Competences of the professional of the future in the circular economy: Evidence from the case of Limburg, Belgium

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Abstract

A sufficient amount of professionals (quantity) with the right competences (quality) is needed to make the transition to a circular economy happen. An important task for higher education institutions (HEIs) is to (re)train professionals towards the competences required by employers. This study determines the relevant competences within the local aspiration of Limburg (Flanders, Belgium) becoming a circular economy and educating for sustainable development. First, roadmaps, literature and vacancies were analyzed to make an inventory of possible competences. Second, a focus group was organized with representatives of companies and company federations to make a first selection of the most relevant competences for the circular economy. Third, companies were asked to rank technical, valorization and transversal competences using best-worst scaling (BWS). The results show that transversal competences and valorization competences are equally important as technical competences for a circular economy. This study contributes to a better harmony between educational programmes of higher education institutions (HEIs) and the competence needs of businesses within the context of the circular economy.

Keywords

Circular Economy – Competence – Higher education - Best-Worst Scaling

1. Introduction

The concept of the circular economy becomes more and more popular within the field of academia (Merli et al., 2018), industry and government (Geissdoerfer et al., 2017). In the field of business, SMEs and large multinationals have increasing interest for the circular economy due to its anticipated financial, social and environmental benefits (Lewandowski, 2016). The topic is covered by several public authorities within Europe (Prieto-Sandoval et al., 2018) and beyond. Examples of how this is done are the *circular economy package* (European commission, 2019) or Agenda 2030 (Silva et al., 2018).

Multiple definitions of the concept circular economy exist. It emanates from the principles of eco-efficiency and cradle-to-cradle which have the aim to reduce the unintended negative consequences of production and consumption processes (Braungart, 2006). The most commonly used definition nowadays is formulated by the Ellen MacArthur foundation. The Ellen MacArthur Foundation describes the circular economy as an economy that aims to redefine growth by focusing on society-wide benefits. The goal of a circular economy is to decouple economic activity from consumption of finite resources and to design out waste together with a transition to renewable energy resources (Ellen MacAthur Foundation, 2017). Kirchherr et al. (2017) tried to define the conceptual boundaries of the circular economy and investigated 114 definitions of the circular economy. After analyzing the definitions, they described the circular economy as "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes."

Despite the increasing interest in different fields for a circular economy, some barriers slow down the envisioned transition. Vermunt et al. (2019), for example, explore the internal and external barriers encountered by firms when implementing specific circular business models like product-as-a-service model, product life extension, resource recovery model and circular supplies. Their results show that barriers differ for each business model. Other studies like that of Kumar et al. (2019) or Sharma et al. (2018), identify sectoral barriers for the transition to a circular economy. Kumar et al. (2019) identified lack of awareness, policy support, financial support mechanisms or tax incentives and high initial investment cost, among other as specific barriers in the manufacturing sector. Ritzén and Sandström (2017) focused more on barriers for implementation of the circular economy (CE) at the organizational level and classified the barriers in the categories financial, structural, operational, attitudinal and technological. One of the organizational barriers is "the shallow understanding of and insight into CE and a knowledge level that is too low, which in turn prohibits an evolutionary change towards CE" (Kiefer et al., 2019)

The transition to a circular economy imposes some requirements. First, stable policies and legislation are required. For instance the case of the changing legislation of green power certificates in Flanders don't support transitions in the energy sector (El Kasmioui et al., 2015). New legal restrictions and economic stimuli are necessary (OECD/IEA, 2017). In addition, legal and administrative barriers need to be identified and remedied. Secondly, innovation must be further stimulated and motivated (Gosuin et al., 2016). A third requirement is access to financial resources. The focus of financial institutions is still too often on short-term gains. In addition, ecological, social and governance factors need to be included more when taking investment decisions (European commission, 2015b) Fourthly, employees should dispose of enough and the right knowledge and skills (Govindan and Hasanagic, 2018) as also awareness and empowering of employees is crucial (Veleva et al., 2017). Competences are described by the OESO as the ability to meet complex requirements by mobilizing and using psychosocial means (including skills and attitudes) in a given context. Competences are, in this respect, more than just knowledge and skills (OESO, 2005). In this research, the goal is to answer the question which competences are the most relevant for the transition of a regional economy towards a 'sustainable' circular economy. There is spoken of a 'sustainable' circular economy in this research as circularity on its own is not always necessarily more sustainable (Haupt and Hellweg, 2019). The specific case of the province of Limburg (Belgium) is used. This research is novel compared to previous research wherein sustainability competences are defined in general for example Mochizuki and Fadeeva (2010). In addition, this research starts from the regional university that want to be a civic university and want to know which circular competences are demanded by the regional actors so that they can educate future professionals the required competences. In this sense, the research is framed as which competences for a circular economy are needed in the opinion of the regional companies themselves.

2. Method

2.1 Qualitative part

In this study, first, literature was collected to detect which competences could be relevant for a circular economy in general. Examples of search terms used are 'Competences and the circular economy', 'Sustainable competences', 'Skills and the circular economy', 'Knowledge and the circular economy', 'Circular economy', 'Cleantech', etc., followed by the snowball method. Articles were included when the search terms appeared in title or abstract. Additionally, vacancies and roadmaps were analyzed.

The literature study was used to get an overview and to make a list of competences that were possibly relevant. After that, a focus group was organized. The choice for this research

technique stems from several advantages that this research technique provides. One of the advantages is that this research technique is a relatively easy way to learn about the opinions and thoughts of the participants related to the different competences (Watson and Newy , 2012). The focus group was organized at Hasselt University on September 21th, 2018. The participants were five experts within the domain. The first participant was a representative of the company 'Group Op de Beeck' and a representative from the company federation 'Go4Circle'. Go4Circle (name in 2020 is Dueno) is the Belgian federation of the waste and recycling sector. 'Group Op de Beeck' mains activity is the processing of various organic wastes and by-products. The second and third participant were from respectively the governmental organization 'Vlaanderen Circulair' and 'Vlaio'. 'Vlaanderen Circulair' is a governmental organization with the aim of stimulating a circular economy in Flanders. 'Vlaio' is the flemisch institution for innovation and entrepreneurship. The fourth and fifth participant were representatives from the companies 'Group Machiels' and 'Futurehead', both companies that deliver sustainable and circular services. The central question in the focus group was 'which competences related to the circular economy are relevant in the province of Limburg'.

The focus group started with a presentation about (1) what is a circular economy, (2) why is a circular economy necessary, (3) how can we go to a circular economy, (4) what are the requirements and the expectations and (5) what are the goals for the sector energy, water, mobility, waste/materials. The presentation was a summary of the information from different national (Be circular Be.brussels, 2016, Bourgeois, 2016, Go4Circle, 2018) and international (European commission, 2015a, European commission, 2018, IRENA, 2018, Nauta, 2014, OECD/IEA, 2017) roadmaps about the future of a sustainable and/or circular economy. Thereafter, an open discussion was held. Without any input from the researcher the experts were asked to list competences that are important to their opinion. Hereafter the input is debated in group to determine which competences are relevant according to the whole group of experts. In the second exercise the experts received the list of competences based on the literature search (see Annex A). Those competences were divided in three categories: technical competences, valorization competences and transversal competences. These categories are based on a similar study done in the Interreg project 'Crossborder Biobased Education' in which competences for the biobased economy were identified (Grenzeloos Biobased Onderwijs, 2019). Technical competences can be described as competences specific related to the circular economy. Valorization competences are competences needed to transform the technical competences in added value for the economy and society. Transversal competences are not related to a specific domain but are key competences w.r.t. lifelong learning, creativity, citizenship and taking initiative and responsibility.

The experts first deleted the competences that they found to be irrelevant. After that, each expert was asked to provide a top ten ranking individually. The ranking was discussed and a joint top three in each category was made by the group of experts. NVivo software for qualitative data analysis (Nvivo, 2015) was used to analyze the experts' answers. The technique of open coding was used to determine important competences (Stuckey, 2015).

The results of the literature search and the focus group were used as an input to the best-worst scaling (BWS) exercise in the questionnaire. During the focus group, the experts mentioned and discussed the competences that are important for a circular economy in the specific region. Competences for which there was a large consensus in the focus group were included in the BWS task. The competences highly ranked and agreed on in group were also included in the BWS task. In total 37 competences were included in the BWS task, of which 13 technical, 11 valorization and 13 transversal competences (see Annex B).

2.2 Quantitative part

Next a questionnaire was developed to ask circular companies or companies that would want to become circular in a quantitative way about which competences are relevant in a circular economy. The questionnaire was spread to different companies using Qualtrics software. The sampling method was voluntary response sampling as the questionnaire was distributed with the help of Go4Circle (Belgian federation of the waste and recycling sector), Agoria (Belgian sectoral employer organization), Valipac (a service company that helps companies facing the obligation to take back industrial packaging) and Greenville (incubator for cleantech and circular economy in Limburg). Additionally, the questionnaire was spread by e-mail to the database of companies of Hasselt University. As the questionnaire was spread by the previously mentioned institutions that are bound by the GDPR rules, there is no overview of who actually received the questionnaire.

2.2.1 Best-worst scaling

Traditional rating scales, for example, linear numeric scale, Likert scale or multiple rating matrix suffer from shortcomings because different respondents use them differently (Baumbartner et al, 2001, cited by Chrzan and Peitz, 2019). To overcome these limitations best-worst scaling (BWS) was introduced as a more parsimonious data collection procedure for scaling problems (Finn and Louviere, 1992). This method of data collection is selected in this research to avoid scale biases (Lee et al., 2008). BWS, also known as maximum difference scaling or maxdiff, is a theory-driven scaling procedure in which a discrete choice task forces respondents to make a choice by requiring them to select both the best and the worst option available in a set of samples (Jaeger et al., 2008). A sample corresponds to one of the 37 competences. BWS is a cost-efficient way of obtaining more information

(Flynn and Markey, 2014) as the two options in the best–worst pair chosen by a person from any particular set are assumed to be the farthest apart on an underlying latent scale (Louviere and Islam, 2008). In the example provided in figure 1, participants have to indicate in each set which competence they find the most and the least relevant.

Figure 1: Example of a question constructed with BWS

Which competence of the list below is according to you the most relevant and which one is the least relevant within your company for a transition to a circular economy.

Most relevant		Least relevant
0	Knowledge and skills related to sustainable energy	0
0	Knowledge of the principles of a circular economy	0
0	Knowledge about sustainable materials	0
0	Knowledge of statistics and data-analysis	0

Balanced Incomplete Block Designs (BIBD) for the BWS exercise in this questionnaire were built using the Sawtooth Software's SSI Web platform. BIBD ensures an experimental design wherein each choice option appears equally often and co-appear equally often (Strasser, 2018). For this research in total three different versions of the questionnaire were created because of the necessary random design, each of them containing three separate block designs, one for the technical competences, one for the valorization competences and one for the transversal competences. The BIBD resulted in 3 questionnaires with 29 questions each containing a set of 4 competences per question.

The Hierarchical Bayes (HB) technique in Sawtooth Software was to analyze the results and estimate the preference scores for each respondent. This technique holds considerable promise for handling a large number of attributes, in this case competences, for measuring respondents' preferences (Park, 2004) and gives better information with fewer respondents (Orme, 2018). The full questionnaire can be found in annex C.

3. Results

3.1 Literature and focus groups

Annex A provides the list of the competences found in the literature search. During the discussion the experts of the focus group mentioned 'systemic thinking and working', 'being multidisciplinary', 'being visionary', 'eager to learn' and 'self-knowledge' as important aspects of competences for a circular economy although those competences did not occur or were described differently in the literature. 'Eager to learn' was described as "motivated to learn at the job, seeing the opportunities while working on a job and open to change". Multidisciplinary was explained in two ways, namely (1) one person that has knowledge from different disciplines or (2) different persons of different disciplines that work together

intensively. Being visionary was important according to the experts as the way towards the transition to a circular economy is not clear and visionary people are necessary to let the transition go faster. 'Visionary', 'systemic thinking' and 'multidisciplinary' were included in the BWS exercise of the questionnaire. 'Eager to learn' and 'self-knowledge' are not included as 'eager to learn' is strongly related to 'lifelong learning' and there was no generally agreement by the experts on 'self-knowledge'.

Of the competences described in the list, the experts indicated competences such as professional knowledge and accuracy as important technical competences, but they were convinced that education is already strongly committed to this. However, professional knowledge should be directed more towards sustainability. According to the experts, other important competences within the category technical competences are 'STEM-skills' (Science, Technology, Engineering, Mathematics) or 'STEAM-skills' in which the 'A' stands for 'arts' and refers to more out-of-the box thinking and creativity. 'Knowledge about the principles of a circular economy' and 'skills related to product design' are mentioned as competences strongly related to the basics of circular economy and are considered as being important. According to the experts, education has little attention for those skills.

In the category valorization competences, the competence 'critically contextualizing of knowledge and knowledge to establish mutual relationships between social, economic and environmental problems' is mentioned as important by the experts in the focus group. Although some experts regret that this competence is written in a passive way i.e., they miss a component calling for the transformation of this knowledge into action. Also 'Project management and implementation' is considered to be important. Actually, the central topic in the discussion of the experts was that, although there are often enough ideas during brainstorms, the realization of those ideas is difficult. They said that ideas from brainstorms often get lost and are rarely being implemented. The experts also stated that the more transversal competences 'problem solving way of thinking', 'analytical skills' and 'project management skills' can support the competence 'project implementation'. Other important competences within this category are 'environmental awareness and the application of ethical and sustainable principles' and 'financial and economic knowledge'. It was mentioned that financial and economic skills are important to create a business and to actually sell and earn money with the circular products. The content of this competence is broad but according to the experts some basic knowledge of different aspects or - as they called it - "common sense" is important.

In the category of the transversal competences, there was a big consensus about the importance of 'entrepreneurship skills', both in terms of its narrow meaning i.e.,

'entrepreneurship' competences required to start and manage one's own business as well as in terms of its broad meaning of 'entrepreneurial' skills or 'intrapreneurship'. The experts further agreed that 'the competence to collaborate', 'creative thinking' and 'flexibility' are important transversal competences. In annex B, an overview of the competences classified as important and used as input for the BWS exercise in the questionnaire can be found. In total 37 competences were included in the BWS task, of which 13 technical, 11 valorization and 13 transversal competences.

3.2 Questionnaires

In total, 30 respondents of companies filled in the questionnaire. Figure 2 shows detailed information about the size of the company in terms of employees, the sector where the companies located themselves and the job of the respondents or their relation to the company.

Figure 2: Information about respondents

Job title	Number of respondents
CEO/ Director of the company	8
Member of the board of directors	4
Part of management team	4
Part of the HR team	3
Part of the sustainability team	3
Staff member	3
Part of the R&D department	2
Part of technical team	1
Shareholder	1
COO/ Operational director	1

In order to show the relevance of this study, the respondents were asked how many additional staff they expect to hire within their companies because of the grow of their (more) circular company. However, this staff can be employed in specific 'circular functions' or in a general one. An overview of their answers can be found in table 2 below. As there

has not been any follow-up study yet, we cannot ascertain whether these estimates correspond to actual job creation within the participating companies.

Table 1: Expected jobs in questioned companies (Numbers from December 2018)

Company size	Within a time frame of 2 years	Within a time frame of 5 years	Within a time frame of 10 years
<10 professionals	3	5	5
10-50 professionals	16	35	47
51-250 professionals	27	64	68
251-1000 professionals	45	110	190
>1000 professionals	550	1000	1500

The responses of the BWS exercises in the questionnaire (Q10-Q40 annex C) were analyzed using hierarchical bayes analysis. All respondents reached a fit-statistic higher than the minimum of 0.25 (Sawtooth Software, 2009). Tables 2-4 show the results of the analysis of the BWS data for the technical, valorization and transversal competences respectively. In the first column, the competences mentioned in annex B are ranked according to their average ranking across all respondents in column three. The latter number is based on the average rescaled utility score. A competence with a score of 10 is twice as preferred or important as an item with a score of 5. In annex D histogram 1-3 visually show the frequency distribution of the average ranking score. Column two of tables 2-4 indicate the ranking place. For the category technical competences, high preference is given to 'knowledge and skills about sustainable energy', 'knowledge about the principles of a circular economy' and 'to use raw materials efficiently'. In the category valorization competences, high preference is given to 'being able to come up with customized business models', 'knowledge about the economic aspects of the environment and ecology' and 'skills about project management and implementation'. In the category transversal competences, high preference is given to the competence 'innovative and open-minded', 'thinking creatively' and 'to be visionary'. When comparing the different categories, overall, the average utility scores of the technical and transversal competences decrease more gradually compared to the valorization competences.

Table 2: Best-worst scaling results in the category technical competences

Rescaled scores (0 to 100 scaling)				
Competences	**Ranking**	**Average**	**95% Lower**	**95% Upper**
Knowledge and skills about sustainable energy	1	12.6928	10.25022	15.13533
Knowledge about the principles of a circular economy	2	12.0084	9.42352	14.59322
To use raw materials efficiently	3	11.3951	9.47158	13.31865
Knowledge about sustainable materials	4	10.0936	8.67794	11.50918
STEM-skills	5	9.9193	7.00190	12.83665
Being able to map the environmental and social impact	6	9.7309	7.64293	11.81890
Research and development skills	7	9.1450	7.10447	11.18556
Skills regarding waste prevention and recycling	8	7.6080	6.56351	8.65259
Skills related to product design	9	6.3066	3.64680	8.96636
Knowledge and skills around water quality and water scaricity	10	3.4740	1.84206	5.10603
Logistic knowledge and skills	11	3.1756	1.82750	4.52371
Knowledge about modelling and simulation techniques	12	2.3169	1.29339	3.34044
Knowledge of statistics and data-analysis	13	2.1338	0.88275	3.38481

Table 3: Best-worst scaling results in the category valorization competences

Rescaled Scores (0 to 100 scaling)				
Competenties	**Ranking**	**Average**	**95% Lower**	**95% Upper**
Being able to come up with customised business models	1	15.5119	11.91698	19.10685
Knowledge about the economic aspects of the environment and ecology	2	14.3885	12.22084	16.55624
Skills about project managment and implementation	3	14.0022	11.22655	16.77779
Environmental awareness and the application of ethical and sustainable principles	4	13.8619	11.28340	16.44046
Be aware of the consequences of climate change	5	8.6730	6.38942	10.95662
Financial skills	6	7.5432	5.60086	9.48545

Skills regarding system thinking	7	6.8069	5.08427	8.52949
Knowledge of the functioning of the economy	8	6.1016	4.21764	7.98562
Knowledge and skills related to marketing and product integration	9	5.9622	3.59018	8.33420
Knowledge of the energy market	10	5.0554	2.46689	7.64400
Legal knowledge	11	2.0931	0.98292	3.20333

Table 4: Best-worst scaling results in the category transversal competences

Rescaled Scores (0 to 100 scaling)				
Competenties	**Ranking**	**Average**	**95% Lower**	**95% Upper**
Innovative and open-minded	1	12.8969	11.09359	14.70020
Thinking creatively	2	10.7675	8.93533	12.59964
To be visionary	3	10.3176	7.05923	13.57588
Problem-solving way of thinking	4	9.6026	7.58382	11.62137
The competence to work together	5	9.0940	6.90563	11.28240
Positive attitude towards sustainability	6	7.2800	5.01825	9.54168
Flexibility and adaptability	7	6.9290	4.92653	8.93142
Entrepreunerial skills (within the company)	8	6.8028	4.31628	9.28936
Critical thinking	9	6.6446	5.03351	8.25579
Communication with stakeholder	10	6.4477	4.00827	8.88719
Multidisciplinary	11	5.5987	3.69832	7.49913
Analytical skills	12	4.2531	2.44448	6.06179
Lifelong-learning	12	3.3655	1.93017	4.80073

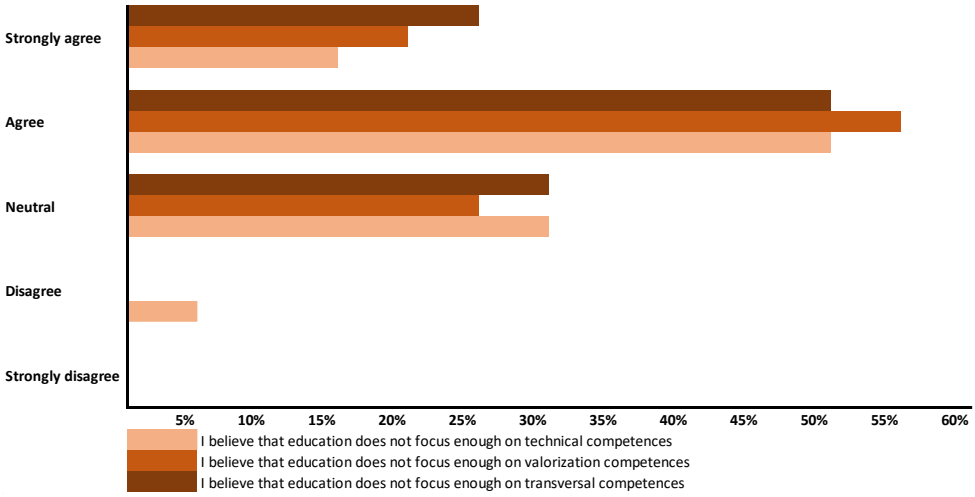
The results of the BWS exercise give a ranking of the competences within each specific category. Subsequently, the respondents were asked to choose five competences across all categories that his/her ideal employee in the circular economy would need (See Q42-Q44 in annex C). The results in table 5 show a preference for transversal competences, which is in line with what we found during the analysis of the vacancies of a list of organizations within the circular economy. However, there is no consensus on which specific transversal competence.

Tabel 5: Preference across categories

	% of times in top 5 (in total)	% of time #1	% of time #2	% of time #3	% of time #4	% of time #5
Transversal competences	39	36	33	37	45	44
Technical competences	34	36	52	26	33	22
Valorization competences	27	28	15	37	22	33

Furthermore, the companies were asked whether extra attention in education for a certain category of competences is necessary (See Q41- annex C). In total 77% of the respondents (strongly) agreed that education should invest more in valorization competences. 70% of the respondents (strongly) agreed that education should focus more on transversal competences as well, but only 63% found that technical competences should get more attention in education (Figure 3). Although extra attention is necessary for the competences of all three categories, there is mainly a need for extra transversal and valorization competences. In the last question, respondents were asked which are the competences of the 'ideal' employee in a circular economy. As many respondents dropped out in the last question, there are no results.

Figure 3: Results of the question whether extra attention in education for a certain category of competences is necessary



4. Discussion

In the category technical competences 'knowledge and skills about sustainable energy' is ranked first, 'knowledge about the principles of the circular economy' second and 'to use raw materials efficiently' third. Theoretically, this is not surprising as all these competences have a direct or indirect link with the definition of a circular economy. If these results are compared to the results of the focus group similarities exists. The competence 'knowledge of the principles of the circular economy' is also mentioned as important. More striking, however, is the fact that 'skills related to product design' stands on the ninth place in the ranking while mentioned as important during the focus group. Theoretically, this competence could be seen as closely linked to, and very important for the circular economy as new product design strategies are necessary to move to a circular economy (Bocken et al., 2016). The authors wonder whether this low ranking can be explained by the local context, as a local subsidiary might not be responsible for product design but rather assembles the products designed within a company's headquarters that might be located outside of the province. More general technical competences are found at the bottom of the ranking of the technical competences. A possible explanation is that these are not specific enough to be linked to a circular economy. Moreover, the experts in the focus group also mentioned general technical competences like professional knowledge and accuracy but explained that education is already strongly committed to that. This might also explain the low ranking of the more general technical competences by the respondents of the questionnaires. As discussed during the focus groups, education should be more directed to sustainability nowadays. The missing link to sustainability in the general technical competences could also explain why they appear lower in the ranking.

The top three of the valorization competences consists of 'being able to come up with customized business models', 'knowledge about the economic aspects of the environment and ecology' and 'skills about project management and implementation'. Two of the competences placed in the top three are related to business economics. An expert in the focus group mentioned that the technical possibilities are not the biggest challenge anymore, but are replaced by economic challenges. New business models and strategies must be created to facilitate the transition to a circular economy. The competence 'skills about project management and implementation' was also important according to various experts of the focus group. They stated that usually enough ideas pop up during a brainstorm, whereas the implementation of these new ideas appears to be difficult. Less important and lower in the ranking of the valorization competences is 'legal knowledge'. A possible explanation, given by an expert of the focus group, is that 'legal knowledge' is an important competence but only for a select group of professionals and not a general requirement for all employees to make the transition to the circular economy happen.

'Innovative and open-minded', 'creative thinking' and 'to be visionary' are mentioned in the top three of the transversal competences. These competences have in common that they deal with finding solutions, give direction and create a strategy for the circular economy. In the discussion during the focus group experts already mentioned these competences, as they think visionary persons who can easily find solutions will stimulate a faster transition to a circular economy. At the bottom of the ranking, 'analytical skills' and skills related to 'lifelong learning' are placed. The experts of the focus group however mentioned lifelong learning as an important skill for the transition to a circular economy, but they were convinced that more and more recent graduates have this skill and extra attention for this is not essential. This could also be an explanation for the low ranking of this competence by the companies as well.

5. Conclusions

This study investigated which competences are important for a transition to a circular economy and was conducted in a specific case in the province of Limburg. In the first stage of this research, literature, vacancies and roadmaps were analyzed to make an overview of possibly relevant competences. In the second stage, focus groups were organized with experts from government, companies and sectoral federations to complement this overview with missing competences and subsequently to select the most relevant ones. Finally, best-worst scaling was used to obtain a ranking of the competences in each of three categories (technical, valorization and transversal) according to local companies currently active in or with the desire to become active in the circular economy. Although the questionnaires were widely spread with the support of several sectoral organizations,

the number of respondents was slightly disappointing. Some respondents communicated that, although they found the study highly relevant, they could not complete the questionnaire due to a lack of time. Hierarchical Bayes average ranking was used to develop a ranking for the competences. This way of ranking is commonly used by practitioners in different fields (Vanschoenwinkel et al., 2014, Tsai and Elshall, 2013). In general, the results show that education should invest more in all three categories but there is mainly a need for increased focus on transversal and valorization competences.

The results of this research are useful for higher education institutions as they provide insight in the main competences that have to be achieved in technical, scientific and economic training. Specifically, this study contributes to a better harmony between training and the business needs in Limburg. However, the results are also useful for other similar regions as the need for competences could be the same. A better match between supply and demand of competences reduces structural unemployment and increases the number of filled vacancies. Specifically, in Hasselt University the results were used for creating the postgraduate program 'biobased and circular economy'.

One of the limitations of this study however is the low number of respondents in the questionnaire. This may be due to the length of the questionnaire, the targeted respondents, the restricted region were the questionnaire was spread or a combination of all previously mentioned factors. The questionnaire took around 30 minutes to fill in. In total 77 respondents started the questionnaire but more than 50% of them did not fully completed the questionnaire. Incomplete questionnaires were excluded. The long length of the questionnaires was caused by the BWS exercise and the amount of competences that were included. This was however essential to make the ranking. Further, the questionnaires were targeted to someone from the management level. That audience is extremely busy and not easy to motivate to respond to the huge amount of questionnaires they receive, although we stressed the value for the individual company by referring to the improved training of graduates as a way to reduce the large number of the company's unfilled vacancies.

The goal of this study was to detect the competences important for a circular economy. The research is applied on the specific case of Limburg. As a consequence, a second limitation is that the results of this research are specific for the Belgian province of Limburg. However, the results can also give an indication for other regions, especially for regions close by. Further research can include a bigger or other region although the difference in outcome could be very small.

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Annex A – Results of the literature search

Technical competences:
Competences related to technical skills in the field of hydrology
Competences/skills related to water sensitive urban design
Competences related to wetland design
Competences related to floodplain assessment
Competences related to aquifer storage and recovery
Competences related to the topic groundwater
Competences/ knowledge related to stormwater
Competences/ knowledge related to the topic water trading
Competences/ knowledge related to topicsalinity solutions
Specific and technical knowledge of the job
STEM skills ~ Knowledge and skills related to science, technology, engineering and mathematics
Knowledge of electricity (installation and operation)
Technical skills
Mathematical skills
Research and development skills
Knowledge of statistics and data-analyses
knowledge of emerging and future water quality issues
Knowledge related to sustainable materials
Material choices and efficient use of materials
Knowledge of materials: purchasing and selection, material use, impact quantification
'Waste skills': Waste determination and monitoring, waste process studies, waste management systems, waste technologies, waste minimization
'Energy skills': Energy minimization, energy management, Energy quantification and monitoring, energy costs and trade, non-renewable technologies, renewable energy technologies
'Building skills': Energy management, integration of renewable energy, energy efficient construction, facility management, energy efficiency calculation of buildings and carbon assessments
Clever with the use of new technologies
General skills to calculate environmental impact
Competences/ knowledge related to the management of environmental flows
Environmental impact assessment skills
Specific 'green' skills
Knowledge and skills related to energy efficiency and renewable energy
Skills and knowledge related to carbon food printing
'Transport skills': transport impact minimization technologies, transport management in business, transport impact minimization processes
Logistic knowledge and skills
Skills related to product design
Knowledge of the state-of-the-art of electromechanics
Knowledge about modeling and simulation techniques
Skills and knowledge about the development of functional physico-chemical of (biobased) building blocks for different applications and sectors
Broad chemical background

Skills related to modern LC (HR) MS instrumentation and sample preparation techniques
Skills related to thermal energy systems
Expertise in the field of inorganic chemistry and material synthesis
Expertise with quality systems
Knowledge about the principles of a circular economy
Being able to map environmental and social impact
Geographical insight
Technical insight
Skills related to montage
Good in reading technical plans
Skills related to synthesis and development of inorganic materials
Knowledge related to electrocatalysis
Research and development skills
Valorization competences:
Critical contextualization of knowledge + establishing mutual relationships between social, economic and environmental problems
Legal knowledge
Financial knowledge
Economical knowledge
Being able to come up with customized business models
Skills related to cost efficiency
Skills to understand policy reforms
Financial knowledge and skills like investment models, new / alternative financial models, quantification of the effects of climate change
Policy and planning skills: strategy development, strategy implementation
Consulting skills to advise customers about green technologies and green solutions
Competences to manage cross-sectoral product integration and communication
Negotiating and mediating skills
Understanding the context of the challenges
Competences and skills related to market research
Competences required to launch a product
Competences related to risk assessment
Identifying and modelling climate change and the associated risks and opportunities for the own company
Being able to assess commercialization options and financial feasibility of new energy sources
Knowledge about legislation, standards and regulation related to climate change
Interdisciplinary skills to create shared problem definitions and shared solution perspectives
Competences related to modelling of the energy market
Customer-oriented
Skills to work with accounting packages
Knowledge of different ISO standards
Negotiating and networking skills
Competences related to selecting suppliers and service providers and checking the services and products delivered
Problem solving way of thinking
Analytical thinking
Skills related to project management
Skills related to supply chain management

Competences related to organization management
Being able to implement a product or an idea
Skills/ knowledge related to product optimization
Skills related to design like eco-design, green production, LCA,…
Competences in decision making
Experience in recruiting, conducting and coordinating studies for private parties or European and foreign governments
Innovative
Creative
Practical developer of analytical methods
Scientifically
Experience with research
Result-oriented
Organized
Decisive
Goal-oriented
Skills to work structured
Skills to follow up appointments and administration
Coordinate and organize the flow of information and the work instructions of the organization
Coping with a large amount of information
Competences related to coding and managing of complex data systems
Skills and knowledge related to networking, information technology and language
Skills for scientific writing
Skills to synthesize results in useful advice
Transversal competences:
Driven by innovation for the transition to a sustainable society
Social and communication skills
Skills to communicate with different stakeholders
Knowledge of different languages and cultures
Skills related to IT, networking and language
Interpersonal skills
Teamplayer/ working in a team
Cognitive competences: the ability to understand and influence thoughts and ideas
Networking skills
Power of persuasion
Creative negotiator
Helicopter view
Skills to communicate on different levels
Skills to coordinate a team
Skills to educate people
Repetitive skills
Individual capacities like being critical, express emotions
Entrepreneurship
Adaptability and transferability skills
Innovation skills to identify opportunities and to create new strategies for green challenges
Competences to use resources sustainable
Applying ethical and sustainable principles on a personal and professional level
Environmental awareness

Lifelong learning
Critical thinking
Applied knowledge
Out-of-the-box thinking
Being able to see opportunities
To take initiative
Creative
Hands-on
Flexible
Accuracy
Open-minded
Keep eye on safety, health and the environment
Dynamic
Stress resistant
Maturity
Punctual
Comply with rules and agreements
Strong work attitude and positive motivation
ICT skills
Programming skills
Knowledge and skills related to different software packages
Knowledge and skills related to statistical or mathematical software
Knowledge of SAP

Annex B – Competences used in BWS exercise

Technical	Valorization	Transversal
Being able to map the environmental and social impact	Skills around system thinking	Problem-solving way of thinking
Knowledge and skills around sustainable energy	Skills around project management and implementation	Multidisciplinary
Knowledge of sustainable materials	Financial skills	Creative thinking
Knowledge and skills around water quality and water scarcity	Knowledge of the functioning of the economy	Communication with stakeholder
Skills around waste prevention and recycling	Legal knowledge	Entrepreneurial skills (within the company)
Skills related to product design	Knowledge and skills related to marketing and product integration	Flexibility and adaptability
Knowledge about modeling and simulation techniques	Environmental awareness and the application of ethical and sustainable principles	Critical thinking
Research and development skills	Knowledge of the energy market	Lifelong-learning
Knowledge about the principles of a circular economy	Knowledge about the economic aspects of environment and ecology	Innovative and open-minded
To use raw materials efficiently	Being able to come up with customized business models	Analytical skills
Knowledge of statistics and data analysis	Be aware of the consequences of climate change	The competence to work together
STEM-skills		Positive attitude towards sustainability
Logistic knowledge and skills		Being visionary

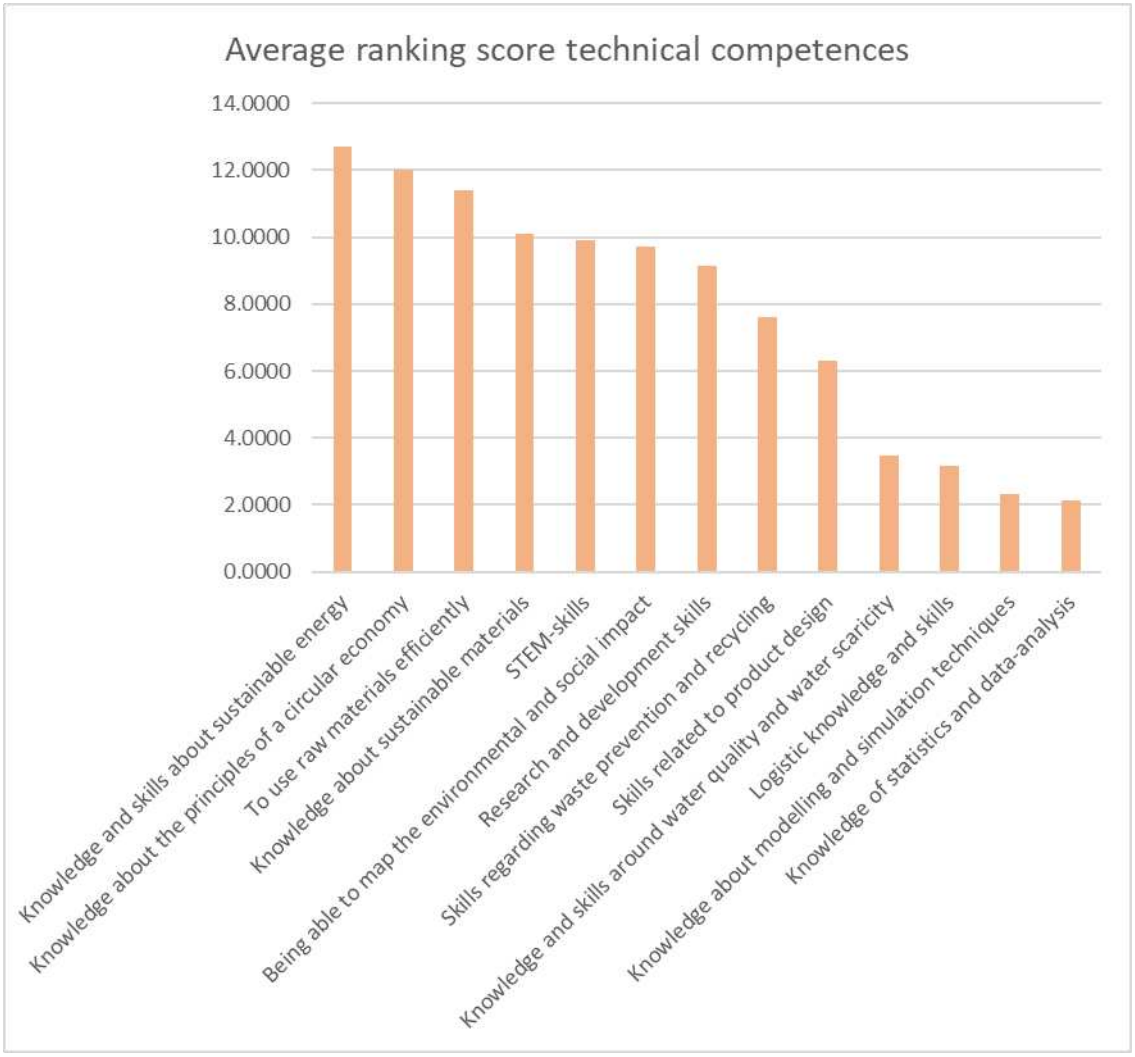
Annex C – Questionnaire (translated)

Q1	Dear participant, To increase the competitiveness and chances of success of companies in the transition to a circular economy, (future) employees must have the right competences. The research group Environmental Economics (Center for Environmental Sciences) at Hasselt University is therefore investigating how the range of education in our province can be better aligned with the needs of the business world. We would like to ask you to complete the following questionnaire. This will take 30 minutes. All data will be treated confidentially. Do not hesitate to contact us with any comments. Thanks in advance for your help!
Q2	What is the name of the company?
Q3	Wat is the address of the company?
Q4	Describe your function within the company.
Q5	The company you work for is active in: • Energy • Water • Materials/ waste processing • Mobility • Other
Q6	How many employees work for the company? (Full time equivalents) • Less than 10 • Between 10-50 • Between 51-250 • Between 251-1000 • More than 1000
Q7	Percentage of employees with highest degree: • % master degree • % bachelor degree • % high school degree • % no degree
Q8	The number of employees that you expect to be recruited in your company: • In the coming 2 years • In the coming 5 years • In the coming 10 years
Q9	To what extent do you agree with the statements below (strongly disagree- disagree- neutral- agree- strongly agree): • Current legislation obstructs the company to realize the ambitions in the field of circular economy. • A lack of stable policies obstructs the company to realize the ambitions in the field of the circular economy. • The company has sufficient financial resources. • The company has access to sufficient external financial resources. • The company features good trained employees • The company has access to sufficient raw materials • There is certainty related to the quality of the raw materials

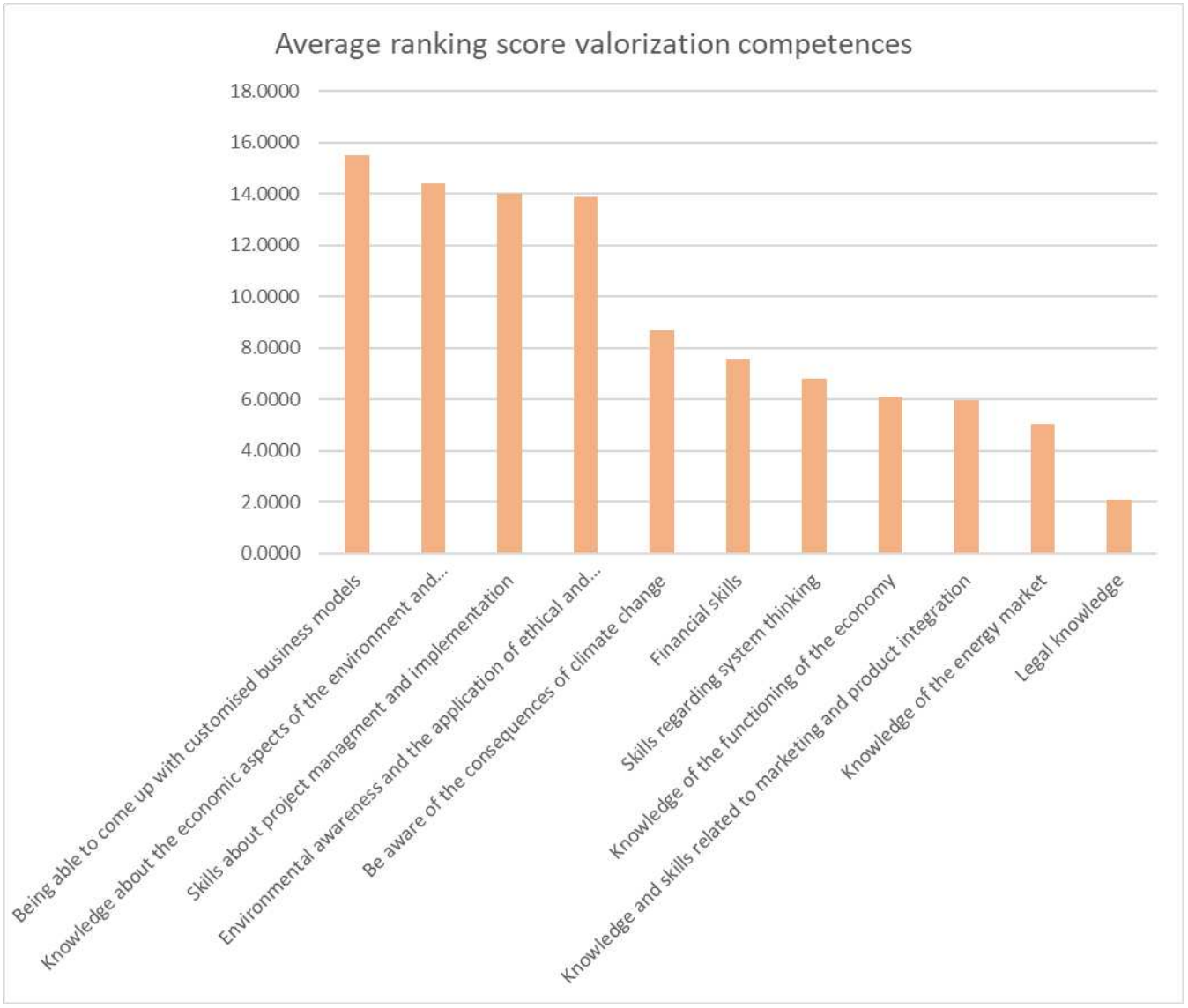
Q10-Q20	BWS exercise of the technical competences
Q21-Q29	BWS exercise of the valorization competences
Q30-Q40	BWS exercise of the transversal competences
Q41	To what extent do you agree with the statements below (strongly disagree- disagree- neutral- agree- strongly agree): • Education does not invest enough in technical competences • Education does not invest enough in valorization competences • Education does not invest enough in transversal competences
Q42	Make a top 5 ranking of the most relevant technical competences
Q43	Make a top 5 ranking of the most relevant valorization competences
Q44	Make a top 5 ranking of the most relevant transversal competences
Q45	This is a hypothetical question. If you could 'make' the perfect employee. Choose 5 competences that this employee has.
Q46	Do you have remarks? Or are there important competences missing? Please note below.
Q47	Thank you for your time. If you have any questions feel free to contact us

Annex D – Histogram of average ranking scores competences

Histogram 1: Average ranking score technical competences



Histogram 2: Average ranking score valorization competences



Histogram 3: Average ranking score transversal competences

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