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Adequacy of existing circular economy assessment tools for higher education institutions

Karen Valls-Val [a], Valeria Ibáñez-Forés [a], Vanesa G. Lo-Iacono-Ferreira [b], Salvador F. Capuz-Rizo [b], María D. Bovea [a,*]

[a] Department of Mechanical Engineering and Construction, Universitat Jaume I, Castellón, Spain
[b] Project Management, Innovation and Sustainability Research Center (PRINS), Universitat Politècnica de València, Spain

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ABSTRACT

Circular economy (CE) has been identified as a key strategy to contribute to sustainable development and the achievement of the Sustainable Development Goals of the 2030 Agenda. In this context, organisations have started to demand methods to measure and monitor their level of circularity. To facilitate this task, several CE tools have been developed in recent years, which automatically measure, track and communicate the level of circularity of organisations based on answers to qualitative questions. In particular, Higher Education Institutions (HEIs), as organisations engaged in education, research and community services, play an important role in promoting sustainability and should be an example in the transition process towards CE. Therefore, they need approaches that allow them to measure and monitor their transition towards CE. The aim of this study is to analyse the adequacy of existing CE tools for HEIs, to check whether they consider the specificities of HEIs and to identify the required changes to make them suitable for HEIs. For this purpose, seven existing CE tools were applied to four Spanish HEIs, and were analysed and evaluated through interviews with the environmental managers of these HEIs. The results show that the existing CE tools need to be reformulated in order to make them suitable for assessing the level of circularity of HEIs and to make their outputs useful for decision-making. As a conclusion, it has been found that it is better to develop a specific CE tool for HEIs, in order to incorporate the specificities and peculiarities of such complex type of organisation, including the teaching, research and management areas.

1. Introduction

Circular economy (CE) is an essential strategy for contributing to the sustainable development objectives adopted by the 2030 Agenda (United Nations, 2015), as demonstrated by Schroeder et al. (2019). At the European level, the New CE Action Plan (COM 098, 2020) has been adopted as the main building block of the European Green Deal (COM 640, 2019) with the aim of extending the value of products, materials and resources for as long as possible in the economy, thus minimising waste generation. At the national level, some countries have formulated plans and policies to favour the transition to a more sustainable and environmentally friendly economic model. For example, Spain has approved the Spanish Circular Economy Strategy "Spain Circular 2030" (EEEC, 2020) and the 1st Circular Economy Action Plan 2021–2023 (PAEC, 2021).

Public awareness and relevant consumer behaviours are crucial to accelerate the transition to a circular economy model, i.e. the successful development of CE strategies requires consumers' involvement (Shevchenko et al., 2023). The Eurobarometer 367 (2012), a survey conducted by the European Commission to assess consumer attitudes towards a green market, concluded that European citizens are concerned about the environment, but lack information. Therefore, Higher Education Institutions (HEIs), as an engine of knowledge and technology, can have a significant impact on the public's CE awareness and future consumer behaviour through CE education to drive the CE from theory to reality (Nunes et al., 2018). Indeed, the 2030 Sustainable Development Strategy of the Spanish Government (MDSA2030, 2020) stated that HEIs can and must contribute decisively to the collective transformation of the current economic and social model, through the generation and transfer of knowledge, as well as the training of future professionals. So, HEIs are uniquely positioned to assist with the implementation of the 17 Sustainable Development Goals (SDG) and

* Corresponding author.
E-mail address: bovea@uji.es (M.D. Bovea).

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169 targets to promote economic prosperity, social inclusion and environmental sustainability (Saralegi et al., 2020). Indeed, in 2020, the UN called for the mobilisations of efforts to implement the principles of the 2030 Agenda and highlighted the privileged position of HEIs in its promotion. Accordingly, Fia et al. (2022) reviewed 130 articles and observed that the 2030 Agenda is resulting in changes within and among HEIs, although the implemented strategies are very different from one case to another. On the other hand, United Nations Sustainable Development Goal (SDG) no. 4 (quality education) acknowledges education's role in promoting sustainable development, sustainable lifestyles, human rights, social responsibility, circular economy, and greening our economy and society (Obrecht et al., 2022). Moreover, it is interesting to create education and training programmes specifically focused on CE, to support companies' investments in CE and contribute to SDG 9 (Industries, Innovation and Infrastructure). These programmes would familiarise students with the concept and would encourage the creation of knowledge exchange networks between companies and research institutions (Stucki et al., 2023). Furthermore, HEIs also represent a source of environmental impacts due to significant resource consumption and waste generation (Mendoza et al., 2019), so by applying management operations to address these issues, they can contribute to SDG12 (Responsible production and consumption) (Saralegi et al., 2020).

So, HEIs, as engines of skills and knowledge, play a key role in the transition towards circular economy, contributing to CE in several ways: by collaborating with industry, assisting policy makers, building human and intellectual capital, supporting community engagement projects, influencing university culture, linking to international CE networks, and promoting an inclusive discourse on CE (Salas et al., 2021). HEIs are one of the effective driving forces for promoting the bottom-up transition towards the CE model (Qu and Shevchenko, 2019) and CE education in universities has been considered one of the most pivotal factors to realize the transition towards the CE model (Bugallo-Rodríguez and Vega-Marcote, 2020) as HEIs can contribute to the preparation of responsible graduates involved in the circular economy and the maintenance of the sustainable development. Consequently, they themselves should be an example for their students and staff, as well as for society as a whole, in terms of sustainability and circular economy transition. Therefore, they should start implementing circularity models on their campus.

The role of HEI in sustainability is recognised by different international declarations such as the Talloires Declaration (TD, 1990), associations/networks such as the CRUE's Sectoral Sustainability Commission (CRUE, 2002), the Association for the Advancement of Sustainability in Higher Education (AASHE, 2022), the International Sustainable Campus Network (ISCN, 2007), the Global Universities Partnership on Environment for Sustainability (GUPES, 2012) or the Talloires Network of Engaged Universities (TUFTS, 2011), as well as rankings such as the Times Higher Education-World University Ranking (THE, 2004), the Sustainability Monitoring, Assessment and Rating System (STARS, 2013) or the UI GreenMetric World University Ranking on Sustainability (UI GreenMetric, 2010). In addition, an adaptable model for sustainability assessment in HEIs has been proposed (Gómez et al., 2015); the suitability of Organisational Life Cycle Assessment for HEIs has been analysed (Lo-Iacono-Ferreira et al., 2017) and a Key Performance Indicators to optimise the environmental performance of HEIs with an environmental management system have been proposed (Lo-Iacono-Ferreira et al., 2018). Furthermore, the carbon footprint in HEIs have been reviewed (Valls-Val and Bovea, 2021), the carbon footprint of Spanish HEIs calculated with a tool developed by the Spanish government was analysed (Guerrero-Lucendo et al., 2022) and a carbon footprint calculation tool for HEIs has been developed (Valls-Val and Bovea, 2022).

On the other hand, regarding CE in HEIs, several publications have analysed the role of HEIs in the transition towards CE to date: Serrano-Bedia and Perez-Perez (2022) reviewed 77 articles to analyse the role of HEIs in the transition to CE and found that they are well placed to collaborate with industry professionals, consumers and governments to address these challenges; Nunes et al. (2018) analysed 70 publications to conduct a rapid evidence assessment to examine the interactions between university assets and CE and identified different areas where universities can support CE; Salas et al. (2021) analysed the role of HEIs in the transition towards a CE in Latin American countries; Qu et al. (2021) defined HEI assets related to CE and developed a theoretical framework for HEI activities related to CE; Mendoza et al. (2019) identified, assessed and prioritised areas of intervention for the implementation of higher education business model innovations in a university context, which can help to inspire HEIs to build a business case for CE implementation; Hopff et al. (2019) analysed how circularity principles can be integrated into the daily practice of university campuses and offered recommendations for an integrated circularity strategy in campus development; among others.

It is therefore evident that if HEIs plan to implement circularity strategies, they need approaches to assess their actual level of CE implementation and tools that allow them to evaluate (in a simple way) and communicate (in a clear and unequivocal way) the results of their transition towards more circular models. However, measuring CE

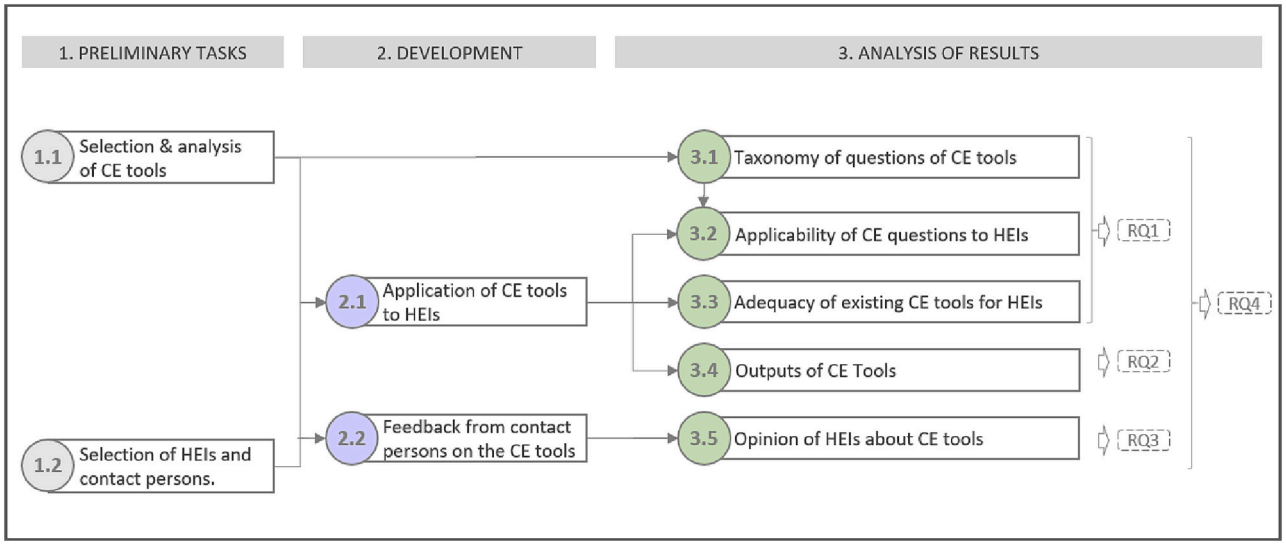

Fig. 1. Methodological approach.

implementation is a complex and challenging process for HEIs worldwide, since they present structural and organisational complexity. At the organisational level, since the European Commission established the need to obtain CE performance indicators for measuring the advance of organisations towards the CE (COM 102, 2020), different approaches have been developed to measure the level of implementation of the circular economy in organisations. On the one hand, studies such as Rossi et al. (2020) or Ibáñez-Forés et al. (2022) have proposed indicators, while Franco et al. (2021) or Ahmed et al. (2022) have proposed methods or frameworks. Moreover, generic CE tools have been developed, which automatically calculate the level of circularity of the organisation based on the answer to certain questions, such as CircularTRANS (2020) or MATChE (2021), among others. On the other hand, normative documents have been developed with the aim of promoting the circular economy: BS 8001 (2017), the first practical framework and guide for organisations to implement the principles of the CE; GRI 306 (2020), the standard to facilitate reporting on waste-related impacts of operations, goods and services, enabling organisations to recognise circularity and waste prevention opportunities; and ISO/DIS 59020 (2023), that is under development and stipulates a framework for organisations to measure and assess circularity. However, despite the evidence of the role of HEIs in contributing to the transition towards a CE, to date no methodologies or tools have been developed to measure the level of implementation of the circular economy in HEIs. Furthermore, as HEIs are structurally and organisationally complex, it cannot be assumed that the above-mentioned approaches aimed at organisations are suitable or appropriate for HEIs.

In light of the observed research gap regarding circularity measurement methodologies for HEIs and given that CE tools are the most automatic measurement approach, the aim of this paper is to analyse the adequacy of existing CE tools capable of measuring the level of circularity of HEIs, and to identify aspects that should be included in a CE tool

Table 1
Categories and number of questions of existing CE tools.

CE tool	Categories defined by each CE tool	No. of questions by category	No. of total questions
CAS2.0 (CAS2.0, 2021)	Information	6	29
	Business Model Potential for Circularity	9	
	Commitment to Circular Transformation	11	
	Type of business model	3	
CE-Diagnosis (CE-Diagnosis, 2017)	Information	7	34
	Procurement	4	
	Processing	3	
	Distribution	3	
	Consume	5	
	Reintroduction	5	
	Symbiosis	3	
	Relationships	4	
CircularTRANS (CircularTRANS, 2020)	Information	6	141
	Socio-cultural	3	
	Suppliers	14	
	Environment	2	
	Economic	3	
	Political-legal	6	
	Technological	2	
	Customers	18	
	Strategic Processes – Strategies	12	
	Strategic Processes – Objectives	2	
	Operational Processes – Product/service offered	39	
	Operational Processes – Design and development	9	
	Operational Processes – Purchasing process	12	
	Support Processes – Facilities	6	
	Support Processes – Training	4	
	Support Processes – Communication	3	
Circulytics (Circulytics, 2020)	Information	15	40
	Strategy & Planning	6	
	Innovation	8	
	People & Skills	4	
	Operations	2	
	External Engagement	5	
CM-FLAT (Sacco et al., 2021)	–	–	45
INEDIT (Inedit, 2020)	Information	6	12
	Education	6	
MATChE (MATChE, 2021)	Information	7	37
	Organisation	4	
	Strategy & Business Model Innovation	5	
	Product & Service Innovation	4	
	Manufacturing & Value Chain	4	
	Technology & Data	2	
	Use, Support & Maintenance	3	
	TakeBack & End-of-Life Strategies	3	
	Policy & Market	5	

focused on HEIs. To fill this scientific gap, four research questions are proposed: RQ1- Are existing CE tools adequate to HEIs? RQ2- Are the outputs of the CE tools useful for decision making in HEIs? RQ3- What is the opinion of HEI environmental managers regarding these CE tools? RQ4- How could existing CE tools be improved to be adequate for HEIs? To answer these questions, this paper is structured as follows: Section 2 describes the proposed three-stage methodology, the application and results of which are reported in Section 3 and discussed in Section 4. The conclusions from the study are detailed in Section 5.

2. Materials and methods

The methodological procedure adopted in this study to answer the research questions was based on three main stages shown in Fig. 1 and described below.

Stage 1 grouped the preliminary tasks needed for the development of the study and consisted of the selection of the CE tools to apply and the HEIs for the case study:

- **Stage 1.1** the CE tools to be used in the study were identified, selected and analysed. Following the recommendations of Valls-Val et al. (2022, 2023), the seven qualitative CE tools were selected for this study: CAS2.0 (CAS2.0, 2021), CE-Diagnosis (CE-Diagnosis, 2017), CircularTRANS (CircularTRANS, 2020), Circulytics (Circulytics, 2020), CM-FLAT (Pigosso and McAloone, 2021), Inedit (Inedit, 2020) and MATChE (MATChE, 2021). Table 1 presents the selected CE tools, with their categories, the number of questions by category and the total number of questions. It is noteworthy that only the qualitative category enablers from the Circulytics tool were calculated in this study using the information provided by EMF (EMF, 2022a, 2022b) and for the CM-FLAT tool the calculations were made by the authors of the study using the methodology described in Pigosso and McAloone (2021), as the CE tool is not yet available.

- In **Stage 1.2**, the HEIs were chosen, to which the CE tools selected in Stage 1.1 will be applied, as well as the contact person to be interviewed in order to apply the CE tools in their HEIs and to obtain their feedback.
  - Four public Spanish Universities were selected, ranging from 13,000 to 32,000 students and from 1700 to 4000 employees, and differed in terms of the age, size of the facilities, number of campuses and degrees offered. To anonymise the results, the four HEIs will be identified as A, B, C and D, since the aim of the study is to analyse the adequacy of the CE tools and not to carry out an assessment of the level of circularity of the HEIs or to perform a benchmarking study.
  - The Environmental Office of each HEI was chosen as the unit in charge of conducting this study, since it is responsible for the management of environmental issues and the integration of sustainability at the university. Among the staff, which ranges between 2 and 7 people depending on the HEIs, the head of each Environmental Office was selected to fill in the CE tools and give feedback. These managers are specialists in environment and sustainability, with bachelor's degrees related to chemistry, environmental sciences or engineering. In addition, three of them have or are about to get, a PhD degree. Moreover, three of them have filled in the UI-GreenMetric ranking and two of them are members of the executive committee of CRUE-Sustainability. Regarding the tasks carried out in the Environmental Office, they are responsible for the Carbon Footprint calculation, the development and maintenance of the Environmental Management System (EMAS/ISO 14001) and the diagnosis of the environmental sustainability of the HEI, using the survey developed by CRUE-Sustainability (the main interlocutor of Spanish universities with the central government on issues related to environmental management).

Stage 2 consisted of the development of the main body of the study and was subdivided into two sub-stages, corresponding to the application of the CE tools selected in Stage 1.1 to the HEIs identified in Stage 1.2. This stage was carried out by guided interviews with the environmental managers of the four HEIs, lasting between 120 and 160 min and structured in two parts that correspond to the following sub-stages:

- **Stage 2.1**, in which the interviewer presented the CE tools to the HEI environmental managers and they completed the required information with the knowledge they had of their HEI. Furthermore, they identified the questions they considered not applicable to their institution. Finally, the result report, the CE indicators and the circularity level obtained by applying each CE tool was analysed.
- **Stage 2.2**, in which the HEI environmental managers answered a questionnaire where their opinion of each tool was collected. This questionnaire was based on the one proposed by Valls-Val et al. (2023) and included different aspects related to the application process, content, results and design. For each aspect, different questions were proposed and measured using a Likert scale from 1 to 5, as shown in Fig. 2. Finally, the HEIs experts provided feedback and additional comments.

Finally, **Stage 3** consisted of the analysis of the results that were directly related to the four RQ. For that, the following sub-stages were developed:

- **Stage 3.1** consisted of grouping the questions of the CE tools into thematic blocks, since, as shown in Table 1 and already observed by Valls-Val et al. (2023), the number of questions greatly differs between the CE tools selected in Stage 1.1, which makes their content analysis difficult. Finally, an analysis of the thematic blocks and categories included in the existing CE tools was carried out.

FUNCTIONALITY ASSESSED		1	2	3	4	5
APPLICATION PROCESS	Adequacy of invested time	Low				High
	Adequacy of the number of questions	Low				High
CONTENT	Clarity of questions statements	Low				High
	Repetitiveness of questions	High				Low
	Consideration of the specificities of the organisation	Low				High
	Difficulty in answering the questions	High				Low
RESULTS	Level of detail of the report	Low				High
	Level of use/exploitation of the report	Low				High
	Level of adjustment of the score to the organisation's reality	Low				High
	Usefulness of the improvement opportunities offered	Low				High
DESIGN	Simplicity of use of the tool	Low				High
	Tool design	Bad				Good

Fig. 2. Opinion questionnaire on each CE tool.

- **Stage 3.2** consisted of analysing the applicability of the questions to the HEIs, through the analysis of the applicability of the proposed thematic blocks and categories. For this purpose, the ratio between directly applicable questions and non-applicable questions was analysed, based on the responses and comments of the HEI environmental managers in Stage 2.1.
- **Stage 3.3** consisted of analysing the adequacy of the existing CE tools for the HEIs. According to the answers and comments of the HEI environmental managers in Stage 2.1, the applicable and non-applicable questions of the CE tools to HEIs were identified. Additionally, for each of the CE tools it was analysed whether the non-applicable questions were penalising questions (they distort the level of circularity obtained) or non-penalising questions (they are optional questions or included the response option "non-applicable" and were automatically removed from the sample for the calculation of the level of circularity). In this way, the adequacy of each of the CE tools was obtained to determine which CE tools were more suitable or appropriate for HEIs. For this purpose, the ratio between directly applicable questions and non-applicable penalising questions was analysed, excluding from the sample the non-applicable questions that do not penalise the score for each CE tool.
- **Stage 3.4** consisted of analysing the level of circularity calculated by the CE tools obtained in Stage 2.1, in order to identify whether the results were comparable or whether there was any trend in the scores (analysing whether any CE tool tended to give higher scores).
- **Stage 3.5** consisted of analysing the opinion and feedback of HEI environmental managers on the CE tools. For this purpose, the results of the evaluation template and the additional comments given by the HEI experts in Stage 2.2 were analysed.

Table 2
Description and codification of the thematic blocks grouped into 10 categories.

Category	Thematic block	Code	Description	% questions
Design	Circular design	D-CD	Consideration of circular criteria in product design, e.g. durability; reliability; modularity; standardisation; facility for disassembly, upgrading, reconditioning, remanufacturing, reuse, or recycling; energy-efficient product design; products with low consumable consumption; minimisation of material use; etc.	13.9 %
	Circular packaging	D-CP	Consideration of circular criteria for packaging design: Shared, reused, recycled, reusable, recyclable, minimal material packaging.	2.1 %
Supply chain	Sustainable suppliers	SC-SS	Use of sustainability and/or circular criteria in the supplier selection process. Assessment of suppliers' circularity or compliance with environmental legislation.	2.5 %
	Proximity of suppliers	SC-PS	Consideration of proximity in supplier selection	0.7 %
	Distribution	SC-DI	Sustainable or circular criteria in the transport of the product produced by the organisation. For example: optimisation of routes to minimise environmental impact, means of transport saturated to the maximum, etc.	2.1 %
Inputs	Materials circularity	I-MC	Sustainable procurement process, procurement of raw materials or components with circular or environmental criteria (secondary sources, certified materials, recycled, biodegradable or compostable materials).	9.8 %
	Sustainable energy	I-SE	Use of sustainable energy (produced in the organisation or purchased) or existence of a sustainable energy strategy plan.	3.2 %
Production	Resource optimisation	P-RO	Optimisation of the use of materials, water or energy in the organisation, through the recirculation of materials, the reduction of consumptions or the use of heat to generate energy.	1.8 %
	Circular assets	P-CA	Use of circular assets: leasing of assets instead of purchase, sharing of infrastructure or machinery with other organisations.	1.4 %
	Standards or legislation compliance	P-SL	Compliance or knowledge of legislation that affects the sector or environmental legislation or presence of a management system (e.g. ISO 14001, ISO 9001)	3.2 %
Outputs	Solid waste management	O-SW	Solid waste management, reduction of solid waste generation or generation of hazardous waste.	1.5 %
	Liquid effluents management	O-LE	Liquid effluent management (reduction, recovery, recirculation, recycling, etc.)	0.6 %
	Gaseous effluents management	O-GE	Gas effluent management (reduction, recovery, recirculation, recycling, etc.)	0.6 %
Environmental impact	Environmental management	EI-EM	Environmental management policy or measurement of the environmental impact of the organisation (carbon footprint, environmental footprint, etc.)	1.4 %
Social	CE Training	S-TR	Development of specific training programmes related to circular economy and need for circular economy knowledge in the organisation.	2.5 %
	CE employment	S-EM	Creation of new jobs related to the circular economy or existence of jobs dedicated to the implementation of the circular economy.	0.7 %
R&D in circularity	Investment in CE	RD-I	Investments in circular economy initiatives.	3.2 %
	CE patents	RD-P	Presence of circular economy patents	0.4 %
Business	Organisational commitment to the CE	B-OC	Commitment to or integration of the circular economy in the organisation. For example, presence of a CE implementation plan or project; strategy aligned with CE; CE objectives; specific CE commitments and responsibilities for employees and managers or active participation in a circular economy association.	9.3 %
	Stakeholder involvement or collaboration	B-SI	Involvement or resistance of or commitment or collaboration with the CE of stakeholders (institutions, universities, competitors, suppliers, recyclers suppliers, logistics companies, market, investors, employees, buyers or customers, end-users).	14.3 %
	Circular services	B-CS	Services offered by the company that promote the circular economy. For example: after-sales repair service, maintenance service, consultancy or advisory service, product rental instead of purchase, sharing platforms, or second-hand sales.	14.6 %
	Symbiosis	B-SY	Value chain partnerships: Utilisation of waste from another company or marketing of waste to another company	1.4 %
	Technology-Digitisation	B-TD	Use of technology to adapt the organisation to circular principles. E.g., industry 4.0, technology use for a more circular production process, digitisation of processes, monitoring of products during the use phase, etc.	4.6 %
Communication	Internal Communication	C-IC	Internal communication on circular economy issues	1.8 %
	External Communication	C-EC	External communication on circular economy issues	2.1 %

3. Results

3.1. Analysis of the taxonomy of questions of CE tools

Firstly, the questions about the same issue were aggregated into the proposed thematic blocks described in Table 2. These blocks were based on the review of the questions included in each CE tool, of the themes used in the circular economy review studies (de Oliveira et al., 2021; De Pascale et al., 2021; Valls-Val et al., 2022 among others) and of the indicators defined by Eurostat (2019). It should be noted that the perspective of HEIs has been considered, analysing only the questions that the CE tools included when an educational sector was chosen and aggregating the questions taking into account the characteristics of HEIs (e.g., all questions related to circular product design have been aggregated, without disaggregating by criteria, as HEIs do not develop products). Subsequently, given that each CE tool considers different categories (as shown in Table 1), the thematic blocks were grouped into the 10 CE categories listed in Table 2 and proposed by Ibáñez-Forés et al. (2022) based on the analysis of the information from 8 frameworks that measure circularity at the territorial level: Eurostat (Eurostat, 2019), GREP (BMUB, 2016), 11KI (SDES, 2021), FBAN (PBL, 2018), CHCEIS (NDCR, 2017), FPSMS (Government of Japan, 2018), ECEI (IHOBE, 2018), and SCES (EEEC, 2020).

It should be noted that Table 2 shows that the CE tools do not include any question related to circular water input, which excludes from the assessment an important part of circularity in organisations. On the other hand, it is important to highlight that the questions related to circularity strategies on the product or service offered have been divided into *Circular Design (P-CD)* and *Circular Services (B-CS)*. Thus, *Circular Design (P-CD)* includes questions related to the consideration of circularity criteria in the design of the product or service (e.g. designing the product to be remanufacturable), while *Circular Services (B-CS)* includes questions related to the circular services offered by the company (e.g. selling remanufactured products).

On the one hand, Table 2 and Fig. 3 show that some thematic blocks and some CE categories are more considered than others. Regarding the categories, the most considered is *Business* (accounting for almost 50 % of the total questions and on average 45 % of questions by tool), followed by *Inputs* (accounting for 15 % of the total questions and of the average of questions by tool), *Design* (accounting for 10 % of the total questions and 16 % of the average of questions by tool), *Supply Chain* and *Production* (accounting for around 5 % each of total questions, and 10 % and 5 % of the average of questions by tool, respectively) and, finally, *Communication*, *R&D in circularity*, *Social*, *Outputs* and *Environmental Impact* (representing together less than 15 % of the total questions and less than 5 % of the average of questions by tool each). In terms of the thematic blocks, the most considered are *Circular Design (P-CD)*, *Circular Services (B-CS)*, *Organisational commitment to CE (B-OC)* and *Stakeholder Involvement (B-SI)* (each accounting for approximately 15 % of the total questions and on average between 10 % and 15 % of the questions by tool), followed by *Materials Circularity (I-MC)* (accounting for approximately 10 %); these five categories correspond to 60 % of the questions. The other 20 thematic blocks account for less than 40 % of the questions, ranging from 5 % to 0.4 % of the total questions each, with the most overlooked being *Liquid and Gaseous Effluents management (O-LE; O-GE)* and *CE patents (RD-P)*.

Fig. 3 shows the percentage of questions for each CE tool, as well as the average, corresponding to each thematic block. As can be seen, each CE tool gives a different emphasis to each of the proposed thematic blocks and categories.

The CE tools (except Inedit) have the highest number of questions directly related to *Business* category, focusing on thematic blocks *Circular Services (B-CS)*, the *Organisation Commitment to CE (B-OC)* and to the *Stakeholders Involvement to CE (B-SI)*.

- **CM-FLAT** includes the widest range of categories and thematic blocks, including the ten categories and the 75 % of thematic blocks. Regarding the categories, it focuses on *Business*, *Supply Chain*, *Inputs* and *Outputs*; and in terms of thematic blocks, the most considered are *Circular Services (B-CS)*, *Distribution (SC-DI)*, *Materials Circularity (I-MC)*, *Solid Waste management (O-SW)* and the selection of *Sustainable Suppliers (SC-SS)*.
- **Inedit** includes the fewest number of categories, and it is the only one that does not consider the *Business* category, since it is the CE tool with the smallest number of questions. It gives greater weight to *Supply Chain* and *Inputs*, considering equally the thematic blocks included.
- **CircularTRANS** includes all categories, except *Outputs*, focusing on the *Business*, *Design*, *Inputs* and *Production* categories. Regarding the thematic blocks, it focuses on *Circular Design (D-CD)*, *Stakeholder Involvement (B-SI)*, *Materials Circularity (I-MC)*, *Circular Services (B-CS)* and *Organisation Commitment to CE (B-OC)*, three of them corresponding to the *Business* category.
- **MATChE** considers 7 categories (excluding *Supply chain*, *Outputs* and *Environmental Impact*), although it focuses mainly on *Business* (with a weight of approximately 75 %). In fact, it includes all *Business* thematic blocks, and *Circular Services (B-CS)* is the most considered, while in the rest of the categories it only includes one thematic block.
- **Circulytics** includes 6 categories, focusing on *Business* (considering *Organisation Commitment to CE (B-OC)*, *Stakeholder Involvement to CE (B-SI)* and *Technology and digitisation (B-TD)*), followed by *Communication* (*Internal and External (C-IC; C-EC)*), *R&D in circularity* (*Investment in R&D (RD-I)*), Design (including only *Circular Design (D-CD)*), *Social* issues (*CE Training (S-TR)* and *Employment (S-EM)*) and finally *Production* (considering only the *Circular Assets (P-CA)*).
- **CAS2.0** has the highest number of questions that can be directly related to *Business* (specifically it focuses on *Stakeholder Involvement (B-SI)* and *Technology and Digitisation (B-TD)*) followed by *Inputs* (*Materials Circularity (I-MC)* and *Sustainable Energy (I-SE)*), Design (including *Circular Design (D-CD)*), *Supply Chain* (selection of *Sustainable Suppliers (SC-SS)*) and *R&D in circularity* (only *Investment (RD-I)*), neglecting the rest of the categories and thematic blocks.
- **CE diagnosis** focuses on the *Business* category (including questions of *Circular Services (B-CS)*, Symbiosis (B-SY) and *Stakeholder Involvement (B-SI)*), followed by *Design* (focusing mainly on *Circular Design(D-CD)*, which is, together with *Circular Services*, the most considered thematic block), *Production* (ignoring *Standards or Legislation (P-SL)* in this category), *Supply Chain* (focusing on the *Distribution (SC-DI)* and the selection of *Sustainable Suppliers (SC-SS)*) and *Inputs* (considering equally the *Materials Circularity (I-MC)* and the *Sustainable Energy (I-SE)*).

3.2. Analysis of the applicability of the CE questions to HEIs

HEI environmental managers identified the questions they considered not applicable to their organisation during the interviews. Considering this information and the classification of the questions into thematic blocks and categories, the applicability of the questions can be analysed. To this end, Fig. 4 shows the percentage of applicable and non-applicable questions identified for the 25 proposed thematic blocks (a) and for the identified 10 circularity categories (b).

Regarding the **thematic blocks**, compliance with *Standards and Legislation (P-SL)*, *Environmental Management (EI-EM)*, *Employment creation (S-EM)*, *CE Patents (RD-P)* and *Internal Communication (C-IC)* were fully applicable to the HEIs interviewed, although these were also thematic blocks that included a small number of questions, so the possibilities of applicability were greater. Moreover, *R&D investments (RD-I)*, *Sustainable Energy (I-SE)*, *Organisational Commitment (B-OC)* and *CE Training (S-TR)* were composed of more than 75 % of applicable questions; *and Circular Assets (P-CA)* and *Sustainable Suppliers (SC-SS)* had more than 50 % of applicable questions. *Proximity of Suppliers (SC-PS)*,

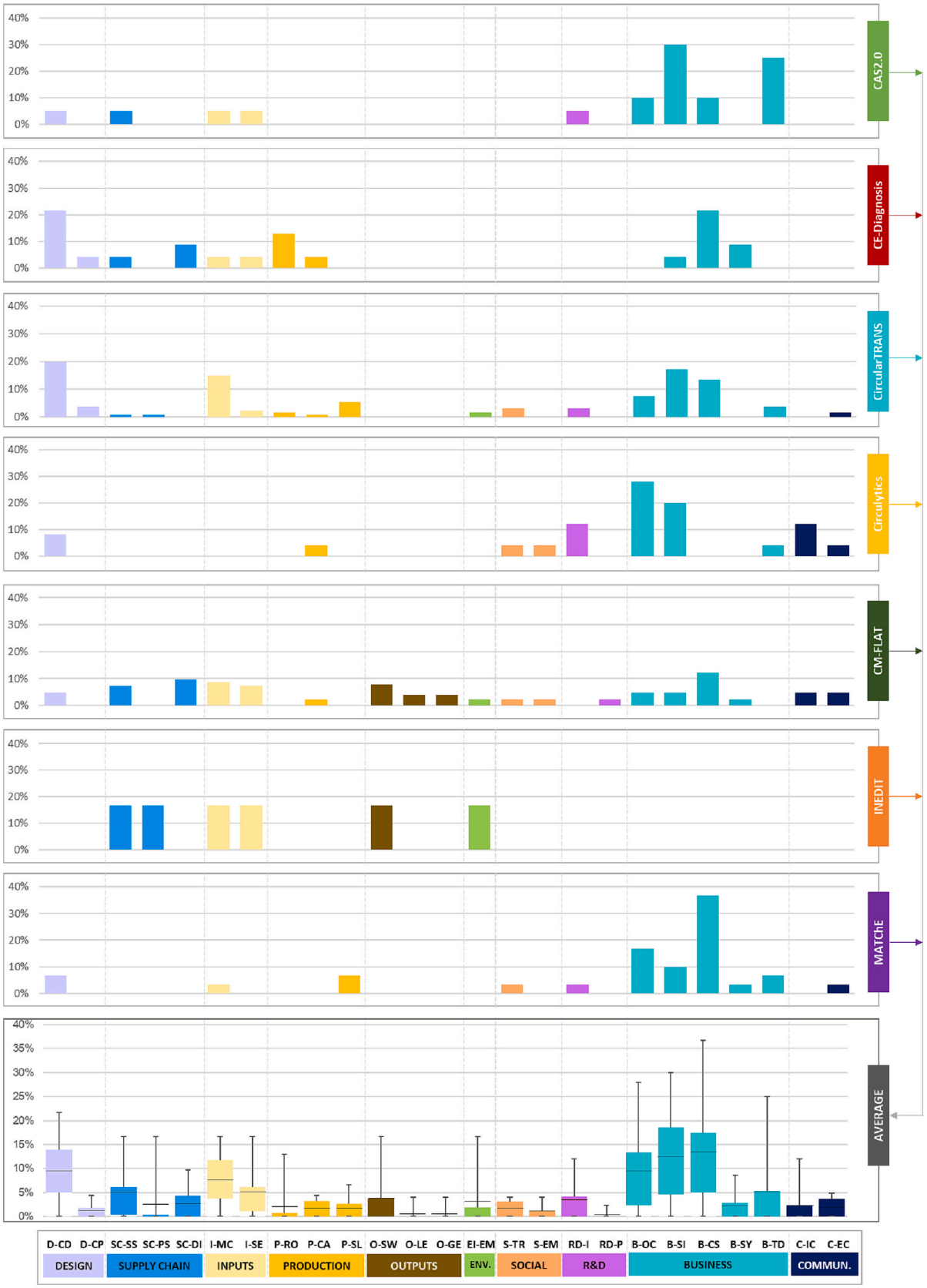

Fig. 3. Classification of CE tool questions by thematic block.

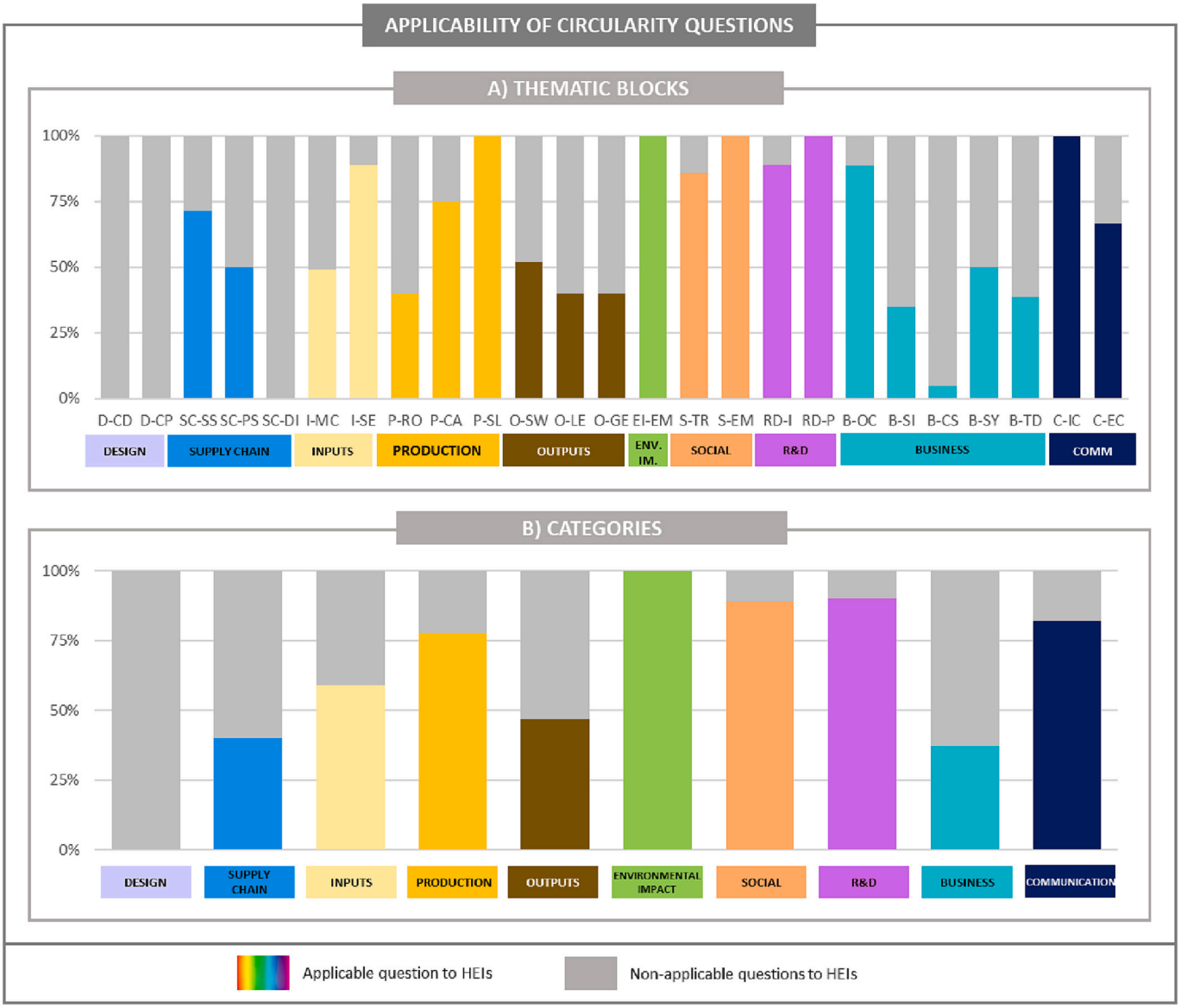

Fig. 4. Applicability of circularity questions: thematic blocks (A), circularity categories (B).

Material Circularity (I-MC), *Solid Waste management (O-SW)* and *Symbiosis (B-SY)* had the same number of applicable and non-applicable questions. On the contrary, questions related to *Circular Design (D-CD)*, *Circular Packaging (D-CP)*, product *Distribution (SC-DI)* and *Circular Services (B-CS)* were not applicable to the HEIs interviewed (all the questions that they include, or at least more than 95 %, are not applicable), as these blocks were directly related to circular products and HEIs do not manufacture products. Moreover, *Resource Optimisation (P-RO) Liquid Effluents (O-LE)*, *Gaseous Effluents (O-GE)*, *Technology or Digitisation (B-TD)*, *Stakeholders involvement to CE (B-SI)* and *External Communication (C-EC)* only include between 25 and 50 % of the applicable questions.

Therefore, it was possible to conclude that the thematic blocks with the highest applicability to HEIs (more than 75 % of applicable questions) can be designed based on the questions currently included in the existing CE tools. On the other hand, the thematic blocks related to the product (*Circular Design*, *Circular Packaging*, and *Product Distribution*) were not applicable to HEIs and should be eliminated in the circularity assessment of an education and research organisation. The remaining thematic blocks included applicable and non-applicable questions, so they should be fully analysed, and the non-applicable questions should be reformulated considering the characteristics of these organisations to make them applicable to HEIs.

Regarding the **categories**, *Environmental Impact* is the only fully applicable category (although also the category with the lowest number of questions). Followed by *Social, R&D in circularity*, *Communication and Production* (composed of more than 75 % of applicable questions), *Inputs* (with more than 50 % of applicable questions), and *Outputs*, *Supply Chain* and *Business* (composed of between 25 % and 50 % of applicable questions). Finally, the *Design* category does not include any question applicable to HEIs.

3.3. Analysis of the adequacy of CE tools for HEIs

As explained in Section 2, to analyse the adequacy of the existing CE tools for HEIs, and thus to determine which CE tools were most suitable or appropriate for HEIs, it is necessary to classify the non-applicable questions into two types: penalising questions (mandatory questions that distort the level of circularity calculated by the CE tool) and non-penalising questions (questions that are optional or have the option

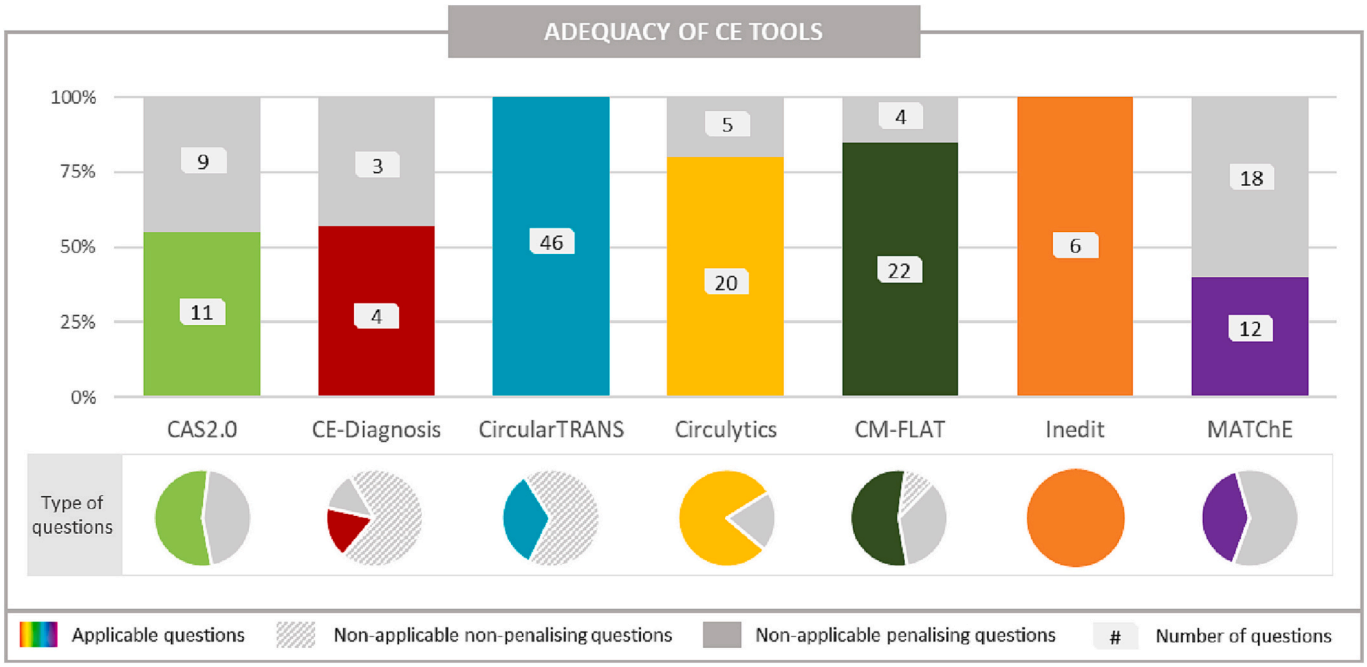

Fig. 5. Adequacy of existing CE tools for HEIs.

"not applicable" and therefore are not used for the calculation of the level of circularity). As a result, Fig. 5 shows the breakdown of the questions for each CE tool in the circular graphs at the bottom of the figure.

Subsequently, non-penalising questions were excluded from the analysis of the adequacy of the CE tools, as they were not used in the calculation of the level of circularity of the organisations, and therefore did not influence the adequacy of the CE tool. Fig. 5 shows the relationship between applicable questions and non-applicable penalising questions identified for the seven selected CE tools, together with the absolute number of questions of each type.

Regarding the **CE tools**, Inedit was identified as the tool with the most suitable tool for HEIs, although it was also the CE tool with the lowest number of questions (see Table 1), so the probability of having some non-applicable questions was lower. In second place was CircularTRANS, and although it had only around 35 % of directly applicable questions, the non-applicable questions were non-penalising and were removed from the sample. Therefore, it provided an undistorted level of circularity but had the disadvantage of requiring a lot of time to read questions that did not apply. Thirdly, CM-FLAT and Circulytics included more than 75 % of applicable questions. It should be noted that CM-FLAT removed 35 % of the questions from the sample because they were non-penalising questions, while Circulytics which is focused on the strategic level, includes questions that can be answered by any organisation. However, the questions that did not apply were mandatory and therefore penalised the level of circularity obtained. Next, CAS2.0 and CE-Diagnosis had 50 % of applicable questions. However, it is important to note that CE-Diagnosis had removed 70 % of the questions from the sample as they were non-penalising, using only 7 questions for the calculation of the level of circularity. Finally, MATChE was the CE tool identified as least suitable, as it included only 40 % of applicable questions since it is highly focused on production organisations.

3.4. Analysis of the outputs of the CE tools

HEI environmental managers filled in the seven CE tools with their organisational data. Table 3 shows the indicators calculated in each CE tool with their scoring scale in brackets, and the score obtained for the four case studies.

Fig. 6 shows the aggregated results for each CE tool. Analysing the results, it can be seen that each CE tool calculated different indicators and used a different scoring scale.

To check the comparability of the results, and to observe whether there is a trend in the scores, the global indicators of the CE tools were calculated on a common scale (0–100). Fig. 6 shows the score obtained for the four application cases (A, B, C and D) in each CE tool and the trend analysis of CE tools score.

Fig. 6 shows that the score obtained for the same case study varies greatly from one CE tool to another, varying to a greater extent in the case of application C, followed by D, B and A. Moreover, Circulytics and MATChE are the CE tools that give the lowest scores overall, while the CE tool that gives the highest scores is CE-Diagnosis followed by Inedit and CAS2.0. The CircularTRANS and CM-FLAT CE tools give intermediate scores.

On the other hand, it is observed that in terms of the average score, the application case with the highest score is D, followed by B, A and C. This should occur in a similar way in all the CE tools; however, it is observed that the trend of each CE tool is different. Any CE tool follows the same trend as the average. Although, in general, case studies D and B obtain the highest scores and case study C the lowest score.

3.5. Analysis of the opinion of HEI environmental managers about CE tools

After completing each CE tool and analysing the results, the HEI environmental managers filled in an evaluation template (described in Fig. 2), to assess the functionalities of each CE tool and give feedback regarding the tool application process, content, results, and design. The managers responded the proposed questions for each aspect using a Likert scale from 1 to 5 and provided feedback and additional comments.

The results obtained from the evaluation template for the seven CE tools are shown in Fig. 7. It shows the assessment results obtained in each functionality analysed for each CE tool. Dashed lines indicate that the CE tool does not have this functionality, so it cannot be evaluated.

As can be seen in Fig. 7, different opinions were found between the

Table 3
Indicators provided by the CE tools for the four application cases.

CE tool	Indicator (scale)	Case study			
		A	B	C	D
CAS 2.0	**Total (0−100)**	**62.7**	**50.1**	**45.9**	**64.3**
	Circular Business Model Potential (0–50)	31.3	22.9	18.8	22.9
	Commitment to the Circular Transformation (0–50)	31.4	27.1	27.1	41.4
CE-diagnosis	**Total (1–7)**	**3.7**	**4.5**	**4.6**	**5.5**
	Purchase (1–7)	4.8	4.5	4.8	5.0
	Transform (1–7)	–	5.7	5.0	–
	Distribute (1–7)	–	4.33	–	–
	Use/Consume (1–7)	–	–	–	–
	Reintroduce (1–7)	–	4.0	4.0	–
	Symbiosis (1–7)	2.7	4.3	5.0	6.0
CircularTRANS	**Maturity level (0–5)**	**1.6**	**2.2**	**2.0**	**2.6**
	Strategic Processes (0–5)	2.0	2.9	2.3	3.7
	Operational Processes (0–5)	0.9	0.8	1.4	0.9
	Support Processes (0–5)	2.9	4.1	3.3	3.7
	Rethink (0–5)	1.2	2.0	1.9	2.5
	Extend Useful Life (0–5)	3.2	1.7	1.6	1.2
	Optimise Resources (0–5)	3.8	2.2	3.0	3.0
	Cycle Closure/end of life (0–5)	1.6	1.2	1.3	1.2
Circulytics	**Enablers (A-E)**	**D**	**D**	**E**	**D**
	Strategy and Planning (A-E)	D-	B-	E	D
	Innovation (A-E)	C-	E	E	C-
	People and Skills (A-E)	C-	D	D-	C-
	Operations (A-E)	C-	D	E	E
	External Engagement (A-E)	C-	E	E	D
CM-FLAT	**Global (0–100)**	**42.0**	**36.0**	**29.0**	**61.0**
	Circularity Performance (0–100)	49.0	32.0	32.0	63.0
	Business Model (0–100)	–	28.0	24.0	–
	Eco-design (0–100)	72.7	100.0	72.7	0.0
	Direct logistics (0–100)	–	–	–	–
	Resource consumption (0–100)	46.7	53.3	40.0	66.7
	Waste management (0–100)	30.0	–	20.0	–
	Resource recovery (0–100)	46.7	24.4	26.7	–
	Post sales services (0–100)	–	–	–	–
	Maturity Performance (0–100)	37.0	40.0	27.0	60.0
	Strategy & vision (0–100)	25.0	44.4	0.0	66.7
	Environmental management (0–100)	88.2	88.2	64.7	82.4
	Cooperation & industrial symbiosis (0–100)	0.0	20.0	13.3	33.3
	Training (0–100)	0.0	20.0	0.0	40.0
	Employee satisfaction & participation (0–100)	20.0	40.0	0.0	60.0
	Ecodesign (0–100)	0.0	0.0	0.0	50.0
	Supplier selection & auditing (0–100)	21.4	28.6	35.7	64.3
	Direct logistics (0–100)	–	–	–	–
	Reverse logistics (0–100)	0.0	0.0	00.	0.0
	Resource consumption (0–100)	87.5	75.0	37.5	75.0
	Waste management (0–100)	75.0	0.0	50.0	100.0
	Marketing & communication (0–100)	40.0	20.0	0.0	80.0
Inedit	**Circularity index (0–100)**	**42**	**67**	**58**	**58**
MAThChE	**Total readiness score (0–150)**	**37**	**70**	**24**	**42**
	Organisation (0−20)	11	9	4	16
	Strategy & Business Model Innovation (0–25)	7	15	5	8
	Product & Service Innovation (0–20)	0	8	0	0
	Manufacturing & Value Chain (0–20)	8	13	5	8
	Technology & Data (0−10)	0	8	5	4
	Use, Support & Maintenance (0–15)	0	0	0	0
	Takeback & End-of-life strategies (0–15)	0	6	0	0
	Policy & Market (0–25)	11	11	5	6

CE tools and between the HEIs selected.

Overall, considering the assessment of all the aspects analysed, CE-Diagnosis was the best rated CE tool, followed by CircularTRANS and Inedit, as already happened in Valls-Val et al. (2023), who assessed these CE tools for different sectors of activity. Taking into account that some CE tools did not have any aspect considered (*indicated in dashed line in the figure*), the relative score of each CE tool was estimated. It was calculated as the ratio of the sum of the average scores of each aspect to the maximum possible score of the CE tool (considering only the aspects that can be scored). In this case, the best rated tool continues to be CE-Diagnosis, followed by CAS2.0 and CircularTRANS, although any CE tool scored more than 65 %.

Regarding the different aspects analysed, the worst rated aspect was the consideration of the specificities of the organisation, with the worst score for MATChE, and the best score for CircularTRANS, without any of the assessments exceeding 50 % of the possible score. The adjustment of the score of the CE tools to the case studies also obtained generally low scores, with averages not exceeding 50 %, which is directly related to the fact that the specificities of the organisations were not taken into account in the CE tools. Similarly, the improvement opportunities, which were included in some CE tools only, also obtained low scores, as they were either very general or not applicable to HEIs. In contrast, the aspects rated highest were the low repetitiveness of the questions, the simplicity of use of the CE tools, the design of the CE tools and the

* Where A.B,C,D are the case studies

Fig. 6. Level of circularity and trend of scores.

application process (time and number of questions). Finally, the clarity of the statements, the difficulty in answering the questions and the detail and the use of the reports obtained intermediate scores.

The aspect that presented the greatest dispersion is the improvement opportunities, given that it is a subjective characteristic, since the same statement can help one person to make decisions but not another. Followed by the clarity of the statements, since the questions of the CE tools are related to production organisations, and for an HEI an interpretation must be made, and this task is easier for some people than for others.

On the other hand, once the evaluation template was completed, the environmental managers provided some additional comments during the interviews. Table 4 shows these comments, indicating whether they are positive (✓) or negative (✗) and which HEI environmental manager made it.

Additional comments detailed in Table 4 can be summarized in the following statements. The HEI environmental managers valued positively the fact that the CE tools were concrete and concise and included different aspects of circularity. Moreover, it was appreciated that the statements of the questions were well formulated and included definitions to facilitate the understanding of the questions. In addition, the use of ranges as possible answers was regarded as more appropriate than Likert scales, as Likert options were considered to be more subjective. In addition, it was considered essential that the CE tools allowed indicating the questions or categories that do not apply to the organisation, removing them from the score so that the level of circularity obtained is not penalised. The inclusion of the "don't know" response option was regarded as interesting, as well as the possibility of automatic filtering of the questions according to the sector of the organisation. Furthermore, the fact that the CE tools offered the possibility to assess the organisation by units or as a whole and allowed to be filled by different members of the organisation, was highly appreciated. In addition, they evaluated as positive that the CE tools were in the native language of the users. On the other hand, they regarded as positive that the report was clear and concise, that it included partial and global indicators, as well as the answers to the CE tool's questions. Finally, they considered it essential to develop a CE tool focusing on service organisations, specifically for HEIs, including educational and research aspects.

4. Discussion

After applying the existing CE tools for assessing the level of circularity of organisations to four HEIs, the research questions presented in the introduction can be answered.

Regarding **RQ1 (Are existing CE tools adequate for HEIs?)**, based on the results of Stage IIIb, it can be seen that the CE tools most suitable were Inedit and CircularTRANS, while those with the least suitable were MATChE and CAS2.0. On the other hand, CE-Diagnosis was the CE tool that gives the highest scores to HEIs, followed by Inedit and CAS2.0. While Circulytics and MATChE were the CE tools that give the lowest scores overall. So, it can be stated that existing CE tools are not suitable for HEIs. It is often difficult to interpret the questions from the perspective of the HEIs, as they do not manufacture or sell products and do not have customers, rather users, as they are service organisations. So, it is necessary to adapt CE tools to include questions related to education-research organisations. This is in line with Koszewska and Bielecki (2020), who affirmed that each branch of industry should have its own methods; and with Lindgreen et al. (2020) and Valls-Val et al. (2023), who stated that organisations may need different CE tools depending on their characteristics.

Regarding **RQ2 (Are the outputs of the CE tools useful for decision making in HEIs?)**, based on the results of Stage IIIc, it can be concluded that the outputs of the existing CE tools are not useful for HEIs. The level of circularity obtained for the same case study varies greatly from one CE tool to another, as the fact that CE tools differ in many aspects leads to mismatches, as already stated by Vinante et al. (2021). In addition, HEI environmental managers considered that the adjustment of the score of the CE tools to the case studies was generally very low, which is directly related to the fact that the specificities of the

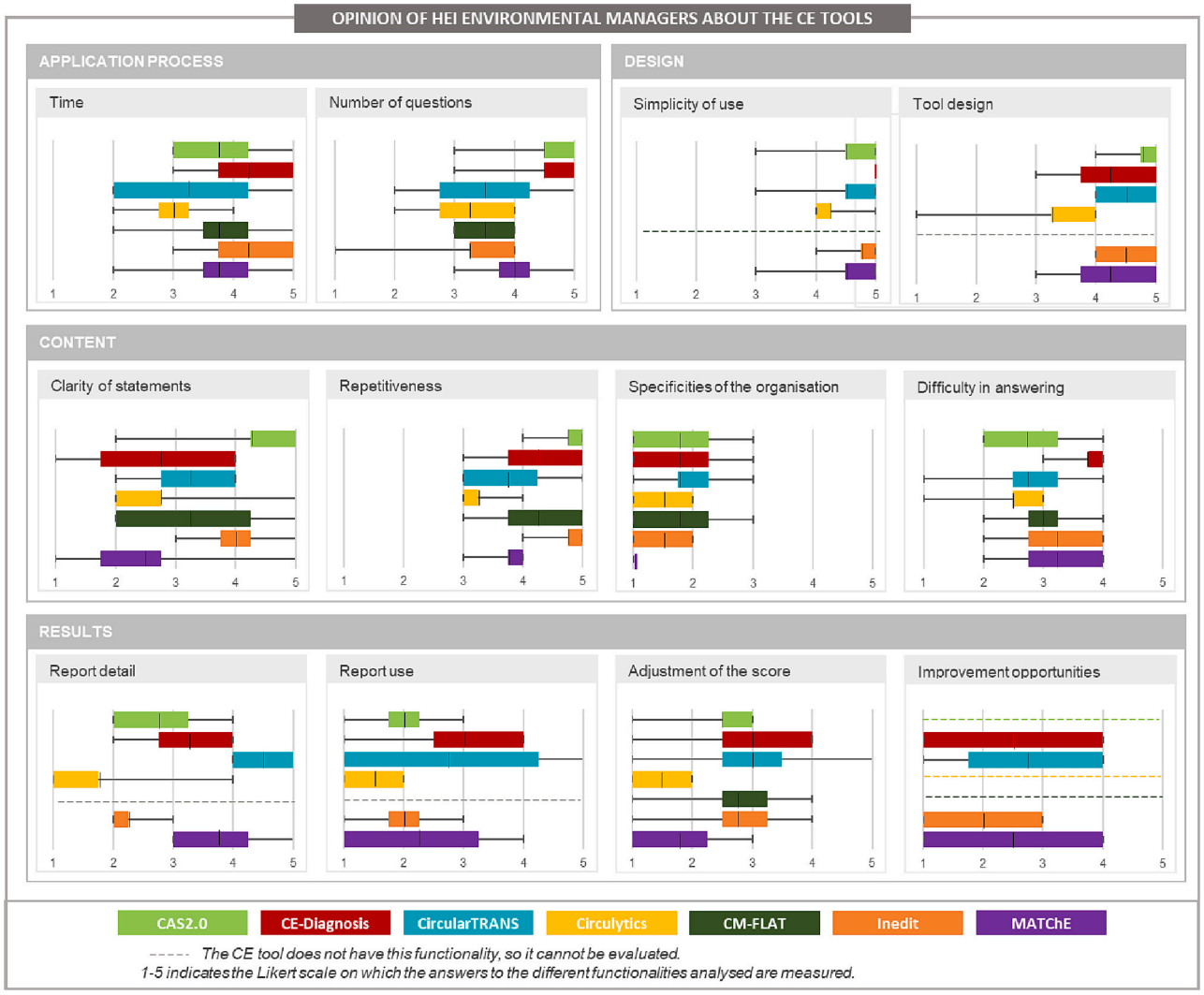

Fig. 7. Evaluation template of CE tools.

organisations were not taken into account in the CE tools. Moreover, each CE tool uses different circularity indicators, maybe due to a lack of standardisation and uniformity in the field of CE, which is in line with the results reported by De Pascale et al. (2021), Corona et al. (2019) or Saidani et al. (2019). Indeed, the lack of standardisation and uniformity is a very critical issue in CE as it generates discrepancies in perceptions regarding what should be contemplated when assessing CE, as stated by Moraga et al. (2019), Lindgreen et al. (2020) or Franco et al. (2021), among others. Depending on the CE tool used, HEIs have different views of the current situation, and the difference in the level of circularity and indicators obtained creates confusion for environmental managers. On the other hand, four CE tools (CE-Diagnosis, CircularTRANS, Inedit and MATChE) as well as being diagnostic tools, offer opportunities for improvement in the field of circularity. However, HEI environmental managers consider that the improvement opportunities offered are too generic and sometimes not applicable to HEIs. Therefore, it is considered necessary to establish more specific improvements that really serve as a roadmap for HEIs. Therefore, it is believed that these tools could be useful to get a general idea of the circularity of the HEIs but are not useful for effective decision-making.

Regarding **RQ3 (What is the opinion of HEI environmental managers on these CE tools?)**, based on the results of Stage IIId, the HEI environmental managers are of the opinion that the existing CE tools are not adequate for HEIs. Moreover, the lack of harmonisation and standardisation results in a low acceptance of the CE assessment approaches by organisations, as already suggested by Lindgreen et al. (2020). So, they consider that the CE tools need to be standardised and updated to improve their adequacy for HEIs. Alternatively, a better option would be to develop a new sectoral tool that takes into account the specific characteristics of HEIs. Despite this, the CE tools that the HEI environmental managers preferred to use were CE-Diagnosis and CircularTRANS. This is because, in their opinion, these are the most clearly structured CE tools that include questions that are relatively easy to answer and incorporate different areas of circularity. Furthermore, they regard Inedit as useful for getting a quick idea of the starting point, even if it is too short and simple for decision making. Furthermore, they think that CAS2.0 and MATChE are not valid for use in HEIs, as they are too focused on productive organisations. On the other hand, the CM-FLAT tool is considered a tool with potential, although some aspects should be improved to make it more adaptable to HEIs.

Regarding **RQ4 (How could existing CE tools be improved to be adequate for HEIs?)**, based on the results of Stage III, some shortcomings were identified in relation to the exclusion of some essential aspects of circularity in the HEIs, such as the management of circular water input, which was already identified by Ibáñez-Forés et al. (2022) for the frameworks that measure the level of circularity that despite focusing on input/output material resources, neglected issues related to water management. Furthermore, CAS2.0 and MATChE include many questions connected to the design category, but these questions are not applicable to HEIs since their focus is on product and packaging design

Table 4
Additional comments.

CE TOOL	ADDITIONAL COMMENTS	HEI*
CAS2.0	✓ Concrete and concise.	A
	✓ Easy to answer by the environmental manager.	A
	✓ Ranges instead of the Likert scale.	D
	✗ Not applicable questions that penalise the level of circularity score.	A,D
	✗ Focused on production organisations.	D
	✗ Native language of users not included (Spanish).	A,C,D
CE-Diagnosis	✓ Concrete and concise.	A, C
	✓ Definitions to facilitate understanding of statements.	B
	✓ Allows selection of non-applicable categories.	A
	✓ Overall result plus partial results by lifecycle stage.	A
	✓ Very clear and concise report.	A
	✗ Likert scale too subjective.	D
	✗ Questions do not have the option "Not applicable".	B,C,D
CIRCULARTRANS	✓ Complete, with a wide range of questions.	A,C
	✗ Generic questions, sometimes difficult to answer.	A,D
	✗ Focused on production organisations	D
	✗ Likert-type scale too subjective	B,D
	✗ Report too detailed, missing important information	A
CIRCULYTICS	✗ Difficult questions to answer.	A,D
	✗ Focused too much on the strategic level.	A,C
CM-FLAT	✓ Ranges instead of the Likert scale.	A,D
	✗ Generic and imprecise statements.	A,C,D
INEDIT	✓ Filter the questions according to organisation sector.	A,C
	✓ The questions included are applicable to a university.	B
	✓ Useful for a first look.	A,B
	✓ Report with the answers to the questions.	D
	✗ Too simple.	A,B,C,D
	✗ Only considers the education sector, excluding research.	D
MATChE	✓ Interesting response option "don't know".	D
	✓ Assessment of the organisation by units or as a whole.	D
	✓ Report with the answers to the questions.	D
	✓ Interesting the option of answering the tools by different members of the organisation	B,D
	✗ Focused on production organisations.	A,B,C,D
	✗ Native language of users not included (Spanish).	A,D
	✗ Likert-type scale unclear and subjective.	D
	✗ Adding the questions marked as not applicable for the calculation of the indicator, giving misleading results.	A,B,C,D

** Where A, B, C, D are the case studies*

and HEIs do not manufacture products, so they are discarded for use in HEIs. On the other hand, in case of adapting the rest of existing CE tools, questions related to the products offered (since there are no products) and those related to customers (since there are no customers, they are service users) should be eliminated; and product purchasing criteria questions should be incorporated (since HEIs are big buyers). However, HEI environmental managers have indicated that the best strategy is to develop a new sectoral CE tool for HEIs, which includes applicable questions to HEIs considering both the educational and research branches. The users of this CE tool (HEI environmental managers) request a concrete and concise CE tool, which includes the aspects of circularity related to education and research, has well-formulated statements including definitions, uses ranges as answers to reduce subjectivity, allows to indicate the questions that do not apply and eliminate them from the scoring, allows assessing the HEI by units and as a whole, can be completed by different members of the organisation and is available in the mother language of the users. In addition, it is essential that the report should be clear and concise, that it should include partial and global indicators and the answers to the questions of the CE tool. Finally, it is interesting to note that the CE tool is based on the methodological approach “Theory of Change” (ToC), which is an illustration that allows to assess the desired change critically and visually (Anderson, 2005; Taplin and Clark, 2012).

5. Conclusion

HEIs as organisations dedicated to education and research should be pioneers and leaders in the transition from linear to circular economy. To do so, they need approaches to measure their level of circularity and their progress towards the CE. To date, however, these approaches have not been developed for this type of organisation. Therefore, the aim of this study is to analyse the adequacy of current CE assessment tools for HEIs. To this end, their strengths and limitations have been analysed, based on the analysis and categorisation of the questions included and the outputs provided. This study has also identified the demands or needs of the HEI environmental managers and the thematic blocks or questions that should be incorporated in order to consider all aspects of circularity in HEIs. As a result, it has been concluded that the current CE tools do not take into account the specific characteristics of these institutions, so HEI environmental managers do not regard them as useful for decision-making.

Therefore, this study is essential to establish the basis needed for the creation of a new sector-specific CE tool adapted to the specificities and peculiarities of HEIs. Consequently, it provides HEI environmental managers with new approaches to measure the circularity of their organisations in an effective way. As a limitation, however, it has included CE tools only in Spanish or English, and has studied only four Spanish HEIs.

As a future development, the need to create a sectorial CE tool for

HEIs that will be useful in the decision-making process towards a more circular organisation is identified. This CE tool should include indicators and questions applicable to HEIs, proposed from the perspective of HEIs and consider the current demands of HEI environmental managers. This CE tool could be applicable to a larger sample of universities, both Spanish and abroad.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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