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Towards a circular built environment – Focus on the new M.Sc. program in real estate and facility management

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Introduction: The sustainability transformation of the built environment is one of the mega tasks of the twenty first century. Real estate professionals who manage sustainability transformation must be acknowledged in all disciplines that reside around the lifecycle of a property. In addition, these managers must have expert knowledge of the megatrend of sustainability and possess the highest level of interpersonal skills to enable society and organizations to manage the associated change.

Methods: Considering the current challenges and the critical role of education to empower real estate (RE) and facility management (FM) students to explore new paths of sustainable development and grow into active citizens, conscious producers, and consumers, this contribution investigates new and elective ways of teaching sustainability concepts, specifically circular economy (CE). To this end, 122 European university degree programs were examined based on a review of all course titles to determine whether the relevant keywords and content for enabling future real estate managers to drive the sustainability transformation toward a circular built environment are present.

Results: The results show that topics on sustainability are covered significantly. Graduates are empowered in several disciplines that evolve around the real estate lifecycle, but not in all the required ones. There seem to be gaps in teaching especially in the subject area of CE.

Discussion: The extent to which students are also socially empowered is hard to trace. Furthermore, this article describes and critically discusses how the introduction of a holistic approach to the management of real estate for master-level students could help them gain a sustainability perspective and prepare them to act circularly in the future.

KEYWORDS

circular built environment, master program, real estate and facility management, sustainability education, circular economy (CE)

1. Introduction

One of the most challenging tasks in the management of real estate is the sustainability transformation toward a circular built environment. On the one hand, the world population is constantly growing and is confronted with new needs for new buildings. This puts an enormous strain on our environment and our resources. The real estate industry is responsible for ~33% of greenhouse gas (GHG) emissions, 40% of waste generation, and 40% of material consumption (Ness and King, 2017; Hossain and Ng, 2018). On the other hand, the European Union (EU) declares its intention to be the world's first carbon-neutral region by 2050 (European Commission, 2021). Along with the EU, Switzerland reached a Climate Agreement stating that Switzerland will also be carbon-neutral by 2050. On a global

scale, the ambition is to reduce GHG emissions to 2 tons of CO₂-equivalents per capita per year by 2050 if the concentration in the atmosphere is to be stabilized at 400–450 ppm CO₂-equivalents by the year 2100. The current Swiss average is 6 tons of CO₂-equivalents per capita per year (Bafu, 2022). These and other laws and regulations, such as the EU Taxonomy, which describes a system for defining “green” or “sustainable” economic activities in the EU, increase the requirements for stakeholders of the real estate industry to adapt to the sustainability transformation (IPCC, 2007; EU Taxonomy Info, 2022).

In the real estate industry, buildings are referred to as “sustainable,” “green,” “blue,” or “circular” (Bernoville, 2022):

- *Green buildings* should enable the efficient use of (renewable) energy, water, materials, and other resources; reduce waste and emissions; enable reuse and recycling; and improve the quality of life for occupants (EPA, 2022). The focus of green building activities is on environmental performance, but green buildings also include the consideration of occupant quality of life during design, construction, and operation (Srinivas, 2015; Nelson and Laquidara-Carr, 2018).
- The term *sustainable building* is often used interchangeably with the term “green building” (Srinivas, 2015). The focus may shift from the ecological dimension to the integration of all three commonly known ecological, economic, and social dimensions.
- *Blue sustainability* is a term that extends beyond the material focus of sustainability and environmental issues to emphasize health and wellbeing, social, and even cultural aspects (Grist Staff, 2008; Cisneros-Montemayor et al., 2021). In real estate, the question would be how employees may benefit from working in a sustainable building in terms of health, social activities, etc.
- A *circular economy* (CE) refers to an economy that includes “industrial processes and economic activities that are restorative or regenerative by design, that enable the resources used in such processes and activities to maintain their highest value for as long as possible, and that aim to eliminate waste through superior design of materials, products, and systems (including business models)” (S. 2364; EPA, 2022). For example, in real estate, the tons of glass, steel, wood, and concrete left over from a building’s demolition or remodeling are taken to an incinerator by a contractor. In the circular economy, demolishable buildings are no longer considered waste, but rather valuable mines of resources that can be reused.

Action plans for the CE include the gradual decoupling of economic activity from the consumption of finite resources and giving waste a second life. In that sense, the concept of CE challenges the current linear model of production and consumption, exploiting the planet’s raw resources, manufacturing and using the product, and disposing of waste. Recent efforts to take more concrete action include, above all, the development of new standardization activities such as CEN/TC 350/SC 1 - “Circular Economy in the Construction Sector” and ISO/WD 59004 - “Circular Economy.” Following the European Circular

Economy Action Plan (ECEAP), multiple efforts have been made to apply circular thinking to construction practices and include resource circularity into sustainability frameworks, such as Level(s). However, despite the endeavors, there is still a lack of a standard tool that fully implements the circularity potential, classifies buildings accordingly, and assesses the realization level of the ECEAP. The application of CE principles in real estate, building design, and use (adaptability, durability, waste reduction, and quality management) is mainly focused on new buildings where circularity can be embedded and enabled. This starts with the early design phase and continues throughout the lifecycle of a building and its components and materials.

Conversely, circularity has not been defined in the context of existing buildings (Kyrö, 2020). It is considered that 75–90% of the building stock in OECD countries will still be standing in 2050 (IEA, 2014). Therefore, the conscious management of real estate is necessary to transform the existing built environment, with building professionals acting as change agents on how society perceives the quality of the built environment. CE must be viewed as a business strategy, not just a waste management or design strategy. Optimizing the use of buildings should also be brought into focus, rather than just considering them as potential material banks where components and materials can be recovered, reused, or recycled for new construction (Adams et al., 2017; Kyrö, 2020).

To meet these challenges, numerous highly qualified and competent workforces are required in all disciplines around the lifecycle of a property. Education is one of the most important success factors in ensuring that future real estate managers and facility managers can deal with the megatrend of sustainability toward a circular built environment. For example, UNESCO defines Education for Sustainable Development (ESD), mentioned in Sustainable Development Goal (SDG) 4.7, as a key tool to implement sustainability from all other SDGs (UNESCO, 2017). As shown above, a variety of terms have been used to describe what is needed to address the challenges of sustainability, including real estate. Nevertheless, it can be assumed that all these terms are not in conflict with each other, as all the above concepts propose real estate for a sustainable future of the built environment. The economic dimension of sustainability is centrally important in the real estate context (ref.). In order to achieve a transition toward a circular built environment, it is important to consider different dimensions that are underpinning all these concepts and that are required for the transformation and management of sustainability in the real estate industry. A study of what organizations in or with real estate are asking of their prospective employees in terms of sustainability in their published job postings shows that companies are significantly demanding “sustainability” (Werneck, 2021). In addition to knowledge in disciplines of real estate, such as architecture, facility management, civil engineering, and real estate management, companies are also demanding competencies and skills that take into consideration the political challenges with its inherent new regulatory frameworks and adaptations arising from societal shifts. Information and operational technologies, ecological thinking, creativity, and collaboration are just some of the key concepts to be mentioned. From this study, we derive six dimensions that need to be taught to be able to manage sustainability in

TABLE 1 Snapshot of the ERES list containing Real Estate Educational Programmes in Europe.

Country	City	Institution	Name of program	Type of degree	Necessary prequalification	Regular period of study (in years)	Total amount of ECTS	FT/PT	Course language	Homepage
Croatia	Osijek	Josip Juraj Strossmayer University of Osijek	Technology Organization and Construction Management	AMES	Bachelor degree or its equivalent	1.5	90	FT	Croatian	www.unios.hr
Croatia	Zagreb	University of Zagreb	Construction Management and Economics	M.Sc.	Bachelor degree or its equivalent	2	120	FT	Croatian & English	www.umizg.hr
Hungary	Budapest	Budapest University of Technology and Economics	Facility Management	M.Sc.	Bachelor degree or its equivalent	2	120	PT	Hungarian	www.bme.hu
...

FT, Full-Time; PT, Part-Time.

general and the transformation toward the circular economy in real estate:

- *Social*: Sustainability is about contributing to society. Skills and competencies include systemic thinking skills, so-called lifecycle thinking, a basic set of values, ethics, etc., as well as the ability to collaborate, problem-solve, innovate, and reflect (Scalabrino et al., 2022). These challenges related to climate change and resource scarcity affect professional ethics and skills required in practice and research. Even more strict building regulations require even “ordinary” transformation projects to stress low carbon emissions and high energy efficiency. Future real estate managers will be expected to work on projects with a set of measures and targets that put energy and GHG emissions at the heart of their performance. Furthermore, they need to be able to negotiate the performance targets of the project with the building owner and real estate team while thinking about the long-term transformation of society and the development of innovative strategies.
- *Economical*: Economic knowledge is essential, especially when defending sustainable real estate finance and investments before decision-making bodies.
- *Processual*: Knowledge of real estate management, facilities management, architecture, and civil engineering is fundamental. These disciplines provide the base layer of the understanding of processes around the lifecycle of real estate.
- *Technical*: digitization is the integration of technologies into processes with the aim of improving them and thus potentially enabling sustainability (Bloomberg, 2018). In real estate, it is important to understand operational, information, and building technologies.
- *Empirical*: Management through data should be the basis for informed decision-making and sustainable action (Jones et al., 2009).
- *Ecological*: The ecological dimension of sustainability has an impulse-giving significance (Enkvist et al., 2007). According to the principles of green and sustainable building, real estate should be designed, built, operated, and demolished in a way that conserves energy, water, and other resources and reduces waste and emissions (EPA, 2022; GovTrack.us, 2023). The OECD project on sustainable buildings for the future identified five objectives for sustainable buildings (John et al., 2005): resource efficiency; energy efficiency (including greenhouse gas emissions reduction); pollution prevention (including indoor air quality and noise abatement); harmonization with the environment; and integrated and systemic approaches.

Tying all these six dimensions together leads to sustainability in real estate, thus enabling sustainability in society, environment, and economics. Introducing education for sustainability at the earliest stages of learning should be a given. Nevertheless, the above discussion shows that a broad and in-depth knowledge of different disciplines and comprehensive competencies are required to cope with the highly complex sustainability transformation of the built environment.

In addition to practical continuing education, such courses-tying all these six dimensions together – are an excellent addition fit for consecutive Master's degree programs at universities. First, successful completion of a future, e.g., Master of Science (M.Sc.) degree opens up competitive career paths in senior management for graduates. Second, unlike continuing education programs (Master of Advanced Studies; MAS), M.Sc. programs always include research-based studies (Schweizerische Konferenz der kantonalen Erziehungsdirektoren Das schweizerische Bildungssystem auf einen Blick, 2021; Schweizerische Eidgenossenschaft Internationale Strategie der Schweiz im Bereich Bildung, 2022).

After having discussed in the introductory part first what is meant by sustainability of real estate, we consequently introduced the concept of CE and what are the resulting management requirements. We then focus on how to acquire the knowledge and skills needed to manage sustainability in real estate toward a circular built environment in the following chapter. Based on the six above-described dimensions, we introduce a model that will support the analysis of whether M.Sc. programs incorporate elements of these dimensions, thus delivering an indication of whether the graduates and future managers will be able to lead and manage the sustainability transformation of real estate. The results are presented in the fourth section and discussed in the last section.

2. Materials and methods

In comparison to the above-described dimensions, it should be possible to assess whether there is a gap among the higher education programs to empower students in sustainability transformation in real estate. The list of the analyzed programs can be found on the homepage of the European Real Estate Society (ERES): <https://www.eres.org/index.php/activities/edueres> (ERES, 2022). One of the aims of the ERES is to improve communication and exchange information on real estate educational programs. Real estate programs are being offered by a wide variety of universities across Europe. The list contains an overview of all Bachelor, Master, and Postdoctoral programs with a real estate focus. The authors try to issue a list that is as complete as possible. The list will be updated every 2 years. The list mentioned below was downloaded in March 2022 (Table 1).

A total of 374 programs are listed. To ensure that as far as possible all higher education programs are compared, we selected the list by "type of degree" for this analysis, which included all Master of Science (M.Sc.) programs, all Master of Arts (M.A.) programs, all Master of Engineering (M.Eng.) programs, and all Diploma programs. Furthermore, by means of in-depth research on these programs, the specializations and module names were searched out by means of the respective homepages from March to May 2022. In some cases, no further information is publicly available, e.g., of the Master of Science in Real Estate and Facility Management offered by the Norwegian University of Science and Technology NTNU. Then, those programs are not considered in the analysis. In consequence, 122 programs are left to be analyzed.

To structure the analytics, the authors introduce a model consisting of the six dimensions, which in the best case are depicted by the respective higher education program (Figure 1).

The higher education programs are analyzed to determine whether the keywords contained in the definitions and descriptions of the sustainability dimensions are presented in the programs (see section "1. Introduction", the herein described six dimensions that need to be taught to be able to manage sustainability in general and the transformation toward circular economy in real estate). For example, the keyword "health" of the category "Social" is selected as a keyword as it is often found in the descriptions of social sustainability. If found, it is marked with "1." If this is not the case, the program is marked with "0." In addition, if the word "health" is found two times or even more, it was counted still as "1." The authors are not interested in how often words related to sustainability were named, but if at all and how diverse the context about sustainability is described. The list of keywords shown here is not final but can be added to at will, depending on the stage of development in the respective definitions and subject matters. The keywords searched for this analysis are presented in the following Table 2.

However, the goal of this analysis is to not necessarily look at individual programs in detail. The results can only be seen as an indication that themes related to sustainability are part of the analyzed program. The central question here is whether there is an overall gap between these dimensions supported by definitions and descriptions in the higher education programs, i.e., do the university programs provide education at all that is relevant to enable future managers in sustainability transformation in the real estate sector or is a gap becoming apparent? To conclude whether there is a link between these sustainability dimensions in the education programs at all, we performed a chi-square test of independence. This test is used to examine whether two nominal variables are independent or not. When two variables are correlated, their values tend to move together, either in the same direction or in the opposite direction (further details about this very well-known and widely used test can be found in Cohen, 1988). The null hypothesis (H_0) and alternative hypothesis (H_1) of the chi-square test are:

- H_0 : The dimensions "processual," "economical," "technical," etc. are presented in the higher education programs in real estate.
- H_1 : The dimensions "processual," "economical," "technical," etc. are not presented in the higher education programs in real estate.

To conclude how strong the effect is, a contingency coefficient is performed. The hypothesis (H_0) and the alternative hypothesis (H_1) of the one-tailed significance test are:

- H_0 : $\rho = 0$ ("the dimensions of sustainability in higher education programs correlation coefficient is 0; there is no association")
- H_1 : $\rho > 0$ ("the dimensions of sustainability in higher education programs correlation coefficient is >0 ; a positive correlation could exist")

where ρ is the sustainability correlation coefficient. Between 0.01 and 0.03, it is a weak effect; between 0.03 and 0.05, it is a moderate correlation; and >0.05 , it is a strong correlation (Cohen, 1988).

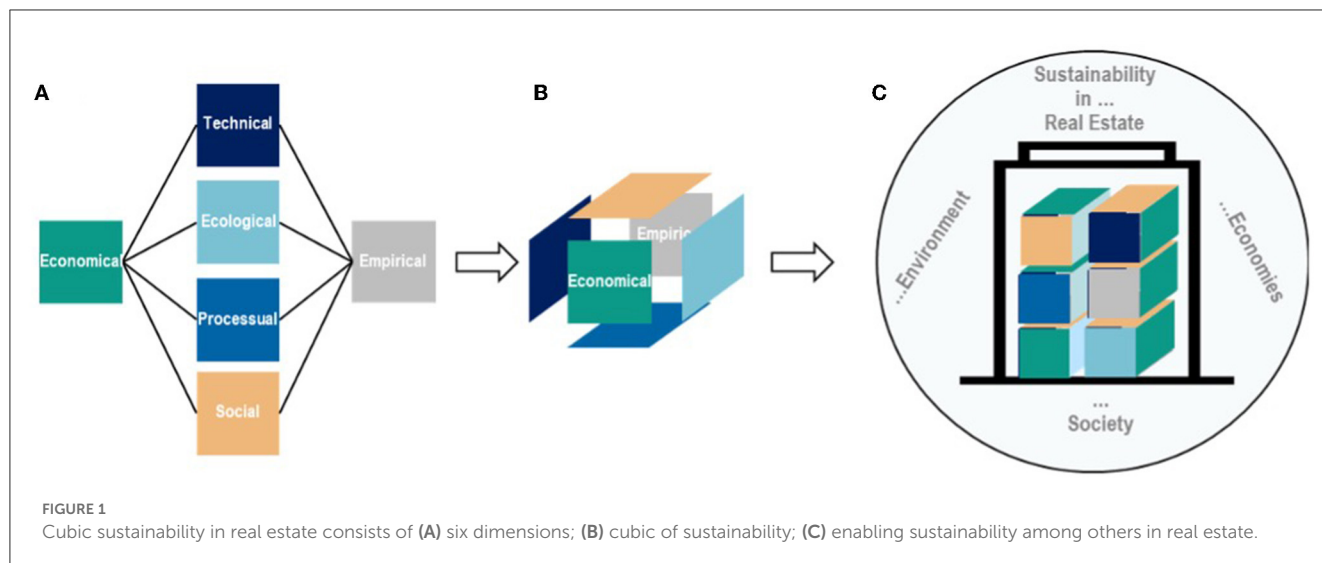


TABLE 2 Keywords of the dimensions of sustainability in real estate.

Category "Processual"	Category "Ecological"
Real estate	Green (building)/ecology
Workplaces	Energy
Facility/-ies	Water
Architecture	Emissions
Civil engineering	Waste
Category "Economical"	Category "Social"
Economy/-ies	Health
Financing	Social
Cost/-s	Ethic
Investment	Leadership/management
Business	Innovation
Category "Technical"	Category "Empirical"
Digitalisation/digitalization/digitisation	Data
Technology/-ies	Information
Operation	Critical thinking
Building	Masterthesis/scientific
IT	Analysis

3. Results

3.1. Results of the descriptive data

The programs originated from various countries across Europe. The United Kingdom (UK) is first in place with 63 programs (54% out of the 116 programs). The German-speaking part of Austria, Switzerland, and especially Germany—the so-called DACH region—shows 31 higher education programs altogether (27% out of all programs). The Netherlands comes third in place according to this analysis (9% out of all programs). The rest of

the programs are almost evenly distributed between the countries Finland, Italy, and France. Further analysis show that the programs in the DACH region are decentralized located other than programs in the UK with London as the leading program hub. On average, it takes a bit more than three semesters to graduate. An average of ECTS 114 credits can be reached. The programs are in majority taught in English (64%) or in German (22%).

Wherever possible, higher education programs in the field of real estate are mainly offered by the faculties of economics and business administration. The second most strongly represented programs are allocated to the engineering departments. Natural and environmental science faculties are in third place. Fourth, these courses of study are also located in the departments of architecture. According to this analysis, it is an exception when such courses are attached to other departments, such as "Social Science," "Real Estate," or "Facility Management" faculties. Multiple responses are possible, i.e., the faculty of "Construction, Surveying, Real Estate" of the University College London is referred to the specializations "Engineering" and "Real Estate." Further specializations such as "Geographic" are possible, but not considered.

The picture changes when it comes to which study area the programs can be assigned to according to their name. For example, the Master of Science in Real Estate and Facility Management of the Zurich University of Applied Sciences is assigned to both "Real Estate" and "Facility Management." According to this classification, most of the program names can be assigned to the field of economics. Close behind is the field of "Real Estate," while "Facility Management" with 19% comes in third place in this ranking. However, although economic and real estate names are dominant according to this evaluation, the variation in the possible depressions is broader. The majors are based on the fields of economics, architecture, civil engineering, real estate, and facility management.

As expected, real estate management is the most frequently mentioned discipline in higher education programs. However, when it comes to the question of whether learners are taught interdisciplinary subjects in all disciplines related to the real estate life cycle, only the ZHAW M.Sc. in Real Estate and Facility

TABLE 3 Ranked M.Sc. Programs based on the variety of found key words.

University: MSc program	Total number achieved
College of Estate Management: MSc in Real Estate	12
ZHAW: MSc in Real Estate and Facility Management	12
College of Estate Management: MSc in Facility Management	11
University of Applied Sciences Berlin (HTW): MSc in Construction and Real Estate Management	9
FHS Kufstein Tirol: MSc in Facility and Real Estate Management	8
University of Applied Sciences Wiener Neustadt: MSc in Business Consultancy with Specialization Real	8
University of Reading: MSc in Real Estate Investment and Finance	8
Liverpool John Moores University: MSc in Commerical property development	7
University G. d'Annunzio: MSc in Building Manager	7
University of Angers: MSc in Real Estate and Construction	7
University of Applied Sciences Aachen: MSc in Facility Management	7
University of Torino: MSc in Real Estate Management	7
Amsterdam University: MSc in Business Economics with Spezialisaton in Real Estate Finance	6
College of Albstadt -Sigmaringen: MSc in Facility Design and Management	6
Danube University Krems: MSc in Facility Management	6
University of Applied Sciences Mainz: MSc in Technical Facility Management	6
University of Greenwich: MSc in Real Estate Development and Investment	6
Aalto University: MSc in Real Estate Investment and Finance	5
Aalto University: MSc in Real Estate Economics	5
City University London: MSc in Real Estate Investment	5
City University London: MSc in Real Estate	5
Eastern Mediterranean University: MSc in Construction Management and Technology	5
European Business School (EBS): MSc in Real Estate	5
Kingston University: MSc in Real Estate	5
Kingston University: MSc in European Real Estate	5
Napier University: MSc in Facilities Management	5
Technical University Darmstadt: MSc in Industrial Engineering and Civil Engineering	5
Technical University Muenchen: MSc in Construction Management and Real Estate Development LO	5
University College London: MSc in Building and Urban Design in Development LO	5
University of Applied Sciences Mainz: MSc in Technical Facility Management	5
University of Glamorgan: MSc in Real Estate Development	5
University of Glasgow: MSc in Real Estate	5
University of Greenwich: MSc in Building Rehabilitation	5
University of Regensburg: MSc in Real Estate	5
Vilnius Glildimas Technical University :MSc in Construction Technology and Management	5
Vilnius Glildimas Technical University :MSc in Engineering Economics and Management	5

Management programs and the College of Estate Management with its M.Sc. Real Estate score higher.

Overall, the dimension “Processual” is presented in 14% of all analyzed programs (Table 3). In every fifth program, economical topics matter. All keywords, except “cost/-s,” are to be found in at least 15% of all programs. Especially the programs in the

UK lead the dimension “Economical.” The Eastern Mediterranean University offers an M.Sc. in Construction Management and Technology with a specialization in “Integrated Master in Architecture.” In this program, “Visual Construction,” “Digital Architecture,” and “Building Technology” play an important role. The dimension “Technical” is represented in 10% of all analyzed

programs. Only 2% of all programs identify the dimension “Ecological,” which is described by the keywords “green,” “ecology,” “water,” and “emissions,” among others. Nevertheless, the word “sustainability,” which is often used non-interchangeably with the ecological dimension of sustainability, is to be found in every fourth program. The Technical University Munich with its M.Sc.-program “Construction Management & Real Estate Development” and its specialization in “Civil Engineering” are examples. The dimension “Social” is represented in 10% of all analyzed higher education programs in real estate. The keywords “leadership” and “management” are to be found in 39% of all programs, whereas “social” and “responsibility” are presented in <3% of all programs. At maximum, the programs scored 2 out of 5 possible points. The programs range from the programs “Real Estate and Construction,” “Facility Design and Management,” and “Commerical property development” from the University of Angers, the College of Albstadt-Sigmaringen, and Liverpool John Moores University. The ability to analyze and interpret data and to write scientifically is requested by 13% of all programs, whereas “Masterthesis” is the keyword with 33%. Especially, the M.Sc. in “Economics with Specialization in Housing Industry” of the University of Cologne emphasizes the empirical dimension in its program.

The word “circular” was only found in two descriptions: one made by the College of Estate Management in the M.Sc. in Real Estate and the other found in the description used for the M.Sc. in Real Estate and Facility Management by the Zurich University of Applied Sciences.

3.2. Empirical results

The word “Sustainability” and the dimensions “Processual,” “Economical,” “Ecological,” and “Empirical” are significantly presented in the analyzed higher education programs in real estate. However, there seem to be gaps between the content of the courses and the dimensions of “Technical” and “Social.” University programs provide education not in all the described dimensions:

- H₀: The dimensions “Processual,” “Economical,” “Ecological,” and “Empirical” are presented in the higher education programs in real estate.

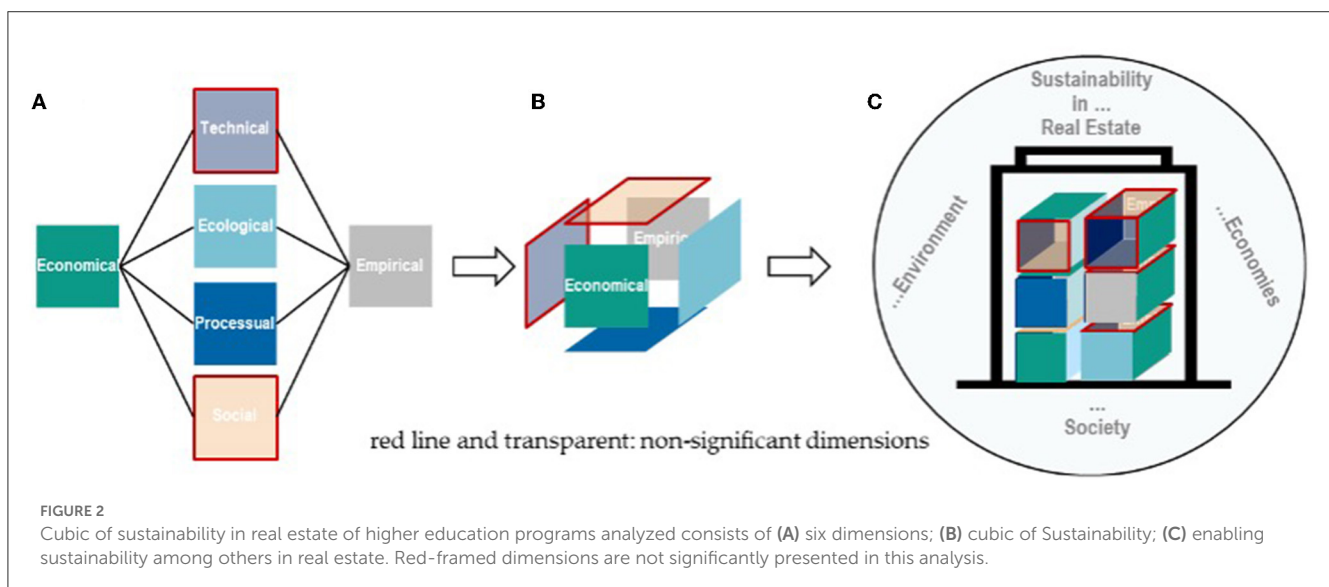
There is a strong correlation between these dimensions and the content of higher education programs in real estate [28].

- H₁: The dimensions “Social” and “Technical” are not presented in the higher education programs in real estate.

To illustrate this model, the Figure 1 in the section “Materials and Methods” may serve. The dimensions of sustainability in real estate, which together enable learners to acquire all the knowledge and competencies necessary for the sustainability transformation of real estate, are present across all training programs but are only meaningful in some dimensions. Figure 2 below illustrates this. The non-significant dimensions are shown here transparently and outlined in red.

4. Discussion

According to this analysis, university curricula of European higher education programs seem to focus to some extent on the required content to prepare graduates for real estate sustainability management but rarely integrate all the required knowledge about the whole lifecycle of a building set in the megatrend sustainability toward a circular built environment. While there are studies that compare the content of courses, the focus of these studies is (supposedly) within one discipline in real estate. For example, one study looks at how many of the engineering programs in Sweden include maintenance (Kans, 2021). Maintenance is part of facility management, which is essential for the sustainable management of real estate. According to the study, maintenance accounts for ~15% of engineering programs. This study is in line with the logic of the dimension “Processual,” which in turn examines the interdisciplinary share of architecture, engineering, facility management, and real estate management in European



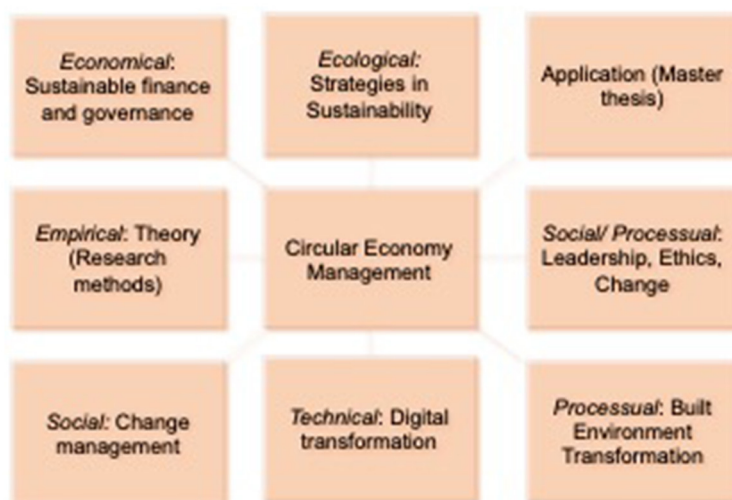


FIGURE 3

Skills for circular economy in real estate of higher education program in line with the six dimensions of Cubic sustainability in real estate.

higher education programs. To be able to manage sustainably, it is essential to understand all the disciplines located around the real estate lifecycle.

One could also argue that a person does not need to be skilled in every one of these disciplines or knowledge dimensions, but a study of job advertisements shows that the dimension “social” is disproportionately and frequently requested in the examined job advertisements (Werneck, 2021). In contrast, this analysis suggests that social competencies are underrepresented in real estate studies. The extent to which students are socially empowered is hard to trace.

Employability is an important criterion for testing training programs for their *raison d'être* (Witt et al., 2013). However, due to the macroeconomic situation, most real estate markets worldwide are still in a booming phase (Renaud, 1997; Agnello and Schuknecht, 2011; Mach, 2019). Workers in the field of real estate have been in demand for decades now. However, this positive development obscures the fact that companies are not only looking for real estate experts but also those who are knowledgeable in areas related to the real estate lifecycle and can help manage and lead the sustainability transformation. Overall, this study can be interpreted as an indication that there are still deficiencies in higher education programs in real estate when it comes to whether to empower students in sustainability transformation. Here, further in-depth analysis of the curricula, interviews, and surveys with industry leaders, as well as university representatives and students themselves, could provide further insight.

Bearing in mind the findings of this analysis, the Zurich University of Applied Sciences (ZHAW) has taken an important step toward introducing sustainability and circular economy management in real estate at the higher education level with a new interdisciplinary M.Sc. curriculum in Real Estate and Facility Management starting in autumn 2022 (Schweizerische Eidgenossenschaft Internationale Strategie der Schweiz im Bereich Bildung, 2022). As stated above, the understanding of the real

estate lifecycle and the interdisciplinary perspective of the six dimensions of sustainability taught in higher education can lead the future workforce to a holistic approach to sustainability and empower them to transition toward a circular economy of the built environment. The main scope of the program is related to the general issue of sustainability including environmental as well as economic and social focus. Considering the high demands of transdisciplinary skills to address sustainable transformation and in particular the circular economy, this M.Sc. curriculum tries to educate real estate and facility managers on the:

- Sustainability consequences of transformation
- Quality of real estate concept with respect to circularity
- Quantity of real estate quality and circularity potential
- Quality of circularity concept
- Management consequences of circularity concepts

The curriculum consists of three consecutive semesters with theory and project courses and a fourth semester during which the participants write their M.Sc. thesis. Throughout the curriculum, a holistic perspective stresses the many architectural expressions and possibilities encompassed within a zero-emission built environment. Here, a specific area of focus is put on the concept of CE as treated in nine distinct modules that are spread over the four semesters as shown in Figure 3:

- Module 1: Sustainable finance and governance (in semester 1)
- Module 2: Theory/research methods (in semester 1)
- Module 3: Change management (in semester 1)
- Module 4: Strategies in sustainability (in semester 3)
- Module 5: Circular economy management (in semester 3)
- Module 6: Digital transformation (in semester 2)
- Module 7: Built environment transformation (in semester 4)
- Module 8: Leadership, ethics, and change (in semester 4)
- Module 9: Master thesis (in semester 4)

Within each of the theory and project modules, the students are trained in interdisciplinary teams and by an interdisciplinary teaching staff. In this manner, the students get to know various distributions of responsibilities and tasks throughout the lifecycle of real estate and learn how to strategize the synergy of their respective expertise. This holistic perspective stresses the many management-related decisions and possibilities encompassed within a sustainable built environment.

The module structure is allowing for different types of research and experiments in theory and management. Regular interactive workshops with discussions among peers and with professionals and the teaching staff help the students become more conscious of their own knowledge and beliefs. The distinction between the M.Sc. program in Real Estate and Facility Management and continuing education programs (MAS) lies in the research-based content of the curriculum. An individually produced research essay each semester allows the students to develop their own scientific potential. Evaluation and reflection form an important part of the students' learning environment in order for them to become creative, active professionals who can keep themselves updated on relevant theories, understand how they interact, and continually update their design routines according to this new knowledge. Furthermore, the students will be able to transfer the findings of research, innovation, and implementation related to sustainability in real estate into their professional practice and perform as collaborators and leaders in any transformation team.

The M.Sc. program ensures immediate contact with practitioners among education and research institutions, stakeholders of the real estate industry, and users in Switzerland and abroad by maintaining a strong link with professional associations (such as IFMA and RICS).

We noticed that more and more real estate companies are seeking to help environmental protection and limit climate change by investing in the research and development of green technologies and practices. Here, it becomes obvious that the main task of future real estate and facility management research should focus on quantifying real estate qualities and qualifying facility management quantities with respect to circularity and sustainability. This must begin with the development of a common vision for real estate and facility management professionals.

5. Conclusion

A total of 122 European university degree programs were examined for enabling future real estate managers to drive the sustainability transformation toward a circular built environment. The results show that topics on sustainability are covered significantly. Graduates are empowered in several disciplines that evolve around the real estate life cycle, but not in all the required ones. There seem to be gaps in teaching especially in the subject area of CE. The extent to which students are also socially empowered is hard to trace.

The critical discussion shows that the introduction of a holistic approach to the management of real estate to master-level students can help them gain a sustainability perspective and

prepare them to act circularly in the future. A concise proposal for how to embed circular economy management into a master course structure is given. It illustrates how the need for research in education and the essential contribution of the educational system, of formal, informal, and non-formal education, can be solved. This contribution may contribute to the current state-of-the-art on educational policies regarding the role of CE in sustainable development, to share a good and innovative practice of CE and sustainability teaching and learning in different countries, and to open and encourage a critical discussion on the topic.

The authors recommend practical educational strategies hoping (i) to encourage teachers to adopt innovative teaching methods and share good practices of the CE teaching and (ii) to urge education policymakers to integrate the CE vision into school curricula. Furthermore, the students' responses to a structured questionnaire before the program implementation indicate that experiential learning should be supported by the teaching of theoretical aspects for the better consolidation of abstract concepts such as CE and sustainability.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

MH contributed with the paper idea, CE modules settings, and paper structure. IW contributed with the paper idea and MSc program survey and paper structure. ZW-S contributed with paper structure and proof-reading and references. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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