The role of Higher Education Institutions in training engineers for the era of circular economy: the Portuguese case

O papel das Instituições de ensino superior na formação de engenheiros para a era da economia circular: o caso português

El papel de las instituciones de enseñanza superior en la formación de ingenieros para la era de la economía circular: el caso portugués

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ABSTRACT
The transition from linear economy (LE) towards a circular economy (CE) is Europe Union’s (EU) concerned and involve lot of efforts and actions. Education for circular economy (ECE) is emergent. This paper aims to map Higher Education Institutions (HEIs) in Portugal, Bachelor’s and Master’s degree programs and Postgraduate courses in Industrial Engineering and Management (IEM) that address CE in their curricula with the aim of empowering students for the new era. A systematic search was performed to identify B.Sc./ M.Sc. in IEM of Portuguese
Universities and Polytechnic Institutes, public and private, analyzing the content of their curricular units. As results, this study did not identify a strong interest about CE on the part of HEIs and their lecturers. Findings suggest that HEIs are not training future IEM engineers for the era of CE. This study contributes to make an alert to HEIs and their lecturers to review their teaching process, stimulating to improve the quality of the IEM curricula. We suggest a deep reform of the professional curriculum system, enriching curricular. Future studies can approach skills and competences developed towards CE what facilitate a redesign of courses.

**Keywords:** Circular Economy. Curricular Unit. Higher Education. Engineering.

**RESUMO**
A transição da economia linear (EL) para uma economia circular (EC) é uma preocupação da União Europeia (UE) e envolve muitos esforços e ações. A educação para a economia circular (ECE) é emergente. Este artigo tem como objetivo mapear as Instituições de Ensino Superior (IES) em Portugal, cursos de licenciatura, mestrado e pós-graduação em Engenharia e Gestão Industrial (IEM), que abordam a EC nos seus currículos com o objetivo de capacitar os alunos para a nova era. Foi efectuada uma pesquisa sistemática para identificar cursos de Licenciatura/Mestrado em IEM de Universidades e Institutos Politécnicos portugueses, públicos e privados, analisando o conteúdo das suas unidades curriculares. Como resultados, este estudo não identificou um forte interesse sobre EC por parte das IES e dos seus docentes. Os resultados sugerem que as IES não estão a formar os futuros engenheiros do IEM para a era da EC. Este estudo contribui para alertar as IES e os seus docentes para reverem o seu processo de ensino, estimulando a melhoria da qualidade dos currículos do IEM. Sugere-se uma reforma profunda do sistema curricular profissional, com enriquecimento curricular. Estudos futuros poderão abordar as aptidões e competências desenvolvidas para a EC que facilitem a reformulação dos cursos.


**RESUMEN**
La transición de la economía lineal (EL) a la economía circular (EC) es una preocupación de la Unión Europea (UE) e implica muchos esfuerzos y acciones. La educación para la economía circular (ECE) es emergente. Este trabajo tiene como objetivo mapear las Instituciones de Educación Superior (IES) en Portugal, los programas de grado, máster y cursos de postgrado en Ingeniería y Gestión Industrial (IEM), que abordan la EC en sus planes de estudio con el objetivo de capacitar a los estudiantes para la nueva era. Se llevó a cabo una búsqueda sistemática para identificar programas de Grado/Máster en IEM de Universidades e Institutos Politécnicos portugueses, públicos y privados, analizando el contenido de sus unidades curriculares. Como resultados, este estudio no identificó un gran interés sobre la EC por parte de las IES y sus profesores. Los resultados sugieren que las IES no están formando a los futuros ingenieros IEM para la era de la EC. Este estudio contribuye a alertar a las IES y a sus profesores para que revisen su proceso de enseñanza, estimulando la mejora de la calidad de los planes de estudio de IEM. Sugerimos una profunda reforma del sistema curricular
profesional, enriqueciendo los planes de estudio. Futuros estudios pueden abordar las habilidades y competencias desarrolladas hacia la EC lo que facilitaría un rediseño de los cursos.

**Palabras clave:** Economía Circular. Unidad Curricular. Enseñanza Superior. Ingeniería.

1 INTRODUCTION

Since 2021, the European Union (EU) has made enormous efforts and actions in favor of the Circular Economy (Rodríguez-Antón et al., 2022). Its concerns have focused on the efficient use of resources, reducing waste, and fostering a sustainable economic growth to accelerate the transition to Circular Economy (CE). However, the transition from Linear Economy (LE) to Circular Economy is not an easy task. According to Busu (2019), the real problem is the change of the “model of consumption” to achieve “production–consumption–reuse model”.

Responses to that problem must be focused on company’s role in using of resources, designing products with less use of scarce resources and their impact on environment and producing products with quality that facilitate their reuse (Mesa and Esparragoza, 2021; Jørgensen and Pedersen, 2018). Thus, it is imperative for companies design circular business models, having professionals for this intent.

In the linear-circular transition, professionals are needed who have the right skills and act as agents of change (Janssens et al., 2021), especially IEM engineers, since their knowledge acquired at HEIs has multiple applications in industry (Mesquita et al., 2015). IEM engineers have functions related to planning, manufacturing process, optimization; they are responsible for processes from product design, the input of raw materials to the output of the finished product.

To ensure organizational performance towards to CE, future IEM engineers can be expected to develop technical and transversal skills previously in a scholar environment. In this context, Tiippana-Uusvasalo et al. (2023) strengthen that education is the key to the transformation from linear to circular model. This is corroborated by Manzini (2021) who explains that with the increase in
technological knowledge, education for engineers become an object of study aiming achieve the future sustainable economic development.

Scholars recognize that for accelerating the transition to CE, it is necessary to educate future engineers, providing CE knowledge, developing CE thinking (Mesa and Esparragoza, 2021) and training future professionals to perform in this new model. in this sense, including CE and sustainability issues in the higher education curricula is the way to implement CE (QU et al., 2020; Mateus et al., 2020). Therefore, HEIs and their lecturers play an important role as strategic drivers of circular economy (Qu et al., 2020; Giannoccaro et al., 2021), designing curricula with contents related to CE, promoting theory and training for CE, especially, in Industrial Engineering and Management field (1st and 2nd cycles of studies) since those future professionals will perform in multiples environments, both industries and service. Mesquita et al. (2015) add that HEIs are expected to foster the development of skills required by employers and society.

Based on the importance of HEIs in promoting innovation, new practices, incorporating theoretical and practical issues that are essential for linear-circular transforming, in this regard, this article aims to answer the following research questions:

RQ1: Are Portuguese HEIs training future IEM engineers for the era of circular economy?

RQ2: is there an Integration of CE principles in academic disciplines in IEM programs (1st and 2nd cycles of studies)?

RQ3: What teaching methods applied in curricular units that address CE principles in IEM program at portugueses HEIs?

This article contributes to the field by presenting a new light on the literature concerning Education for Circular Economy (ECE) and as an alert to HEIs and their lecturer to review their teaching process, stimulating to improve the quality of the IEM curricula (1st and 2nd cycles of studies) towards to CE and encouraging research in the field, as well.

Thus, this study aims to map Higher Education Institutions (HEIs) in Portugal, Bachelor’s and Master’s degree programs and Postgraduate courses in Industrial Engineering and Management (IEM) that address CE in their curricula with the aim of empowering students for the new era. It is organized as follows:
The following section presents Education for Circular Economy (ECE). The research method is addressed in section 3. The results and discussion in section 4. Lastly, conclusions and suggestions are presented.

2 THEORETICAL FRAMEWORK

2.1 EDUCATION FOR CIRCULAR ECONOMY

Circular Economy concept is widely used by scholars and practitioners (Camacho-Otero et al., 2018, p.1) achieving numerous definitions. Based their study of 114 definitions for CE, Kirchherr et al. (2017, p.229) consider CE 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” having reached the field status (Kirchherr et al., 2023).

The transition towards a Circular Economy (CE) has become a critical global priority, driven by the need for sustainable development and resource efficiency (Kirchherr and Piscicelli, 2019; Renfors, 2024). The concept of CE moves away from the traditional linear economy model towards a regenerative system where waste is minimized, and materials are reused and recycled (Geissdoerfer et al., 2017). Education plays here a critical role, equipping future professionals with the knowledge, skills and attitudes necessary to implement and innovate within a CE framework (Marouli, 2016; Kyriakopoulos, Friant and Desing, 2020; Aming’a, Marwanga and Marendi, 2023).

2.2 IMPORTANCE OF CIRCULAR ECONOMY EDUCATION (CEE)

Circular Economy Education (CEE) includes the development of syllabi and learning activities that integrate CE principles, pointing to prepare students to think critically regarding resource use and to innovate for sustainability. According to Kirchherr and Piscicelli (2019), CEE should focus on relevant five teaching principles: problem-based learning, systems thinking, interdisciplinary learning, stakeholder engagement, and active learning. These principles ensure that students not only understand CE concepts but can also apply them in real-world
2.3 CHALLENGES AND OPPORTUNITIES

The initial challenges in advancing CE education include the need for curriculum reform, the development of interdisciplinary courses, and the creation of partnerships for practical learning (European Environment Agency, 2024). Manzini (2021) stresses that addressing these challenges requires a concerted effort from educators, industry leaders, and policymakers to redesign educational frameworks that prioritize sustainability and innovation. Opportunities for developing CE education lie in the adoption of innovative teaching methodologies. García-Peñalvo and Colomo-Palacios (2015) advocate for active learning approaches, such as project-based learning (PBL) and collaborative problem-solving, which can actually engage students and forward the development of critical skills needed for CE.

To accelerate this urgent transition, it is vital that HEIs carry out a comprehensive review and reform their curricula, as suggested before. This might include the introduction of mandatory CE courses, the integration of CE principles across various subjects, and the promotion of interdisciplinary research and collaboration. This should focus on identifying specific skills and competencies required for CE and developing frameworks to assess and enhance these competencies within educational programs (Nikolaou, Jones and Stefanakis 2012; Chi et al., 2023).

3 METHODOLOGY

Previously, the important role of HEIs in promoting CE was discussed. This study aims to respond the research questions: “RQ1: Are Portuguese HEIs training future IEM engineers for the era of circular economy?”, “RQ2: is there an Integration of CE principles in academic disciplines in IEM programs (1st and 2nd cycles of studies)?”, “RQ3: What teaching methods applied in curricular units that address CE principles in IEM program at portugueses HEIs?”. For this it is required to investigate whether CE issues are present in the curricula in B.Sc./ M.Sc. degree
programs in IEM of Portuguese Universities and Polytechnic Institutes. Are HEIs preparing future engineers to perform in this scenario?

To guarantee the replicability and reliability of the results, detailed and transparent description of our research is presented. It was conducted a systematic search based on analyses of M.Sc. and B.Sc. in IEM at Portuguese HEIs and its respective curricular units ‘content. A protocol for searching was followed: (1) Accessing website of the central service of the Ministry of Education and Science of Portugal, Direção-Geral do Ensino Superior (DGES), searching for HEIs that offer “Industrial Engineering and Management” for the 1st cycle of studies. For 2nd cycle of studies searching, it was considered the previous information of HEIs in DGES website; (2) HEIs identification (University or Polytechnic Institutes; public or private; region, city, website) pointing each region of Portugal (North; Centre; Lisbon Metropolitan Area; Alentejo; Algarve; Autonomous Region of the Azores; Autonomous Region of Madeira); (3) Courses identification (M.Sc. and B.Sc. in IEM) and their program overview; (3) Each curricular unit was analyzed (content). Table 1 shows the form that was used in this step. Likewise, analyses for Master course in IEM were performed.

<table>
<thead>
<tr>
<th>HEI identification</th>
<th>Polytechnic Institution of Porto</th>
</tr>
</thead>
<tbody>
<tr>
<td>University/ Polytechnic Institution</td>
<td><a href="http://www.ipp.pt">www.ipp.pt</a></td>
</tr>
<tr>
<td>City</td>
<td>Porto</td>
</tr>
<tr>
<td>District</td>
<td>Porto</td>
</tr>
<tr>
<td>Public/Private</td>
<td>Public</td>
</tr>
<tr>
<td>Bachelor’s degree/Master’s degree</td>
<td>No</td>
</tr>
<tr>
<td>Program overview (Is CE mentioned?)</td>
<td>No</td>
</tr>
<tr>
<td>Website</td>
<td><a href="https://www.ipp.pt/ensino/cursos/sem-grau/issep/219">https://www.ipp.pt/ensino/cursos/sem-grau/issep/219</a></td>
</tr>
<tr>
<td>Mapping curricular units</td>
<td></td>
</tr>
<tr>
<td>Available content of curricular unit on website?</td>
<td>NO</td>
</tr>
<tr>
<td>Number of curricular units</td>
<td>39</td>
</tr>
<tr>
<td>Curricular unit named with “CE”</td>
<td>None</td>
</tr>
<tr>
<td>Curricular units mentioning CE in its syllabus?</td>
<td>None</td>
</tr>
</tbody>
</table>

Analyses of program overview of M.Sc. and B.Sc. in IEM and contents of curricular units were carried out in February 2024. However, a deep analysis was possible only for information that were available on HEIs website. It is worth noting...
for Bachelor’s degree program, 100% of HEIs present a program overview and more than 80% of the Universities and 50% of Polytechnic Institutes have their contents of curricular units available. On the other hand, for Master’s degree program, more than 88% of universities and 75% of Polytechnic Institutes have their contents of curricular units available.

4 RESULTS AND DISCUSSIONS

The searching for “Industrial Engineering and Management” for the 1st cycle of studies resulted in 12 Universities and 6 Polytechnic Institutes, considering public and private HEIs, according to the DGES website that are presented in table 2:

<table>
<thead>
<tr>
<th>Industrial Engineering and Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Aveiro</td>
</tr>
<tr>
<td>University Beira Interior</td>
</tr>
<tr>
<td>University of Coimbra</td>
</tr>
<tr>
<td>University of Evora</td>
</tr>
<tr>
<td>University of Lisbon</td>
</tr>
<tr>
<td>University of Minho</td>
</tr>
<tr>
<td>Nova University Lisbon</td>
</tr>
<tr>
<td>University of Porto</td>
</tr>
<tr>
<td>University of Trás-os-Montes e Alto Douro</td>
</tr>
<tr>
<td>Polytechnic Institute of Bragança</td>
</tr>
<tr>
<td>Polytechnic Institute of Castelo Branco</td>
</tr>
<tr>
<td>Polytechnic Institute of Cávado and Ave</td>
</tr>
<tr>
<td>Polytechnic Institute of Coimbra</td>
</tr>
<tr>
<td>Polytechnic Institute of Leiria</td>
</tr>
<tr>
<td>Polytechnic Institute of Porto</td>
</tr>
<tr>
<td>Lusófona University</td>
</tr>
<tr>
<td>Lusiada University- Vila Nova de Famalicão</td>
</tr>
<tr>
<td>Portucalense University Infante D. Henrique</td>
</tr>
</tbody>
</table>

Source: Adapted from DGES Portugal

For 2nd cycle of studies searching, 18 HEIs (table 1) was analyzed, but only 13 HEIs have a Master’s program in IEM, resulting 9 Universities and 3 Polytechnic Institutes, including Lisbon School of Engineering (ISEL / Polytechnic Institutes of Lisbon), since the DGE list just includes Bachelor’s degree program and ISEL is an exception for offering a 2nd cycle of studies and not offers 1st cycle of studies in IEM.

Based on the data collected and the analyses carried out during the study
it was analyzed 567 curricular units for Bachelor’s degree program and 283 curricular units for Master’s degree program. Curricular units such as “Project”, “Dissertation” and extracurricular activities” were not considered since students choose topics to study. Thus, it was possible to reach the main findings and answer the research questions bellow:

**RQ1:** Are Portuguese HEIs training future IEM engineers for the era of circular economy?

Universities play an important role on CE transition through the curriculum education activities of CE (Qu et al., 2021). In this sense, it is they are expected to offer courses (Bachelor’s, Master’s degree program and postgraduate courses in Industrial Engineering and Management) that address CE in their curricula, training students to perform in this scenario, i.e. as leaders or policymakers, incorporating CE thinking. However, among 18 portuguese HEIs analyzed (Universities and Polytechnic Institutes), only Polytechnic Institute of Castelo Branco offers a Curricular unit named with words “Circular Economy” for IEM Bachelor’s degree program (see table 3). However, its syllabus is not available. Related to postgraduate courses, it was identified a couple of curricular units but not in IEM field, i.e. Environmental Engineering (“Circular Economy – Environment as sustainability factor” from Lusófona University), Information Science (“Sustainable Management and Circular Economy” from Institute Polytechnic of Porto) and Metallurgical and Materials Engineering (“Circular Economy” from Porto University).

**Table 3** - Bachelor’s degree programs in IEM

<table>
<thead>
<tr>
<th>HEI identification</th>
<th>HEI</th>
<th>Website</th>
<th>City/Region</th>
<th>Curricular unit</th>
<th>Syllabus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institute Polytechnic of Castelo Branco (IPCB)</td>
<td><a href="https://www.ipcb.pt/">https://www.ipcb.pt/</a></td>
<td>Castelo Branco/ North</td>
<td>Circular Economy</td>
<td>No available</td>
<td></td>
</tr>
</tbody>
</table>

Source: Prepared by the authors themselves.

**RQ2:** is there an Integration of CE principles in academic disciplines in IEM programs (1st and 2nd cycles of studies)?

*Bachelor’s degree programs in IEM*

Based on information from the website of 18 HEIs, CE principles are not mentioned in their program overviews. However, it was identified just one public
Polytechnic Institute that offers a curricular unit that involves the concept of CE (see table 4).

Table 4. Bachelor’s degree programs in IEM

<table>
<thead>
<tr>
<th>HEI identification</th>
<th>Website</th>
<th>City/Region</th>
<th>Curricular unit</th>
<th>Syllabus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institute Polytechnic of Coimbra (IPC)</td>
<td><a href="https://www.ipc.pt/">https://www.ipc.pt/</a></td>
<td>Coimbra/ Centre</td>
<td>Economics for Engineering</td>
<td>Sustainable Development and the Strategic Value of Sustainability; Concept of CE</td>
</tr>
</tbody>
</table>

Source: Prepared by the authors themselves.

Master’s degree programs in IEM

There are only 13 HEIs that offer master’s degree in IEM in Portugal. Based on their website, CE principles are not mentioned in their program overviews. There is only an intent related to sustainable development on Institute Polytechnic of Porto (IPP) program overview. However, 2 public universities and 1 public Polytechnic Institute have CE principles mentioned in their syllabi according to table 5. Note that University of Aveiro offers two Curricular Units and both are optional ones. Furthermore, sustainability is a topic that is associated to CE for all curricular Units analyzed.

Table 5. Master’s degree in IEM

<table>
<thead>
<tr>
<th>HEI identification</th>
<th>Website</th>
<th>City/Region</th>
<th>Curricular Unit</th>
<th>Syllabus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nova University Lisbon (UNL)</td>
<td><a href="https://guia.unl.pt/pt">https://guia.unl.pt/pt</a></td>
<td>Almada/Centre Lisbon Metropolitan Area</td>
<td>Sustainability and Operations</td>
<td>Identify the Sustainability goals; Categorize the principles of Circular Economy throughout the product life cycle</td>
</tr>
<tr>
<td>University of Aveiro (AU)</td>
<td>ua.pt</td>
<td>Aveiro/North</td>
<td>Eco-design and Eco-efficiency</td>
<td>Development of sustainable products and processes, in scope with circularity</td>
</tr>
<tr>
<td>University of Aveiro (AU)</td>
<td>ua.pt</td>
<td>Aveiro/North</td>
<td>Advanced Production Technologies</td>
<td>Ecological production and sustainability: Eco-design and circular economy</td>
</tr>
<tr>
<td>Institute Polytechnic Câvado and Ave (IPCA)</td>
<td><a href="https://ipca.pt/">https://ipca.pt/</a></td>
<td>Braga/North</td>
<td>Ledearship and Sustainability</td>
<td>Topics related to CE such as waste management and renewable energies</td>
</tr>
</tbody>
</table>

Source: Prepared by the authors themselves.

Figure 1 displays the map of Continental Portugal since there is no HEI in
IEM in Autonomous Region of the Azores or Autonomous Region of Madeira. In this map it can find 4 HEIs that address CE in Bachelor’s and Master’s degree program: Nova University Lisbon (UNL), University of Aveiro (UA) and Institute Polytecnic Câvado and Ave (IPCA). Note that the institutions are geographically dispersed. Furthermore, University of Aveiro (UA) and Institute Polytechnic of Coimbra (IPC) are found at the same region, Centre, that is not recognized by industrialization, but the north region.

RQ3: What teaching methods applied in curricular units that address CE principles in IEM program at portugueses HEIs?

Based on evidence, curricular units that address CE principles in both Bachelor’s and Master’s degree programs IEM are focused on traditional methods of theoretical and practical classes, with expository classes associated to practical exercises (with guidance), besides debates fostered in the classroom.

Innovative methodologies to support the teaching-learning process aiming intended learning outcomes were not identified.

5 CONCLUSION

Circular Economy is gaining greater attention of governments, industry and academia (Pieroni et al., 2019; Kirchherr et al.,2023). The concept is considered
an important way to achieve sustainable development (Kirchherr and Piscicelli, 2019) and it has emerged as a trending word that has generated many scientific publications every year that demonstrates its importance for companies such a business level to the global level. For achieving successful implementation of circular economy, Qu et al. (2020) highlight joint participation of the whole society, mainly Universities through their curriculum education activities. Furthermore, the authors add that the effective implementation of CE curriculum education in universities is an important guarantee for the implementation of the human resources strategy of CE.

After a long period of maturation, the European Commission approved an Action Plan for Circular Economy in 2015, pointing 54 actions in order to “... stimulate Europe's transition towards a circular economy, boost global competitiveness, foster sustainable economic growth and generate new jobs” (EC, 2015). In this sense, HEIs and their lecturers can play an important role (QU et al., 2020), become foundation for promoting the CE transition. However, this study did not identify a strong interest about CE on the part of HEIs and their lecturers. Their attention is still incipient.

In Portugal, as highlighted in the current study, the integration of CE principles in Industrial Engineering and Management (IEM) programs is still emerging. A systematic search of Portuguese HEIs revealed that while some institutions have started to incorporate CE related topics into their curricula, there is a significant gap in dedicated CE courses, particularly in IEM programs. For instance, only a few institutions such as the Polytechnic Institute of Coimbra and the University of Aveiro have introduced CE related content in their engineering programs.

To be more specific, findings suggest that HEIs are not training future IEM engineers for the era of CE. The lack of curricular units named with words “Cicrular Economy” (CE) make us think if CE is a concept that has not been appreciate by HEIs. Furthermore, the Integration of CE principles in academic disciplines in IEM programs (1st and 2nd cycles of studies) is still under developement. In a total of 18 HEIs that offer Bachelor’s degree program, it was identified only Institute Polytechnic of Coimbra (IPC) that bring in the “Economics for Engineering” curricular unit’s syllabus one topic about CE. For Master’s degree program, in a
total of 13 HEIs analyzed, it was identified only 3 HEIs (Nova University Lisbon, University of Aveiro and Polytechnic of Cávado and Ave) that offer curricular units that address CE in their syllabi (“Sustainability and Operations”, “Eco-design and Eco-efficiency”, “Advanced Production Technologies” and “Leadership and Sustainability”). It is important to mention those curricular units are optional ones and bring sustainability associated to CE.

We observe that the teaching methods of curricular units that address CE in their syllabi are mainly focused on traditional methods of theoretical and practical classes. For García-Peñalvo and Colomo-Palacios (2015) implementing innovative teaching methods in engineering field is mandatory to allow new knowledge arises. In this sense, we suggest the adoption of innovative methodologies to support the teaching-learning process. Active learning approaches based on real projects and problems can be an option.

This study contributes to make an alert to HEIs and their lecturer to review their teaching process, stimulating to improve the quality of the IEM curricula (1st and 2nd cycles of studies) towards to CE and encouraging others to openly discuss about the subject, as well.

It is recognized that CE field is still in development at Portuguese HEIs in IEM discipline. A recommended approach to overcome these issued would be a deep reform of the professional curriculum system, enriching curricular at first step with topics about CE in curricular units´syllabi, building a body of knowledge and then create a curricular unit totally towards to CE, encompassing transversal knowledge of a range of curricular units. Future studies can approach skills and competences developed towards CE what facilitate a redesign of courses.

At last, authors are aware of the study limitations. Their analyses were based on information available on the accessed HEIs websites. It is recognized that 50% curricular units´ syllabi of Polytechnic Institutes were not available at the time of research what be configured a shortcoming (Bachelor’s degree program). Still, it is an opportunity identified for Polytechnic Institutes pay more attention on information delivered on their websites for attract future students and professionals who cares about CE and its implications for society.
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