisciplinary working environment for students from varying backgrounds (e.g. product design, design management and materials science) and the expected learning outcomes of the internships were identified as follows:

- Creating an environment for interns *to self-learn and experience* the necessary tools and techniques for circular design.
- Facilitating learning for innovative, sustainable design *for both the interns and the industry partners* throughout the design process.
- Presenting the potential of innovative design tools and techniques for the CE and sustainability as applied to *real-life innovation processes* (Bakırlıoğlu and McMahon, 2021).

The structure of the internship programme and its effects on the practices of industry partners are presented elsewhere (Bakırlıoğlu and McMahon, 2021). This paper introduces the differences between these four internships and especially focuses on how design briefs incorporated the CE in different contexts. A total of 11 design briefs for these internships were developed in collaboration with 16 local industry partners in the four partner countries, and their content has changed to adapt to not only the different educational approaches of partner universities but also the industry partners' processes, resources, knowledge and experience.

The rest of this paper is organised as follows. Section 2 presents the background of the study. Section 3 describes the research methodology. Section 4 discusses the steps of brief making for circular design. Section 5 mentions the design briefs throughout the four consecutive internships. Finally, Sections 6 and 7 present a discussion and the conclusion.

2. Background

The CE is an alternative economic model for environmental sustainability (Ellen MacArthur Foundation, 2020), building on previous life-cycle assessment-based approaches to product development and holistic approaches to environmental sustainability. CE suggests that through innovation in supply chain management for a strict separation of biological and technical materials and the development of product-service systems enabling CE strategies (such as repair, remanufacturing and recycling on the technical side and cascading, biochemical extraction and composting on the biological side), the embedded value in products can be recaptured at the end of the use phase of products and materials loops can be closed without any waste (Ellen McArthur Foundation, 2013). CE is considered to be one among several solutions in terms of sustainability (Bocken *et al.*, 2014) or even the main condition to reach a sustainable system (Bakker *et al.*, 2019). It is also thought to foster certain aspects of sustainability while lacking in others – especially the social aspect (Murray *et al.*, 2017). Designing for the CE or circular design as it is referred to in this paper, concerns itself with designing products and services that would enable and facilitate the CE strategies, addressing not only the technical aspects (e.g. designing for disassembly, repair and upgrading) but also the societal and systemic aspects of it (e.g. behaviour change, collaboration among stakeholders, localisation, etc.). In this sense, this study regards the implementation of the CE from a larger, systems-level perspective and in relation to other affecting social and systemic aspects and circular design as the utilisation of various approaches to design for sustainability for this implementation (Ceschin and Gaziulusoy, 2016).

The role of HEIs to initiate change towards sustainability was discussed widely through capacity building (O'Rafferty *et al.*, 2014; Lozano, 2006), changes in learning outcomes (Shephard, 2008) and facilitating change in practice (Doğan *et al.*, 2016; Zilahy and Huisingh, 2009). However, there are barriers to integrating sustainability at all levels of education (de Eyto, 2010; Sterling and Witham, 2008; Boks and Diehl, 2006) and influencing the adoption of these concerns in real-life design processes (Bakırlıoğlu and McMahon, 2021). Mainstreaming sustainability throughout third-level design education and integrating

principles of sustainability and its design-related competencies present potentials in deep learning over an extended period and ready future designers for sustainability challenges ahead (O'Rafferty *et al.*, 2014; de Eyto *et al.*, 2008). For companies in need of or with a desire to change their practices, HEIs can act as intermediaries through using the expertise of academics on design for sustainability (Küçüksayraç *et al.*, 2017). The circular design internship programme adopts an integrated approach, where knowledge exchange among researcher/educators, industry partners and novice designers is facilitated in a collaborative and multi-cultural setting. Multi-cultural knowledge exchange for learning about and developing projects on sustainability and CE is considered to instil and reinforce more in-depth and comprehensive thinking in higher education (Leal Filho *et al.*, 2018). As the initiator of this collaborative learning environment, design briefs were important tools and they were adapted throughout the four implementations of this internship programme.

Taking a step back and understanding how design studio and project-based learning has evolved, Green and Bonollo (2003) identify how it differentiates from problem-based learning. Drawing from the early discussions on theory-based learning against apprenticeship and presenting the early instances of studio learning (e.g. Bauhaus in mainland Europe and Carnegie Technical College in the US), the authors claim the fundamentals of studio learning remained more or less similar (ibid). The training of professionals that can command from giving and technology has been the main goal of design schools and the studio is a space that reflects the professional design practice. While the design studio has certainly changed ever since, to tackle different challenges and to respond to different expectations from designers, its project-based learning approach remains as its most fundamental attribute. The problems presented in the design studio – and the problems generally presented to designers in professional practice – are generally *ill-defined* (Cross, 1989; Rowe, 1987). This is where project-based learning differentiates from the problem-based one, as designers often need to understand and identify the problems first – and more often than not they do so by proposing design solutions (Cross, 1989). Tackling ill-defined problems and framing them through the design process; however, cannot be taught through lectures – the future designers need to acquire such skills by themselves, and through coaching and learning-by-doing (Schön, 1987).

This is reflected in the design briefs as well. In the past, the briefs adopted a rather mechanistic perspective, with the problem, process and expected outcomes clearly defined as much as possible (Blyth and Worthington, 2010). However, this perspective has changed and developing briefs is now considered to be an integral part of the design process – rather than just the starting point (Dewulf *et al.*, 2012). Design briefs framed in a more abstract manner can result in a divergence of ideas, as opposed to more concrete briefs with strictly identified constraints (Zahner *et al.*, 2010). According to Phillips (2004), design briefs consist of seven elements:

(1) a *project overview* articulating the scope, objectives and desired outcomes;

(2) a *category review* examining clients' industry;

(3) a *target audience* review;

(4) a *company portfolio* outlining the activities of the company;

(5) *business objectives and design strategy*;

(6) the *project scope*; and

(7) *timeline and budget* providing an overview of project phases and their monetary and time constraints.

While this list of elements provides a good starting point for developing a brief, some elements can be purposely left abstract in educational contexts for novice designers to gain experience in framing problems and better scoping design projects. Partially defined problem and solution areas can co-evolve throughout a design project (Maher and Poon, 1996). The constraints of the design brief are identified according to the expected learning outcomes in the context of design education; however, the internship programme in question attempts to reconcile the learning outcomes intended by educators and expected for the interns, as well as the expectations of industry partners. This is where this programme differs from a design education studio, as the real-world challenges were presented through the expectations of industry partners. The multi-faceted challenges of tackling sustainability and the CE, and reconciling those challenges in real-world contexts within the capabilities and limitations of industry partners, are incorporated in the development of educational design briefs to facilitate a fruitful learning-by-doing process for the novice designers.

3. Methods

All of the four design departments that took part in this project adopt the practice-based learning approach in a studio environment; however, the structuring of their curriculum and content varies greatly. The interns participating in the internship programme from different institutions have different competencies or approaches to design, which affected the structure and the content of the internship programme. These institutions agreed to adopt the collaborative action research (CAR) framework in Figure 1, to reflect on and build upon the previous implementation of the programme, and to provide reflections and guidance for the subsequent implementation. Action research is a commonly used methodology in educational contexts for the continuous development of curricula and educational content, by bringing together the development and education as research (McKernan, 2008). The educators become researchers that perform continuous self-evaluation and work on the problems they identified (McKernan, 2008). In CAR, various stakeholders (e.g. lecturers, human resources, researchers) are brought together to improve pedagogical practice and contribute to educational theory (Oja and Smulyan, 1989). In the case of circular design internships, different institutions from different cultural backgrounds and pedagogical perspectives are involved and the development of the programme requires reflection of the involved researchers on the existing design education. There are concerns about action
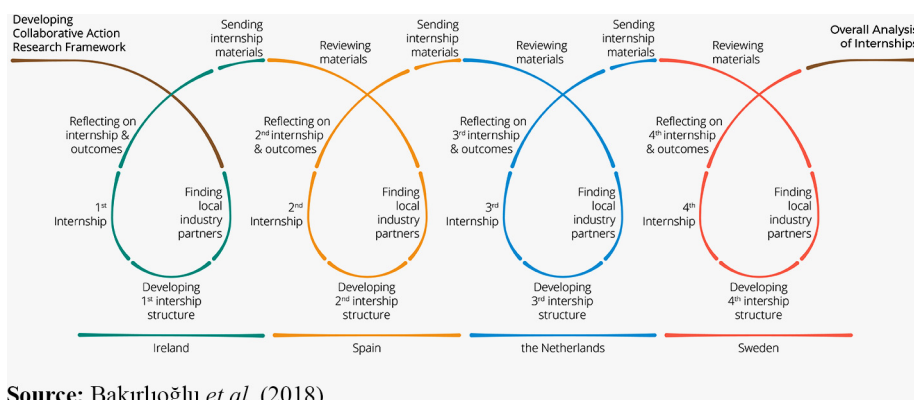

Source: Bakırlıoğlu *et al.* (2018)

research in terms of reliability and objectivity, due to its practice-based approach and reliance on self-reflection (McNiff and Whitehead, 2006). The triangulation of data collection can be adopted in action research to ensure the analysis reveals reliable and objective results (Piggot-Irvine, 2008). To ensure the reliability of the research and its outcomes, the educator/researchers' observations were analysed along with the data collected through more formalised methods (i.e. focus group sessions) and the insights of external experts regularly monitoring the process.

In total, 11 circular design briefs were developed for the circular design internship programmes in the design departments of four different institutions, in collaboration with 16 industry partners. To facilitate structured knowledge exchange among the design educators, a secure, cloud-based folder – circular design internship pack – was used to store all the relevant internship material. This folder included four separate folders for each internship and their contents were organised with subfolders as follows:

- design briefs;
- masterclasses, workshops and assignments;
- relevant visual materials;
- internship outcomes;
- feedback gathering materials; and
- an extended schedule with reflections.

For the first internship in UL, Ireland, the researcher/educators developed the first instances of design briefs with their local industry partners and scheduled focus group sessions with the interns in intervals throughout the internship. The focus groups were structured around the process and the content of the programme and aimed to reveal interns' perceptions, needs and preferences. The focus groups helped create an interactive and dynamic discussion, in comparison to interviews or surveys (Stewart and Shamdasani, 2014). The UL team then analysed these sessions and prepared an *extended schedule* – an annotated schedule with the reflections of researcher/educators, the outcomes of the focus group sessions with the interns, and suggestions for improvement on every deliverable and structured content of the programme. This procedure was adopted by the subsequent internship teams, building upon the previous material, improving it and adapting it to their approaches to design education.

In addition to enabling communication among researchers/educators from different institutions to assess and improve the programme based on the experiences gained in the previous rounds and to adapt the internship materials and design briefs of the next one accordingly, the extended schedules provided a structured way of collating and categorizing interns' feedback gathered through focus groups and researcher/educators' field notes. The results presented in this paper are based on the data collected from the field notes of the educator/researchers, student focus group sessions and the briefs developed during the internships.

The accumulated data throughout the internships were analysed from three interdependent perspectives in this study, using the expected learning outcomes of the programme to explore the brief development process for circular design. Firstly, and foremost, the changes in brief-making processes were studied according to the objectives of the programme. Secondly, the industry partner choices and the dynamics of the selection processes were studied to map the differences. This included the co-creation and communication of experiences between the educator/researchers and the industry partners. Finally, the project briefs were analysed using content analysis to assess the steps of the

brief development process for circular design projects. The digital versions of these 11 briefs can be found in the L4IDS project's Open Educational Resources (OER) Database: http://circulardesigneurope.eu/oer/circular-design-internships-design-briefs/

4. Steps of brief making for circular design

This section introduces the steps taken to develop circular design briefs in four consecutive internship programmes and how they changed in each implementation. While these are more or less the steps taken by each internship's coordinators, the implementation varied according to their approaches to design education and circular design. The reader should not regard these steps as definitive; rather, they should consider this section as an objective presentation of the steps taken and the changes made in subsequent programmes.

4.1 Reviewing the existing resources related to the circular economy

Reviewing relevant existing resources is the first step of brief preparation. These resources could be previous modules, assignments, projects or design competitions prepared with a similar purpose or about the same subject area. In the L4IDS project, the UL team reviewed OERs, courses, assignments and projects initially to prepare the first set of briefs for the first internship. An online database was developed, collating openly available resources and materials about CE and sustainability such as theories, tools and methods that can be used at different stages of the design process. The number of OERs in this database grew throughout the implementations of the internships, as all partner HEIs uploaded new material as they found. The database provided a pool of resources to review and inspire from in the brief development process.

After the first internship, each subsequent university partner initially reviewed the materials of the previous internships (i.e. their briefs, extended schedules, supervisor reports and the final projects). The aim of this was to improve the subsequent internship by reflecting on the previous experiences and to explore other educational tools and techniques for circular design.

4.2 Emphasizing the importance of systems thinking in a circular economy while defining the objectives

There are many competencies required to be conveyed to novice designers and engineers for them to tackle the challenges of sustainability and the CE (Quelhas *et al.*, 2019) such as interdisciplinary collaboration (Staniškis and Katiliute, 2016; Korkmaz, 2012), critical thinking (Thürer *et al.*, 2018; Guerra, 2017) and local awareness (Hedden *et al.*, 2017; Mintz and Tal, 2014). However, systems thinking is considered integral for transitioning towards and achieving lasting change in terms of sustainable practices (e.g. behaviours, businesses, etc.) (Soini *et al.*, 2019).

Defining specific objectives is a key step in the brief development process, which would clarify the desired outcomes to be achieved through the resulting design solutions. Depending on the overall goals of the project, these objectives could be identified with the industry partners. While the clarity of the objectives is crucial for efficient learning, the systems thinking aspect should be embedded in an equally clear way to the partners and novice designers. Although the core objectives of the internship programmes were identified as part of L4IDS (Section 1) and did not initially specify systems thinking, the authors agree with Soini *et al.* (2019) on the importance of systems thinking in educational projects on sustainability and the CE. All the actors in the system including designers and manufacturers should focus on optimising the whole system rather than the product (Ceschin and Gaziulusoy, 2016). All university partners incorporated systems thinking into

the internship process and the project-specific objectives were detailed with regard to systems thinking during the design brief preparation. For example, the UL team's aim was to define three different scales – i.e. material exploration, product-service system and local/city-scale – as starting points for each project brief and to prime the interns to explore the other scales throughout the project where necessary. On the other hand, the NHL team's aim was to specifically start the process by introducing interns to systems thinking. As the interns have never studied on a circular design project before, the idea behind this was to make it easier to understand how things are connected on a meta-level, before working with specific design aspects of such systems.

4.3 Selecting the industry partner and emphasizing the importance of collaboration for the circular economy

In a circular design project, it is important to choose industry partners who are enthusiastic about the CE and open to sustainable solutions that can inform and transform their business practices. Industry partners were chosen from different sectors to provide a diverse range of projects for the programme (Table 1).

Ease of accessibility was an important consideration while selecting industry partners, to enable regular partner meetings between the interns and the partner companies. For the internship in Ireland, not all the partners were in Limerick and the interns were provided with detailed information on transportation. In the case of the NHL internship, all the partners were local companies from the Fryslan area of The Netherlands. This not only enabled the interns to visit the industry partners regularly and be in touch with them during the programme but also allowed interns to develop sustainable solutions for the local contexts they were in. The personal networks of researchers and educators played a big role in finding contact persons to approach potential industry partners, like the companies they have collaborated with before in educational or research projects. As the focus of the internship was circularity, it was important that the companies provided a real-world problem on this topic. However, instead of directly asking for a well-formed assignment, the

University partner	Industry partner	Industry sector
University of Limerick, Ireland	Mamukko	Craft-producer company
	One-off	Furniture and interior design consultancy
	Southern Region Waste Management Office	Government institution
Universitat Politècnica de Catalunya, Catalunya	ENT	Environment and management consultancy
	UPC Recircula	A project that promotes the CE in UPC
	ZICLA	Producing solutions for cities with recycled products
NHL University of Applied Sciences, The Netherlands	House of Design	Professional design platform
	LIMM Recycling	Recycling of plastics
	Lankhorst Engineered Products	Plastic products
Linköping University, Sweden	Saiibo	Textiles-workwear
	Tricircular AB, El-Kretsen, Neptunia Invest AB, Tiranious AB, Electrolux, Stena Recycling	White goods recycling

Table 1.
List of industry partners chosen from different sectors

briefs were developed together with the industry partners. Below are the following steps that were taken to approach the industry partners:

- The first contact was made through phone or email to explain the L4IDS project, including the aim and structure of the internship. The educational backgrounds of the interns were also briefly introduced.

- Face-to-face meetings were arranged with the industry partners. The purpose of the meetings was to discuss details of the assignments and the expectations from the interns, as well as understanding their company portfolios, facilities/resources and existing collaborations.

- A draft brief was created and presented to the industry partners to initiate constructive discussions and reach a consensus.

- The industry partners were informed about the programme structure.

- The detailed project schedule was shared with the industry partners before the internship started.

Stakeholders in a CE are dependent on each other to close the material loops. Accordingly, acquiring a comprehensive understanding of their capabilities and motivations is crucial. Hence, the industry partners would need to cooperate with external stakeholders when they want to implement the outcomes of this internship. To emphasise the importance of collaboration for the CE, an initial list of the existing stakeholders in the internship area was included in each brief (Figure 2). Also, the interns were encouraged to get in touch with and/ or visit them for starters. These lists included the industry partners' existing network – i.e. they were either companies and institutions that they have collaborated or were planning to collaborate with (the inner circle of the map in Figure 2). The internship supervisors additionally included relevant, easy-to-access local stakeholders to help kickstart interns' scoping and research for the project (the outer circle of the map in Figure 2).

4.4 Detailing with a particular focus on circularity
This phase corresponds to defining the details of the brief and writing the final brief document. All the ideas developed with industry partners are refined into brief content, bringing forth the real-world challenges in implementing CE strategies. The circularity aspect was reflected as inevitable, not as an add-on feature of products and services. The programme's objectives, interns' knowledge and capabilities were other primary considerations that determined the content. Accordingly, all 11 design briefs consisted of the following elements:

- *Description of the assignment:* this starts with a one-sentence objective as a quick introduction and continues with a more multi-faceted description of several challenges identified by the industry partner. General challenges of the project were presented in this section, outlining a problem definition formulated along with the industry partners. When formulating the design briefs, it is essential to identify challenges that participants find relevant and meaningful (Sosa *et al.*, 2018). Accordingly, this section was structured according to the challenges specific to the industry partner in regard to CE.

- *Information about the industry partner:* introducing key contacts of the industry partner, their roles and contact details.

- *Potential stakeholders in the area:* collaboration within organisations and between the stakeholders is crucial for the CE as explained before. To kickstart the research

Figure 2.
Potential stakeholders in the area were identified and listed/mapped on the brief to emphasise the importance of collaboration on a CE and encourage students to visit them

phase and meetings, potential stakeholders in the area were identified and listed/mapped on the brief. An example of the stakeholder map that the UL team prepared is shown in Figure 2.

- *Deliverables (expected outcomes):* the deliverables were identified based on the problems or opportunities that the project intends to solve or satisfy. What was expected from the interns and how this would be presented were explained in the brief. The common deliverables for each team included a process book, a final presentation and a prototype.

- *Schedule:* detailed schedules outlining all the deadlines, resources, deliverables, scheduled meetings and holidays were prepared. An example of the schedule that the UL team prepared can be seen in Figure 3. The schedule also includes the masterclasses and workshops that were planned according to the possible needs of interns arising at different stages of the internship. The guest lecturers were identified on the brief and the topic of their masterclasses. There were sustainability-specific masterclasses and general upskilling-oriented ones. Besides, for every stage of the process, OERs they could use were identified.

Figure 3.
Detailed schedule
outlining all the
deadlines, resources,
deliverables,
scheduled meetings
and holidays were
prepared

- *Practical information about the country and the city:* in addition to the project-related information, basic information related to the country and the city was provided to help interns find their way around.

4.5 Communicating expectations

Communicating expectations in a clear way is key for dealing with the aspirations of the industry partners. What the clients should expect from this project was explained in detail when the internship supervisors initially approached them, discussing the overall objectives of the internship programme, the duration of the internship, the scope of educational projects and the potential deliverables. Some of the industry partners were not familiar with product design education and the studio environment. As they were informed about the nature of an educational project, most of them did not have out-of-context expectations. However, it should also be kept in mind that the industry partners did not financially support the project, so they were different from real-world clients.

During the internships, the students' autonomy was fostered by offering and implementing creative approaches outside the conventional frameworks of the institutions. This was operationalised through facilitating experimentation in a collaborative environment. Design thinking, which can be seen as a tool for experimenting, opens up the path towards a hands-on, iterative and user- and problem-based learning culture (Micheli *et al.*, 2019). However, the iterative, discursive and process-oriented nature of such project-based learning practices requires alignment with industry partners on multiple layers to avoid discouraging disagreements between parties. One example of such disagreement was seen at the beginning of the NHL internship, as the importance of the systems approach was

not immediately clear to one of the industry partners. They were interested in novel product concepts rather than exploring the implications of these concepts to society, environment or physical space. As the project progressed; however, they were satisfied with the quality and detail of the outcome and acknowledged the importance of the systems thinking approach. The expectations of the industry partners also affected the roles they adopted throughout the internship; while some regarded the intern teams as collaborators, others positioned themselves as mentors. Some of these roles were discussed in detail through interviews conducted with the industry partners of the first internship one year after its completion (Bakırlıoğlu and McMahon, 2021).

5. Design briefs throughout the four consecutive internships

The design briefs changed throughout the consecutive internships conforming to the education programmes in the four different universities, as presented in Table 2. The previous internships had been the main reference during the brief development processes. Extended schedules were primarily used to transfer interns' feedback and supervisors' experiences. Additionally, supervisors for each internship reviewed other materials of previous internships (e.g. the briefs, supervisor reports, the final projects, etc.) and held online meetings with the previous internships' supervisors.

An extended schedule is an annotated version of the actual schedule of the briefs. In addition to the date and the title of the activities, it explains the content of each activity and the supervisors' reflections in detail. A critical approach was taken towards each project to be able to identify potential areas for improvement. Although successful parts and failures were expressed openly in extended schedules, these remarks mostly resulted in small-scale improvements, rather than structural change. The briefs were altered mostly to adapt to the structural differences of institutions' curricula and approaches to design teaching. For example, the UL and UPC teams prepared the briefs based on the four-phase product development process. Including research, ideation, detailing and prototyping phases, this programme structure suited well with their approach to design education and their student profile. The NHL and LiU teams, on the other hand, preferred to adopt the internship schedule to their programme structures. The NHL team used the multi-level design model for open innovation. According to this structure, the interns went through three phases of project development representing the three bottom levels in the multi-level design model (Joore and Brezet, 2015), including the socio-technical system, product-service system and product-technology system. The LiU team adapted the internship schedule to its gate structure and aligned the programme with the third-year studio course. The LiU interns were supposed to take the third-year design studio course and continue with the same project as their bachelor's degree thesis for the fourth year. Gate structure consists of four gates (i.e. steps), namely, feasibility, planning, concept review and completion. Feasibility was the initial stage where interns conducted research about the given topic and determined the conditions for implementing the project. Additionally, they identified the aim of the project, target audience and stakeholders. Considering these conditions, interns developed a project plan in the planning stage. This plan described how the project was organised, how the results were to be submitted and how potential risks were to be managed. Then, interns generated ideas, prototyped and tested them to develop three design concepts out of these ideas in the concept review stage. At the completion stage, interns created the final prototypes, wrote the project reports, prepared their presentations and posters to communicate the results of the project.

All four internship programmes also used similar learning mediums. For the first internship, the UL team used one-day masterclasses, workshops and field visits as

University partner	Internship duration	Programme structure	Scales of design	Assignments' field
University of Limerick, Ireland	Three months 01.09.2017– 28.10.2017	Four phase product development: 1. Research 2. Ideation 3. Detailing 4. Prototyping Masterclasses, workshops and field visits	Each project started with one of the three scales of design 1. Materials 2. Products/services 3. Whole systems	Reclaimed material exploration Retrofitting Food waste management
Universitat Politècnica de Catalunya, Catalunya	Four months 09.02.2018– 20.06.2018	One month of lectures prior to the internship Four phase product development: 1. Research 2. Ideation 3. Detailing 4. Prototyping Masterclasses, workshops and field visits	Each project started with one of the three scales of design 1. Materials 2. Products/services 3. Whole systems	Material innovation for urban application Selective separation of waste Municipal waste management
NHL University of Applied Sciences, The Netherlands	Three months 03.09.2018–23.11.2018	Triple helix of open innovation, three-level design model: 1. Socio-technical 2. Product-service 3. Product-technology Masterclasses, workshops and field visits	System perspective: each project focusses on all three scales of design 1. Product level 2. Strategy level 3. Service level	Rainwater harvesting and application Bioplastic use and Sustainable user Experience Recycled plastic exploration
Linköping University, Sweden	Three months 04.02.2019– 26.04.2019	Gate structure: 1. Feasibility study 2. Planning 3. Concept review 4. Completion Masterclasses, workshops and field visits	System perspective: each project focusses on all three scales of design 1. Materials 2. Products/services 3. Whole systems	Circular system for white goods and appliances Textile circularity

Table 2.
Differences between the internship structures conforming to the four different education programmes

structured learning mediums. Other than that, self-learning was facilitated through well-structured assignments and OERs that the interns could easily access online. The UPC internship started two months after the UL internship's completion, according to the L4IDS project calendar. While the UL programme had a duration of three months, the UPC programme was conducted for four months, as the interns were offered the opportunity to participate in introductory courses with other local and exchange students. The remaining two internships also used masterclasses, workshops and field visits as learning mediums like UL.

As mentioned before, these programmes were structured with a self-learning approach for building competencies and upskilling and it was important to embed this aspect in the design brief as well. All 11 design briefs presented a balance among the real-world challenges faced by industry partners and possible approaches to sustainability and CE in an attempt to bring this forward. This was reflected in the programme schedules in the form of assignments to explore different design approaches or to conduct a desk study on finding tools and techniques to adopt throughout the design process. Considering the variety of the projects and the intended CE strategy to facilitate, the framing of the briefs needed to present a fuzzy end-goal in line with the industry partners' expectations while enabling the exploration of various designs for sustainability approaches.

During the internships in UL and UPC, the interns identified certain areas where they needed to upskill themselves through more structured learning sessions for sustainability-related competencies (e.g. on analyzing the data they gathered through their field studies) and general design competencies (e.g. on design communication). These instances were translated into an even more flexible schedule for the NHL internship. This was also related to the curricula of NHL, as it specialises in multi-disciplinary courses where students from different departments come together to work on a design assignment. Therefore, the initial strategy was to understand the interns' level of knowledge and adapt certain parts of the schedule based on their needs throughout the programme. Apart from a certain number of courses that aimed at providing a holistic understanding of circularity, design process and prototyping, the internship followed a flexible structure where guest lecturers were invited to work with the interns. This difference influenced how the briefs for the NHL internship were developed.

To diversify the kind of projects undertaken and maximise the potential of the internship, the UL and UPC teams prepared each brief for one of the three scales of design (i.e. materials, products/services and whole systems). The NHL team structured the programme to address not only the product level but also the service and strategy levels and the briefs were developed with larger scopes so that the focus of the projects shifted and narrowed down to the product level throughout the project. The NHL team also focussed on the societal applicability of all three projects and challenged the interns to understand and explain the societal implications of their designs. Finally, the LiU team prepared the project briefs based on the three scales of design like UL and UPC; however, they emphasised realising all three levels in each assignment with a systems perspective.

Other than the differences between the structures of the programmes, there were similarities in the ways the briefs were presented. For example, the approach UL adopted for presenting a set of challenges provided by the industry partners was useful to kick-start the design process and this way of framing the design brief was adopted in the consecutive internships as well. On another note, all the design briefs included pre-scheduled meetings between industry partners and the intern teams to ensure immersion and a certain level of exposure and encouraged the interns to schedule further meetings as required throughout their process. This approach offered some flexibility for the industry partners and the interns to find and adopt ways of collaboration suited to them.

6. Discussions

Equipping novice designers for their future professional lives and empowering them with the necessary skills, knowledge and critical perspective to adopt inherently sustainable and circular professional design practices were the purposes of the circular design internships. This task was multi-faceted, from finding the right collaborating industry partners and developing the right educational materials to more mundane preparations such as logistics and accommodation. However, our authors claim that the design brief, as the first written document introduced to the interns, was one of the most crucial elements of these internships.

As explained in the *background* section, there are resources for creating professional design briefs for sustainability and the CE, yet not many resources exist for developing educational ones. Educational design briefs are different from professional briefs because educational ones not only convey certain expectations from final design outcomes but also communicate underlying learning outcomes of the whole process. Hence, through the reflections of the authors, internship supervisors, interns and industry partners, the value of this paper lies in presenting the key characteristics of 11 educational circular design briefs developed throughout the four implementations of the circular design internship programme.

The foremost characteristic of these briefs is how concerns about sustainability and the CE are woven into the objectives of the design projects. These objectives were clearly stated and emphasised throughout the project briefs and circularity was an inevitable aspect of the projects. As was the case for the four internships presented in this paper, it is crucial to collaborate with companies and/or institutions already implementing sustainable business practices or willing to take on environmental challenges and adopt such practices. The impact of this is two-fold:

(1) industry partners bring real-life sustainability challenges they (want to) tackle and engage with the project and interns' progress more effectively, and

(2) interns experience more grounded, multi-faceted, real-life challenges for sustainability and the CE, preparing them for their future design practice in which they will hopefully continue to use the critical lens they acquired.

In this regard, it was inspiring for our authors to see the interns seeking positions and postgraduate programmes relevant to design for sustainability and the CE. As for industry partners and their collaboration with higher education institutes, the internship programmes provided an opportunity to explore ways of adopting alternative business practices for sustainability and the CE. A follow-up study with the collaborating industry partners revealed the impact of this programme on their business practices. The results of this study are beyond the scope of this paper and are discussed elsewhere (Bakırlıoğlu and McMahon, 2021).

Systems thinking is an important aspect in developing circular solutions, as it enables designers to account for various aspects beyond their direct influence and to develop solutions that operate amongst these aspects and initiate change (Soini *et al.*, 2019; Jones, 2014; Pourdehnad *et al.*, 2011). For novice designers, this might sound too advanced or complex to undertake; however, with the right guidance, they can acquire skills, knowledge and supporting design tools and methods to adopt this perspective and gain experience in using them in an educational context. This guidance should be embedded in the educational design brief, in which systems thinking should be emphasised and demonstrated through the real-life challenges of the industry partners. Furthermore, understanding the potential impact and the limitations of their design outcomes is another important aspect for novice designers. Hence, the importance of collaboration should also be emphasised and demonstrated throughout the design brief to ensure that they actively assess their design outcomes and their contexts (e.g. capabilities and motivations of industry partners and other stakeholders).

Finally, keeping the problem definitions broad was useful to initiate self-learning throughout the internship. This enabled not only a thorough scoping of the problem and its context but also a critical assessment of design ideas. As a result, the interns developed a wide range of ideas for each brief, critically assessing those ideas at every stage, along with the industry partners and other stakeholders where applicable.

7. Conclusion

Transitioning towards CE requires multi-disciplinary collaboration among a wide range of stakeholders, including industry and HEIs and addressing various levels of design intervention (i.e. products, services and systems). Design and engineering education have been tackling these problems for a while, exploring ways of integrating sustainability and CE into their curricula; however, this paper argues that conducting an educational circular design project would be more effective when design briefs are considered as integral and they are developed with CE aspects embedded. Furthermore, novice designers would be better equipped for the real-world challenges of designing for the CE, when industry partners are engaged in the brief development process and contribute with such real-world challenges in terms of their capabilities and limitations.

The brief development processes of 11 circular design internship projects were examined in this study and five steps of brief making for circular design were presented. While creating educational design briefs to achieve circular design solutions that tackle real-life challenges of the industry is a complex task and these challenges cannot be solved in the context of a single research project; the educational design briefs presented here aimed to initiate and facilitate a new approach to collaboration between HEIs and industry partners in the context of an internship programme. In this context, it is argued that educational circular design briefs should communicate not only the expected learning outcomes but also the expectations of the industry partners in a clear manner, and their development should bring forward circularity, systems thinking and the importance of collaboration in CE as inherent aspects. The five steps presented here can inspire both design educators and designers to develop circular design briefs to better frame their circular design processes.

The research outlined here can be regarded as a basis for further research on educational circular design briefs. The researchers/educators did not develop these briefs independently; rather, they reflected on and built upon each other's brief development processes. There were noteworthy similarities between the brief development processes of the four different universities, providing valuable insights for other educators interested in incorporating CE into educational projects in collaboration with industry partners. However, we also acknowledge that four iterations of the brief development process may not be enough to draw general conclusions and we encourage future research on the circular design brief development processes by researchers/educators in the field to identify potential gaps and to further improve on this study's outcomes.

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