18th European Roundtable on Sustainable Consumption and Production Conference (ERSCP 2017)

KATCH_e: Introducing circular economy into higher-education design curricula

Overview of the training needs, state of the art

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Abstract

Circular economy (CE) claims to overcome the current production and consumption models based on a so-called “linear economy” or “take, make and dispose”. The transition to a CE, where the value of products, materials and resources is maintained in the economy for as long as possible and, the generation of waste is minimized, is an essential to a sustainable, low carbon, resource efficient and competitive economy.

Designers and developers need to cooperate to co-create and produce “utility” in which the possible services and performance, safety, collection, recycling, littering and end-of-life possibilities are taken into account, like cascading, refurbishing, reuse or biodegradation, and replacing products with services (IMSA, 2013). However, the current knowledge base to turn theory into practice is fragmented and studies point to the need of adequate skills and education for CE (EU, 2016), and that the principles of a CE should become an integral part of education programs.

KATCH_e is a knowledge alliance between Higher Education, companies and research centers to promote the building of competences in the field of product-service development for the circular economy and sustainability in the construction and furniture sectors. This work presents an analysis of the training and competence needs and gaps on topics related to circular economy.

This analysis has been complemented with interviews with multidisciplinary key stakeholders in order to identify the needs and barriers in this transition process within the target sectors and in the higher educational field. In addition, a workshop on “Discussion and prioritization of CE needs in the construction and furniture sectors” has been organized. This paper presents the key findings of the review and recommendations for future developments and research.

KEYWORDS

Circular Economy, design, product-service-system, business model, training needs, implementation barriers, learning recommendations

1. INTRODUCTION

The European Union economy is largely linear (take – make – use – dispose) by design, resulting in avoidable environmental and human health impacts (EEA, 2017). In 2012, the average European used 16 tonnes of materials. Sixty percent of discarded materials were either landfilled or incinerated, while only 40 percent were recycled or reused as materials. In value terms, Europe lost 95 percent of the material and energy value, while material recycling and waste based energy recovery captured only 5 percent of the original raw material value (Ellen MacArthur Foundation & McKinsey Centre for Business and Environment, 2015).

Three billion new consumers entering the market worldwide in the next 20 or 30 years will put an enormous pressure on our shared resources based if we continue along the linear way. Under 'business as usual', annual global material extraction has been projected to reach 183 billion tonnes by 2050 (Schandl et al., 2015, as quoted in UNEP, 2016), more than double the amount in 2015 (UNEP, 2016).

The European Commission is engaged in fostering the transition from the largely current linear to a circular model where the value of products, materials and resources is maintained in the economy for as long as possible and the generation of waste is minimized or avoided. In 2015 the roadmap: "Closing the loop – An EU action plan for the circular economy" (COM (2015) 614 final) was approved, which sets out initiatives including ecodesign. In January 2017, the Commission published a report (COM (2017) 33 final), which gives an overview of the actions already delivered in the implementation of the mentioned plan since its adoption, and introduces key deliverables for 2017. In the European Council conclusions regarding the EU Action Plan for the circular economy, the European Commission is called on to tailor the Ecodesign Directive on products to the relevant criteria for the circular economy before 2020 (Council of the EU, 2016). This regulation pertains to aspects such as product lifespan, reuse, repairability, renovation, and recyclability.

In this sense, design is responsible, to a large extent, for defining the circularity potential of products (Bocken et al, 2016). Nowadays, designers are challenged by new environmental, social and economic needs and must adopt a holistic approach to problem solving, since 70-80% of the environmental impacts are determined in the design phase.

Despite such challenges (and opportunities), knowledge of sustainable design (which includes design for CE) is not mandatory within the profession (Andrews, 2015). The current knowledge base to turn theory into practice is fragmented and studies point out to the need of adequate skills and education for CE (EC, 2016), and that the principles of CE should become an integral part of education programs. As recognized in the EU Action Plan, the transition to a circular economy will require a qualified workforce with specific and sometimes new skills. If the right skills at all levels are to be developed, they will have to be espoused by the education and training systems (EC, 2015).

Within this context, the KATCH_e project was proposed, whose rationale is a knowledge alliance among higher education institutions, companies and research centers to promote the building of competences in the field of product-service development for the CE and sustainability in the construction and furniture sectors.

One of the first steps of the project has been to carry out a detailed analysis of the state of the art of the training and competence needs and gaps on content topics related to the implementation of CE at product-service and production levels, related to the two sectors. This in-depth review, which will be the baseline to develop the KATCH_e results, was complemented with interviews with multidisciplinary key stakeholders in the four participating countries (Portugal, Spain, Austria and Denmark)). On top of that, a workshop on *"Discussion and prioritization of CE needs in the construction and furniture sectors"* was organized in each of the four partner countries.

The paper presents the key findings of the interviews, workshop to draw the challenges and recommendations for KATCH_e project.

2. OBJECTIVES AND SCOPE

The objectives of the interviews and the workshops were diverse. Firstly, to get a good grasp of how the main stakeholder groups understand the concept of a CE, the related practical drivers and barriers – and especially the type of competences to be enhanced through the university curricula to support the transition towards circularity.

Secondly, since the KATCH_e training materials should encourage cross-curricular and multidisciplinary learning, the interviews served as a platform for discussing the missing links and needs to be included to be able to develop new educational focus through a cross-sectoral and problem-based learning approach, involving university students, professors, researchers, companies and other stakeholders to integrate CE thinking in design education.

Finally, both the interviews and the workshops supported the buildup of the national stakeholder network that will be involved in developing, testing and implementing the training materials. This co-working process is an important element in fostering new learning approaches among universities, business, knowledge centers and other relevant stakeholders.

3. METHODOLOGY

To detect the weak points (needs) and main barriers in this transition process within the target sectors and in the higher educational field (Universities), several activities were carried out, such as different types of interviews for the respective target groups on which the KATCH_e project is focused. Finally, and to complete this information, a workshop was held in each of the four partner countries, with the same objectives.

The target groups established were Business, Higher Education and Knowledge Centers, but in each of the activities performed (interviews and workshops) this profile division was customized, allowing a better fit of the activities in order to obtain a more relevant and accurate results. People within the furniture or construction sectors profiles were selected for the interviews and workshop making them fit with KATCH_e purpose.

Different interview scripts considering the interviewees profiles were developed. The different profiles were grouped as follows: T01: Students; T02: Professors; T03: Researchers; T04: Business people; T05: Associations; T06: Public authorities and T07: NGO's. A total of 49 interviews were performed in the following way among the participating countries and target groups (see Table 1).

Table 1 Number of interviews performed

	Portugal	Austria	Denmark	Spain	TOTAL by target
T01: Students	-	1	-	4	5
T02: Professors	1	7	2	1	11
T03: Researchers	2	1	2	3	8
T04: Business people	4	3	2	3	12
T05: Associations	1	1	1	3	6
T06: Public authorities	2	-	1	2	5
T07: NGO's	1	-	-	1	2
TOTAL by country	11	13	8	17	49

Once all the interviews were done (mainly face to face, but also by phone, mail in particular cases), all the results obtained were analyzed and summarized in order to obtain the required conclusions. The analysis allowed the identification of the different understandings of the CE concept, the degree of implementation of CE-issues in university education, existing training needs, how the CE is being implemented in the business world, the main drivers of the CE, the demand

and existing barriers, how the CE is being promoted and the role of public authorities in the implementation of the CE. The main perceptions extracted by the interviewer were also collected.

The workshops took place in June 2017 in all four countries, with a total of 100 participants from Higher education, Business community and Knowledge centers. The participants were selected and invited personally according with the needs and objectives of the project.

In the workshops, CE-related issues were discussed by the participants. In most of the sessions, guided questions were answered, organizing the participants into multidisciplinary groups, and a general discussion was also held, either at the beginning of the session or after the team work session. In table 2, a summary of the content for the workshops in each country is shown.

Table 2 Content of workshops hold in each country

Portugal	*The Portuguese workshop raised the questions "What are the priority challenges, products and services for design for the CE in the construction and furniture sectors?" and "What are the needs in terms of skills and training for the design and development teams?"*
Austria	The overall idea was to discuss the current status of CE-related initiatives (research projects, business practices) and potentials/barriers for implementing CE in the furniture and the construction sectors and reflect on the need for competences.
Denmark	In Denmark, the theme was "Circular business models in the furniture sector, and the related need for competences". Different types of circular business models related to the furniture sector and the challenges related to design, business development and sustainability were presented and discussed.
Spain	In Spain, the workshop aimed at discussing CE, the potentials and barriers for the transition towards circularity in Spanish companies and the related need for competences. On this case the workshop did not concentrate on furniture and construction sectors, it was open.

The sessions also focused on expanding the project's stakeholder networks. The participants were potential members of the network or people who were already part of it. In the sessions, the operation of the network and the advantages of being part of it was explained, and collaboration opportunities were also discussed.

Half-day workshops took place in all countries and, although each partner did it in its own way, in general the schedule for the workshops was as follows:

- KATCH_e Project introduction
- Circular Economy explanation
- Creative Session
- Common discussion
- Stakeholders network explanation

4. RESULTS

The answers of the 49 interviews and the main findings from the workshops were classified in five main topics and the analysis was done considering the different profiles and nationalities, highlighting the main differences per profile and country when it seems significant.

4.1. Understanding and perceptions of Circular Economy

Those who are familiar with the concept of a CE referred to the model from Ellen MacArthur Foundation, either directly, or indirectly by mentioning the circles. They defined the "" novelty of a CE by its strong focus on the economy and creating new types of business value.

Those who are less familiar with the CE concept typically related it to something about recycling but also added many other topics, depending on their own background and experiences. Some of the participants had difficulties in seeing what the innovations a CE implies compared to related topics like sustainability, resource efficiency, recycling, etc.

For example, students seem to have a simpler vision, putting the focus on terms related to resource efficiency while the other target groups show more complex and complete perspectives, including economic and social aspects to their answers.

4.2. CE implementation

Within the higher education curriculums, CE topics are included in subjects related to sustainability. Students thought that training in CE is insufficient related to its importance and future projection and, professors agreed with this answer, justifying that the current level of knowledge is quite low and it is necessary to delve into it more deeply and introduce it in the curricula in a more systematic way.

In companies, it is possible to see certain similarity between some partner countries, some of them (Spanish and Portuguese companies) are currently implementing strategies related to the CE in isolation but these are not implemented systematically, others (Austrian and Danish companies) showed through their answers a greater focus on CE, and are even including strategies at a business level.

4.3. CE promoting actions

The different target groups promote CE according to their interests and capacities to their stakeholders through different channels, for instance, professors help to promote CE in the design degree through participation in different projects, seminars, etc.; Associations, in general, are proactive through the participation in committees, networks, working groups, platforms among others. Their initiatives are focused on isolated strategies such as recycling, industrial symbiosis, funding schemes, etc. and public authorities support and promote CE in each country through the development of specific legislation, funding schemes, tax incentives, dissemination activities, etc.

There are some interesting actions carried out in the different KATCH_e countries, for instance, Denmark recently launched a report including 27 recommendations, Portugal supports CE in the state budget through economic incentives for ecodesign projects, a funding program for CE (FITEC), the Action plan for CE in Portugal (under development) and other initiatives such as the Environmental education strategy which includes a full chapter on CE and the national agenda on research and innovation for CE

4.4. CE: Demands and needs

Demands and needs differ completely depending on the target group considered and even for the same target group there are differences, probably due to cultural aspects and background. Following main findings for each target group are presented:

Professors need more institutional support from University and from public authorities to promote change in curricula, more resources (time, examples, material…) to create new content and learning approaches and financial support from government/industry as a teaser to adapt educational contend and methods.

Students showed opposite points of view, probably due to cultural background. In any case, it has been identified that students perceive an increasing /incipient demand from companies regarding CE actions in order to become more competitive and environmental friendly due to the scarcity of resources.

Besides this, from a business perspective, students need basic business understanding – also as they need to understand the traditional linear practices. But they ALSO need to understand how and where a circular approach is different and how to create adequate and sustainable solutions. The challenge is, that these solutions will need to work both in a traditional economic and social setting, and pave the way for more circular approaches. Students should be able to reflect, not just do business-as-usual, and they should be creative in their problem-solving.

Examples of these training needs for students that could be applicable as well for companies or stakeholders interested in gaining knowledge on CE are:

- Systems thinking,
- How to deal with dilemmas and complexity
- Basic concepts related to economic and market development to be able to develop or support new business models.
- Cooperation and knowledge sharing across disciplines and professions – the training materials should facilitate learning in multi-professional teams, internally in companies and externally,
- Redesigning mindset
- How to make new, circular solutions simple and attractive for the users. Design new identities. developing the inner circles and on resource cascading,
- Designing network instead of designing “stuff”,
- Integration into value chains, value creation,
- Systematic assessment of materials, their functionality and impacts in a life cycle perspective
- Understanding quality – creation, maintaining, developing, avoid degradation,

Researchers demand clear objectives from public authorities. They need to gain more knowledge (practical orientation) about what a CE implies such as for example new business models, more information about LCA, design for sustainability, social aspects, quantification of resources, construction indicators, among others.

Concerning **business people**, it seems that product developers do not have specific knowledge on CE and related issues but, they would like to improve their knowledge in new business models, markets and industrial symbiosis, among others. However, they considered that to succeed in this matter, they should have the opportunity to co-create new solutions and having cross-disciplinary competences. Regarding the demand from clients, business people, in general, do not see any specific demand in CE. **Business associations** demand information about CE but not training..

Regarding **public authorities**, all countries are adapting the European policies to National Strategies and Action Plans. Additionally, several projects in this line are being carried out in the different countries.

Finally, **NGO’**s see the necessity to integrate CE and highlight its social benefits in all types of curricula, particularly for designers, but also for business administrators, logistic managers, political scientists, etc.

Other horizontal needs or demands identified during the interviews and workshop are:

- Financial support for investments, new business models, processes, etc.; for example: the lack of venture capital investors as a main gap;
- Practical examples of successful application of the CE principles in practice in the given sectors;
- Support material for the development of accustomed strategies and implementation in own field
- Policies and concerted actions between the different ministries. In particular, the ministries for environmental and economic issues working together to implement national CE plans.

4.4. CE: Drivers in present and future

Political commitment is the most mentioned driver, either through legal requirements or tax incentives. Other relevant drivers are market development, resource scarcity and social presure. The education of the next generations will play a relevant role in the adoption of CE principles in the future.

4.5. Barriers in implementing CE

Traditions and culture among politicians, authorities, companies, educational institutions are regarded as a main barrier since the social structures and infrastructures are used to a linear practice.

From the point of view of the **professors** interviewed, the main barriers to implement CE in University studies are:

- Lack of University commitment as organization.
- Lack of time and motivation, to get updated in this subject,
- Difficulty in introducing CE contents in a sector specific training curricula owe to the multidisciplinary requirements of CE (design, materials, management, marketing, business models, value chains, engineering, etc.).
- The interdisciplinary character of CE means that an own Chair for CE may not be reasonable which can slow down the implementation at University level.

The main barriers for **companies** can be summarized as follows:

- Lack of awareness for global resource depletion, scarcity and negative environmental, economic and social effects
- Lack of knowledge, skills and competences to adapt business concepts and implement CE strategies although a lot of information is available.
- Legal barriers, such as the problem of waste reclassification (i.e: waste only can be reclassified legally as sub-product if a market has been identified for it previously). In addition, purchasing secondary raw materials raises guarantee of performance/quality issues and manufacturers avoid it.
- Stuck in daily business, inability to adapt to development and changes, moreover CE is not recognized as a success factor yet
- Low demand from market, low recognition and acceptance of the consumers to CE practices and products.
- Resistance accepting new products, services or businesses models, issues related with the confidentiality aspects (sharing of data, information, etc.) in the internal business policies.

5. CONCLUSIONS

Considering the previous results, this section presents the main challenges for implementing CE within companies and universities and the main recommendations to take into account to develop the KATCH_e training materials. Relevant challenges and recommendations are listed below, this list should be considered as a non-prioritized list.

5.1. Challenges

Challenges for companies:

- **Keeping up with developments and trends** constantly and develop strategies how to adjust the own portfolio to the demands of the market, environment and legal requirements and anticipate future developments **under the CE perspective and still being profitable**.

- **Meeting customer demands** and work with or influence consumer view for new products or features within **CE strategies**.
- **Shift from production** (=sell physical products periodically) **to selling services** (or combinations). Generating value from services poses economic changes.
- **Transition from sectorial specialization to objectives and services**, therefore, trying to survive in the transition from linear towards circular economy.

Challenges for Universities:

- **Keeping up with developments and trends** constantly.
- **Think and act in an interdisciplinary manner**, exchange and communicate with other disciplines, faculties, universities.
- Act as a service **provider** for companies **with qualifying future CE experts.**
- **Co-create** and influence industrial/business developments.
- **Develop** innovative strategies and **ways to implement CE**.
- **Exchange with companies** in order to support the implementation of CE strategies.

5.2. Recommendations for KATCH-e content

According to training needs for students and for companies or stakeholders interested in gaining knowledge on CE are, several recommendations for KATCH_e were defined:

Regarding to the **understanding CE with with social developments and trends,** KATC_e should:

- Contribute to a better understanding of the CE concept and related issues, i.e. its principles and implications of the new paradigm, which means opposition when it comes to implementing new strategies and solutions to implement CE.
- Promote the CE with positive messages and clear information for the final user. This is, to get CE demanded because society realizes that it is convenient for all of us.

Regarding to the **understanding CE with related policies and trends,** KATCH_e should**:**

- Contribute for a better understanding of the CE concept and related issues, i.e. its principles and implications of the new paradigm, which means opposition when it comes to implementing new strategies and solutions to implement CE.
- Promote the CE with positive messages and clear information for the final user. This is, to get CE demanded because society realizes that it is convenient for all of us.
- To discuss and show the companies and students how EU policies and regulations on CE can be articulated with global competition – how to make companies more competitive and simultaneously make the economy more circular.
- Take into account the National Agenda for Research and Innovation on CE and its areas of knowledge that need to be explored.
- Identify the possible existing fiscal and financial incentives that in some way could support the CE initiatives and/or the creation of new and specific for the CE in companies.

Concerning the **combination of design and business models solutions,** KATCH_e should:

- Include in the training material **case studies and practical examples**, with a heightened focus to generate business models in circular economy.
- Include information about this **new business models** and the capability to adapt the theory to the type of companies (sizes and position).
- Introduce in the training the thematic of **value chains analysis**, rather than (or complementary to) a sectoral approach in the project.

About the **combination of design and CE solution,**

- Include in the project **training in materials and substitute materials**, which designers lack.
- Include not only product design, but also **service design** in the project Clarify the possibilities of integrating **CE principles with other existent strategies** (such as labelling, environmental, quality, energy, H&S, and other management systems, innovation tools, etc.) already tested and implemented in companies.

In relation to the **learning approach: The Knowledge Alliance perspective in the two sectors need,** KATCH_e should:

- Promote a **multidisciplinary approach** to teach, implement and test CE principles and also, **bring different stakeholders to the discussion** (e.g. companies, universities, public sector, NGO's etc.).
- Validate the in-classroom training through **case studies developed in partnership** between universities, companies and other entities.
- Include in the project **visits to companies** for students to structure knowledge based on practical case studies.
- Compile the most relevant information on CE and adapt it according to the needs and demands identified during the situation analysis. Moreover, KATCH_e should act as a **filter of relevant resources for the target sectors**.
- Develop simple and easy tools and methods to perform a self-checking in companies.

As one of the outputs from the KATCH_e project is a massive open online course (MOOC), some questions were raised during interviews regarding its content and learning approach. In this sense, most of the interviewees expressed a personal interest to participate in it. Some feedbacks to consider specifically in its development are:

- Include **basic understanding of CE and how it differs from**, or adds to, related concepts like **sustainable development, Product-Service Systems, re-design and design for re-use, among others**.
- Support didactical content with **LOTS of practical examples** on how-to-do.
- Include **techniques for assessing impacts and effects**, both economic, environmental and social.
- Explain **new ways of cooperating from a multi-disciplinary approach**, how to building a network.
- Include **contents related to materials and their impacts** from a life cycle perspective.

ACKNOWLEDGEMENT

KATCH_e project, with reference 575793-EPP-1-2016-PT-EPPKA2-KA is co-funded by the ERASMUS+ Programme of Knowledge Alliances supported by the European Commission. The authors of this paper also would like to extend their gratitude and assistance to all partners involved in KATCH_e project.

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