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Research Article

Global Change Challenge in the Higher Education Curriculum on the Approach of Blended Learning

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Abstract: Global change is one of the greatest challenges facing societies today. Higher education plays a crucial role in providing knowledge on global change, contributing to the achievement of the Sustainable Development Goals (SDGs) and the 2030 Agenda for Sustainable Development. How is global change integrated into the planned, delivered and achieved curriculum? Has the pandemic promoted the development of blended learning courses on global change? To answer these two research questions, we conducted 25 interviews with academics about the prominence of global change in their courses and curriculum. We also analysed several geography curricula. It emerged that universities play a central role in mainstreaming global change into curricula in the context of education for sustainable development (ESD) and climate change. There were two main findings: (i) ESD has been implemented selectively in higher geography education, with a focus on environmental issues and different approaches and (ii) blended learning is a useful approach to develop new curriculum structures and content to educate students about global change.

Keywords: geography education, education for sustainable development, curriculum, higher education, blended learning

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Highlights:

- To date, higher education has dealt with global change in a fragmented way in the higher geography curriculum
- Higher education is a powerful element in preparing societies for global challenges
- The aim is to develop and share a common long-term, structural, sustainable and systemic cooperation on education, research and innovation in teaching ESD
- Blended learning approaches to higher education could incorporate a whole-system new curriculum structure in the context of global change

1. Introduction

The emergence of the COVID-19 pandemic and its rapid global spread presented schools and universities with the enormous challenge of transforming their teaching and converting to blended learning in a matter of days. Distance conferencing platforms largely replaced the traditional classroom. In addition, new geospatial technologies were integrated into teaching and learning (de Miguel Gonzalez, 2019). Teachers have also been tasked with discussing global issues related to the pandemic with their students, particularly the resulting context that challenges our human–environment ecosystem (Stoyan et al., 2019). The pandemic has highlighted the urgent need to prepare students to understand and be ready for global change and its implications.

According to de Miguel Gonzalez (2019), global change is one of the greatest challenges facing societies today. These challenges are related to the current human–environment dynamic, which Larsen et al. (2022) describe in terms of issues such as pollution, anthropogenic climate change and biodiversity decline. These problems were once localised but now threaten to cross international boundaries and could render the Earth's ecosystem in an uninhabitable state. However, global change can affect ecosystem processes in a particular place, not in isolation but as a result of multiple changes whose interactions in the form of synergies, complements and others are difficult to explore (Zhou et al., 2023). Geography education must now rise to the challenge of developing collaborative ideas for a better future in the face of global change. The goal of our societies must be to mitigate these phenomena by informing people, building resilience and strengthening adaptive capacity (Mochizuki & Bryan, 2015, p.

18). Higher education has an important role to play in informing global change in order to contribute to the achievement of the Sustainable Development Goals (SDGs) and the 2030 Agenda for Sustainable Development.

This study was conducted as part of a European project called V-Global, which focuses on two research questions:

- How is global change integrated into the intended, implemented and achieved curriculum?
- Has the pandemic encouraged the development of blended learning courses on global change?

In the V- GLOBAL project, global change is understood to be the changes that are triggered at the global level by the relationships of societies and people to their biophysical environment. Global change affects the entire ecosystem of our planet (Friis-Christensen, 2018) and impacts the socio-ecological system as a whole (National Academies of Sciences, Engineering and Medicine, 2021; Steffen et al., 2006). Global change includes—but is not limited to—climate change and the impact of human activities on this phenomenon.

To explore these issues, this paper is structured as follows. In the first part, we emphasise the central role of universities in mainstreaming education for global change as part of the curriculum for education for sustainable development and climate change. The second part presents the research methodology, which includes analysing different university curricula and conducting interviews with various academics. The third part details the findings of the curriculum study and interviews, which are then discussed in the final part.

2. Facing global change in higher education

2.1 Theoretical concepts about global environmental issues

Education for global change requires the implementation of education for sustainable development (ESD) in higher education. This means that teachers need to be sensitive to local and global issues and increase their knowledge of sustainable development (Corres et al., 2020; Millican, 2022; Scherak & Rieckmann, 2022). UNESCO (2019) highlights the important role of teachers and educators in promoting and increasing their knowledge of sustainability. However, implementing sustainability approaches in courses can be challenging, as most teachers do not yet incorporate them. A specific barrier in higher education is the lack of knowledge and investment among teachers (Leal Filho et al., 2019). 'Geography is essential for education and the environment, but also for society, the economy and politics: globalisation, sustainable development, climate change and technology are at the forefront of global and European challenges. Therefore, the international contributions of geographers are also essential to better understand the current context and to help in problem solving and decision making' (De Miguel Gonzalez, 2019, p. 1). In this broad field, three educational concepts in higher education are related to and explored through the project approach (Figure 1), and there are some overlaps between them, as described in the literature. These are: 1. education for sustainable development (ESD), 2. global learning and 3. climate change education (CCE).

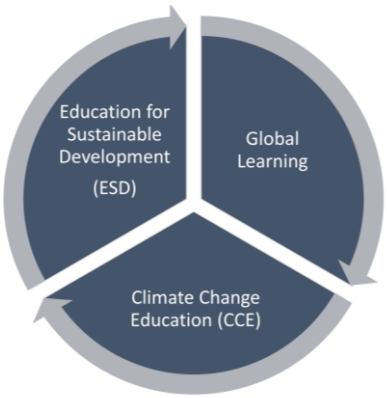

Figure 1. Climate change education and global learning in the framework of ESD

Education for sustainable development 'aims to develop skills that empower individuals to reflect on their actions, taking their current and future social, cultural, economic and environmental impacts into account, from a local and global perspective. Individuals should also be empowered to act in complex situations in a sustainable manner, which may require them to strike out in new directions, and to participate in sociopolitical processes, moving their societies towards sustainable development' (UNESCO, 2017, p. 7). Although theoretically addressing all levels of education from pre-school to adult education, universities are widely considered to have a more significant role in implementing ESD (e.g. Barth & Rieckmann, 2016), with a focus on the whole-institution approach (Bauer et al., 2021; Singer-Brodowski et al., 2019). In recent years, a variety of curricula have been developed at universities and other educational levels that implement the concept of ESD (Brundiers et al., 2021). Teachers also play a central role in this process (Barth & Rieckmann, 2012). The Bologna reform process has led to a significant change in teaching methodology, which has inevitably resulted in a change in teaching content (Baylina & Villanueva, 2021).

The second learning concept driving the project is global learning (Maastricht Global Education Declaration, 2002; Scheunpflug, 2021), which overlaps with ESD and is linked to Sustainable Development Goal 4, which emphasises the importance of quality education. The Maastricht Global Education Declaration (2002, p. 2) defines global learning as 'education that opens people's eyes and minds to the realities of the world and awakens them to bring about a world of greater justice, equity and human rights for all'. Global learning aims to equip global citizens with the knowledge and skills necessary to take transformative action (Murga-Menoyo, 2021). It addresses issues such as climate change, population growth, global migration and the consumption of natural resources (Scheunpflug, 2021). Despite the importance of the concept of global change, which goes beyond the idea of climate change, there are very few examples of its use in the curriculum. Therefore, it can be concluded that the topic of global change is largely absent from higher education curricula, and most examples focus on the related concept of CCE.

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CCE 'seeks to help learners develop knowledge, skills, values, and actions to engage and learn about the causes, impact and management of climate change' (Chang, 2014, p. 33). Mochizuki and Bryan (2015) combine CCE and ESD under the term 'climate change education for sustainable development' (CCESD) and describe its main organising principles (Table 1).

Table 1. Key organising principles of CCESD[1]

Approach	Main principles
Thematic	1. Ensuring an integrated and interdisciplinary approach to knowledge about climate change.
Territorial scope	2. Addressing local and global perspectives on climate change.
Ethical perspective	3. Taking a climate justice perspective.

[1] *Own creation*

The introduction of cross-cutting issues with local and global perspectives into higher education poses significant challenges that need to be identified and addressed.

2.2. Challenges to introducing global change in the curriculum

Integrating global change into university education requires organisational change in both management and curriculum, which can be achieved through a curricular approach (as shown in Figure 2). The curriculum is divided into three different parts: the intended curriculum, the implemented curriculum and the achieved curriculum, as described by Keeves (1992). The intended curriculum includes all written or oral instructions that define what is taught, including official curriculum guides, accompanying documents, textbooks and regional pedagogical writings produced by school authorities. Prescribed university curricula usually result from contractual agreements with the state and are regularly evaluated. The locally prescribed curriculum is usually based on the national reference systems. At the university level, the intended curriculum is co-designed by the teaching staff and not imposed from above. The implemented curriculum refers to the actual teaching that takes place in classrooms or lessons. Finally, the achieved curriculum refers to actual student learning. The transition between these three curricular levels is not always linear and requires significant restructuring, disruption and continuity. A curricular approach to global change requires an examination of the different curricular levels (Jonnaert, 2011; Lantheaume, 2014) and their interactions, as shown in Figure 2.

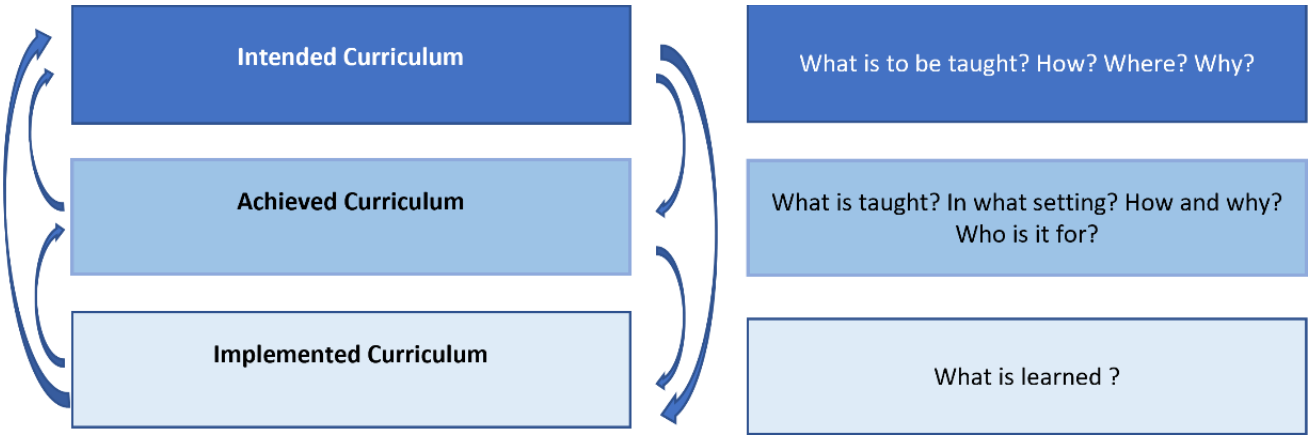

Figure 2. The interrelationship between the different types of curricula

In order to integrate global change into the curriculum, space must be made for it in the designated programme, which requires a restructuring of the degree programme. However, this is a complex task that can involve a variety of strategies. Molthan-Hill et al. (2019) identify four strategies for dealing with climate change: 1) integrate the topic into existing courses in a concise way; 2) create new specialised courses; 3) design cross-disciplinary courses for all students, either as electives or as compulsory courses and 4) create a transdisciplinary course for all students at the same university, regardless of their background, which is a major challenge. This approach requires enormous teaching resources and imposes constraints in terms of scheduling and space logistics. Blended learning can be used as a means to overcome these challenges.

3. Blended learning, a lever with which to implement global change in higher education curricula

Blended learning is still an ambiguous concept today (Hrastinski, 2019). It encompasses a wide range of pedagogical approaches that intentionally combine distance, online and face-to-face learning to activate and support learning (Boelens et al., 2015; Castro, 2019) at all levels and scales from local to regional to global. This method of learning does not require tutors to have continuous and immediate face-to-face interaction with their students in classrooms, ranging from 30% to 70% of non-face-to-face learning (Mueller & Mildenberger, 2021). Blended learning has evolved with the help of various tools such as webinars, audio/video conferencing, virtual and augmented realities, social networks, email and digital learning management systems (such as Miro, Openboard, Moodle, etc.). Today, there are numerous platforms that offer synchronous tools

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for simultaneous communication between lecturers and students, as well as asynchronous tools that promote self-directed learning with online materials for teaching, including global change.

Blended learning offers flexibility and individualisation, allowing students to enhance their autonomy and take advantage of asynchronous options, ultimately leading to effective learning that encompasses content, tools and knowledge building, as Moor (1989) states. Effective learning is the main goal of teaching and leads to motivation, satisfaction and success, as Parasakevas et al. (2011) point out.

Blended learning is increasingly used as a teaching method and offers the opportunity to reach a new group of learners (Huang et al., 2021). In this approach, instruction is delivered to learners through printed texts, electronic materials, mechanical aids and other techniques so that communication between teachers and learners can take place remotely. According to the work of O'Donoghue et al. (2015), three types of interaction are necessary for effective learning. First, learner–content interaction establishes a social presence and encourages collaboration and critical discourse, which ultimately increases motivation. Careful planning of learning activities with participants is a crucial aspect of any ESD learning experience (Leininger-Frezal, 2018). Secondly, learner–facilitator interaction requires a facilitator who can consistently assess the nature of the discourse and encourage the critical thinking component, which increases satisfaction. The aim is to identify the main topics (concerns, problems or risks) to be addressed in order to provide the participants with the knowledge they need for their learning. Finally, learner–learner interaction is the key element for integrating social and cognitive presence during the learning process. This learning environment provides a foundation for deliberative learning at the intersection of shared concerns, where participants can use their existing knowledge to make sense of what they see and experience. Through shared engagement, learners can work together to address their common concerns.

During the pandemic, universities were forced to adapt to new teaching methods, highlighting the need to intentionally integrate distance, online and face-to-face learning to facilitate and support learning (Boelens et al., 2015; Castro, 2019).

It is likely that this type of organisational approach can also be found or should be implemented in global change education. Interdisciplinarity and transdisciplinarity are necessary when dealing with global change issues (Mauser et al., 2013; van der Pluijm, 2006). However, it is not easy to implement inter- and transdisciplinary content in the classroom. For example, if we want students from different disciplines to take such courses, they may have different and potentially conflicting schedules. In this sense, the introduction of blended learning methods could facilitate such implementation. This is the aim and scope of the V-Global project: to explore the feasibility of introducing changes in the curriculum through blended learning.

4. Methodology

We used a methodology to identify the necessary choices for implementing education on global change in the intended and achieved curriculum at the university level. For reasons of feasibility, we focused on geography, which is a discipline that intersects the natural environment and society. We undertook two main methodological actions to achieve our research objectives: first, we analysed university curricula to determine if they include teaching and/or learning about global change or sustainability, ESD or similar concepts and observed the pedagogical approach and the skills to be acquired. Second, we conducted interviews with university teachers to learn how they teach sustainability issues and if they use or will use a blended learning approach (before and after the lockdown). In this regard, we also wanted to know if they use or were willing to carry out virtual field trips or virtual labs as specific blended learning tools.

4.1. Curriculum analysis

This research is based on the analysis of randomly selected curricula from five European universities: Université Paris Cité (UPC), Universität Hamburg (UHH), UNED (Madrid), National Technical University of Athens (NTUA) and University of Castilla-La Mancha (Spain). We have collected various components of the local curriculum standards for bachelor's and master's degrees in geography or geography education, including programme flyers, regulatory documents, syllabi and so on. These documents provide essential information about the structure of the curriculum, but say nothing about actual teaching practice, as each academic enjoys academic freedom. Table 2 shows the sample of curricula analysed.

Table 2. Curriculum corpus analysed

Criteria	Sample
Number of courses	NTUA (4); UHH (8); UNED (9); UPC (5); University of Castilla-La Mancha (3)
Degree programme	Bachelor's (15); Master's (14)

We identified the courses related to the concept of global change in these documents using the following three criteria:

- Curriculum geography: These courses belong to the subject area of geography in the broadest sense, including related professional training, such as teacher or engineer training.
- Subject: The course focuses partly or entirely on the interaction between society and the environment. It is not limited to courses that explicitly mention the concept of global change, so we can analyse the concepts used to address these issues.
- Scale: The course takes into account the global dimension of environmental issues.

Each course was then analysed using the analytical grid in Table 3 below. We tried to capture technical data such as the type of course, the level of the course, the course description, the format and the duration. In addition, we looked for information on the learning objectives and pedagogical strategies, the theoretical frameworks related to environmental issues and the tools used. We also wanted to know which teaching and learning approach was used and whether blended learning was introduced before or after COVID-19.

Table 3. Curriculum analysis grid

Item	**Content of the courses**
Degree programme	*Geography; Engineering; Teacher training; Other*
Level	*Bachelor's degree; Master's degree*
Course format	*Lecture*: theorical input with a large group of students *Workshops/tutorials:* supervised practical or theorical work *Seminar*: small group working on research *Working group*: students work together to complete a given task
Learning objectives	Content knowledge: Physical geography Human geography Interdisciplinary content Transversal/cross-cutting content ESD content: teaching and learning SD content Skills: *how something is done* *Analysing documents* *Reading maps* Professional skills: *Teaching ESD* *Choosing content in the classroom (pre-service teacher)* *Using GIS* Life skills, values and attitudes: *Autonomous:* able to work alone *Responsibility* Sustainability Skills: *Critical thinking* *Spatial thinking* *Problem solving* *Thinking about the future*
Theorical framework (about environmental issues)	*Environment* *Climate change* *Global change* *Anthropocene* *Sustainable development/sustainability* *ESD* *Transition*
Pedagogical strategy	Content-based learning Problem-based learning Collaborative learning Professional work-based learning: internship Experiential learning Place-based learning: fieldwork Project-based learning Inquiry learning: research-based learning
Tools used	GIS Story maps Maps Documents Google Earth Quizzes Participatory tools (Miro) Video Action bound Virtual campus (e.g. Moodle) Videoconference tools (Zoom, BBB, Teams)
Place of blended learning before COVID-19 period (now)	Physical face-to-face course Online face-to-face course E-learning course Enhanced course (face-to-face course + complementary activities online) Alternating asynchronous distance learning and synchronous face-to-face classes Flipped classroom

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Place of blended learning after lock-down	Physical face-to-face course (none) Online face-to-face course (synchronous) Enhanced course (face-to-face course + complementary activities online) Alternating asynchronous distance learning and synchronous face-to-face classes E-learning: all online Flipped classroom
Evaluation	Optional Mandatory
Duration	Time in hours per week and term
Target group	Students General public Other
Organisation	*Name of the university*
Keywords	*Add keywords*

We collected data and used it to create a database that gives us an overview of the information we have collected. We can compare this data with other universities and courses. To complement this initial analysis, we conducted semi-structured interviews (n = 25) across Europe.

4.2. University teacher interviews

We conducted interviews with 25 university teachers in various positions, including assistant, associate or full professors and doctoral students. All interviewees teach at least one course related to issues of environment–society interaction at either bachelor's or master's level. The interviews were conducted by partner universities of the project in eight countries, namely France, Germany, Greece, Spain, UK, Bulgaria, Portugal and Poland. Table 4 gives an overview of the interviewees.

Table 4. Academics interviewed

Item	**Population interviewed**
Country	France (5); Germany (5); Greece (5); Spain (5); United Kingdom (2); Portugal (1); Poland (1); Bulgaria (1)
Position	Professor (7) Associate or assistant professor (13) Post-doc (3) PhD student (2)
Institutional affiliation	Faculty of Geography or comparable (10) Faculty of Education (9) Engineering school (4) Faculty of Sciences (2) Faculty of Politics (1)

The interviews were semi-structured and lasted about 30 minutes each. They were recorded and transcribed only after consent was obtained from the interviewees. Our primary aim was to gain insight into how the interviewees teach sustainability topics in their courses and whether they have introduced or plan to introduce a blended learning approach. In addition, we asked whether they have used virtual field trips or virtual labs as specific blended learning tools. To facilitate the comparison of responses, the interviews were structured around these questions, and the order was maintained throughout the interview:

1. How do you teach sustainability or related issues and the underlying pedagogical approaches in your classes? Describe how you do this.
2. How do you teach the topic of sustainability or related topics and the underlying pedagogical approaches in your lessons? Describe how you do this.
3. How do you judge whether these goals have been met?
4. Do you use or plan to use blended learning?
5. If yes, please describe why and give a case study of virtual field trips or virtual labs.
6. Please describe the opportunities and disadvantages of these approaches (strengths and weaknesses).

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The interviews were conducted in different languages, often in the national language of the interviewee. They were subsequently translated into English for analysis. The analysis was conducted using both quantitative and qualitative methods, namely qualitative content analysis (Mayring, 2014) and quantitative analysis using Iramuteq software (Baril & Garnier, 2015). Iramuteq is a software application that enables the statistical analysis of text data. The software analyses the text corpus based on the proximity of words in the text segments.

5. Results

5.1 Thinking about global issues: A disparate theoretical framework

Different concepts are used to address global environmental issues, revealing the diversity of theoretical frameworks. The concept of environment is mentioned most frequently in both the interviews and the intended curricula (see Figure 3). It is followed by the concepts of climate change and sustainability. It is noteworthy that certain policy concepts, such as transition or global change, do not seem to have been widely included in geography education at the university level. The graph below shows the spread of concepts used.

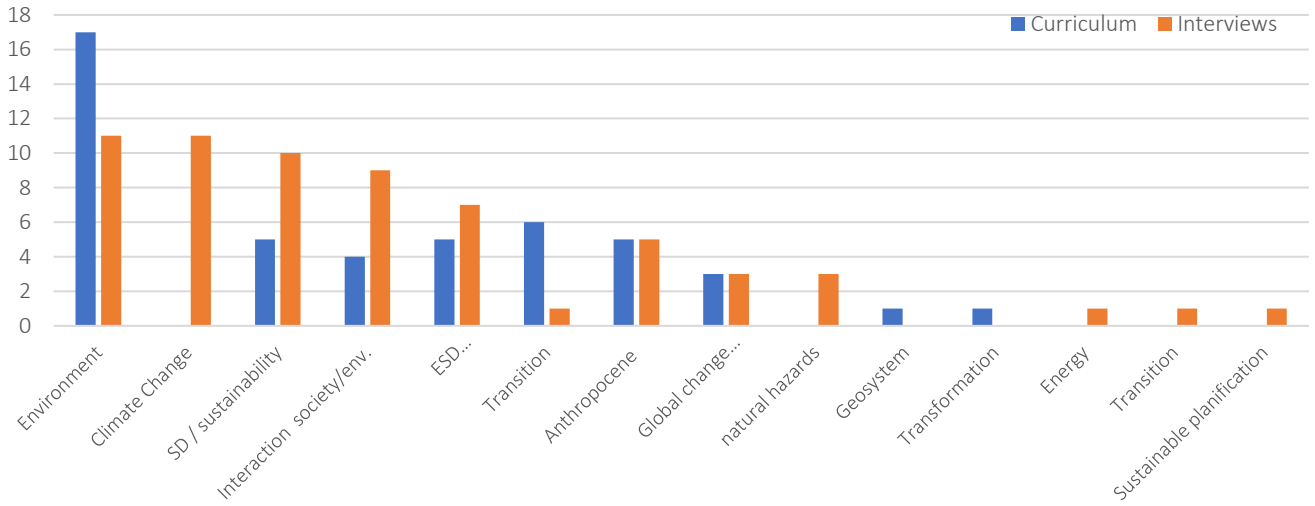

Figure 3. Number of references to concepts in the written curricula

Environmental and sustainability issues are addressed through the intersection of physical and human geography and an ecological approach. These lessons often go beyond the disciplinary framework by adopting an interdisciplinary or transversal perspective, as shown in Figure 4. The approaches listed under the category "ESD" are covered in teacher training.

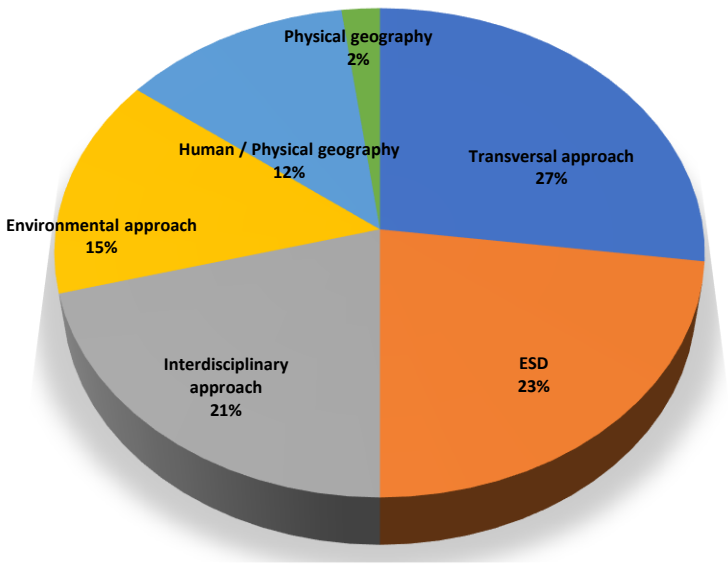

Figure 4. Theorical framework (interview corpus)

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These transversal approaches are not limited to a particular university. As emerged from the interviews, they are even applied at four universities:

> *I try to teach students that environmental problems do not exist in a vacuum; that there are socio-environmental problems, there is an economic and social dimension. One of the objectives of the course is that students must be capable of integrating social and environmental issues and to see that, if we were to leave economic and social issues aside, environmental problems themselves could have much easier solutions. (UNED1)*

> *These questions are fundamentally interdisciplinary questions. It is essential to adopt interdisciplinary approaches and teach each discipline if it does not do interdisciplinarity and if it is interested in the big picture. It is essential to have interdisciplinary approaches and each discipline. (UPC2)*

> *The goals are essentially related to any kind of development intervention, spatial, that is, the social part encompassing poverty, hunger and infrastructure. We also try to open the conversation up a little into the marine environment and are mainly interested in the relationship between land and sea and design in the marine environment, which is also one of the goals of sustainable development. (NTUA5)*

> *The approach is conducted through three major sections in relation to sustainability—climate issues being not only climate change and global change but also technology adaptation. It's a cross-cutting subject. (NTUA2)*

Interviewee one from UHH provides an excellent example of how ESD has been integrated into the training of geography teachers at university level and the importance of this: 'I think it is crucial to incorporate environmental and sustainable development issues into geography.' The topic is integrated into teaching through discussions on interdisciplinary or transversal issues and contexts, such as 'water supply in certain regions and how climate change affects water supply in such regions' (UHH1). Furthermore, the teaching of ESD at university level includes the involvement of 'external experts' and participation in participatory events such as the 'ESD-day of the week'. In addition to the teaching methods related to ESD, the interviewee emphasises the contribution of the interdisciplinary and transversal nature of ESD and its implementation at university level to deepening the understanding of the relationship between humans and nature, raising future teachers' awareness of the subject and making an important contribution to their professional training: 'the first aim is always teacher professionalisation' (UHH1). Thus, the learning objectives encompass professional skills such as teaching ESD as well as life skills, values and attitudes, such as responsibility and sustainability skills related to future thinking.

The results of this interview are consistent with the findings of the curriculum analysis. In the introductory module for teaching geography, it explicitly states that ESD and the associated skills should be included in the lecture: 'Introduction to the central questions and content areas of geography education: concepts and guiding principles of geography education, e.g. education for sustainable development (…)' (UHH Bachelor Curriculum, 2020, p. 87).

The NTUA respondents emphasised the importance of integrating technology and different subjects into the theme of global change for management, conservation or modelling. All teachers shared the view that the terms used, such as climate change, sustainability or vulnerability, involve changes in relation to both the environment and people. 'Sustainability is not only environmental but also social' because 'I think we must approach sustainable development at this level, i.e. infrastructure/society' (NTUA5).

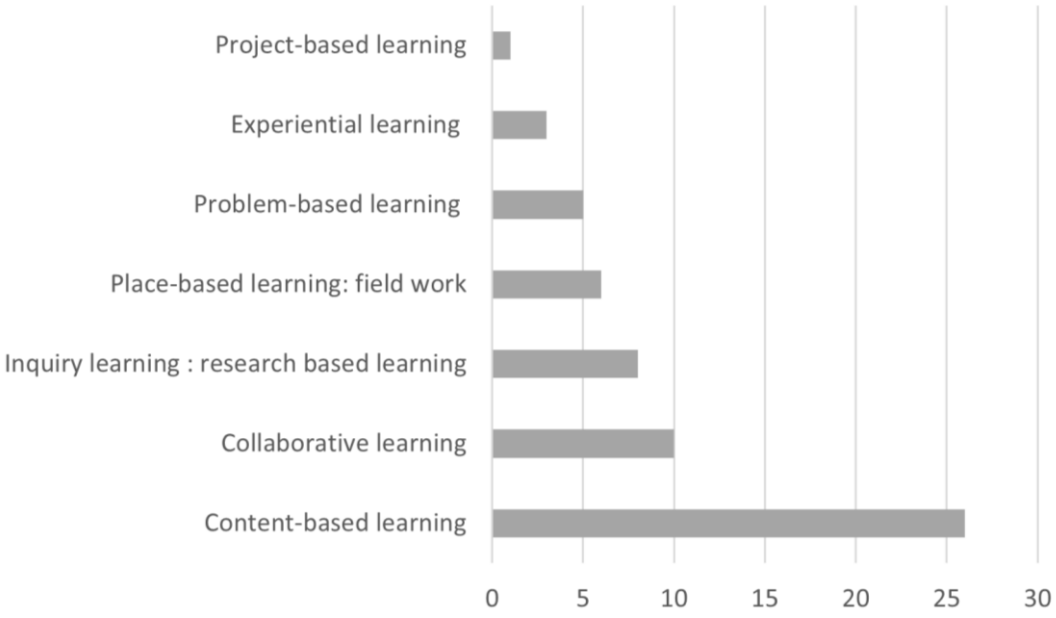

Figure 5. Pedagogical approaches (Curriculum corpus)

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Although all courses focus on skills related to new methods and technologies, the main learning objective is to 'raise students' awareness as well as help them understand the future and encourage them to take action' (NTUA2).

Finally, the approach of problem-based learning is described in detail, and new participatory methods are addressed in the new curriculum. However, some teachers are experimenting with this approach in their courses. 'These are very interesting methods aimed at raising public awareness, and I'll give you an example: our students have prepared material to teach in schools. They discussed issues such as the circular economy and water resource management,' and 'in this way, the chain for raising awareness is activated, mobilising students and their families' (NTUA5). However, problem-based learning is rarely mentioned in the curricula analysed.

The most commonly used pedagogical approach in geography teaching is content-based learning, as shown in Figure 5. However, other pedagogical approaches such as collaborative learning, inquiry-based learning and problem-based learning were also mentioned in the interviews or in the analysis of the curricula. Interestingly, the results indicate a low prevalence of place-based learning. Active pedagogical approaches were implemented through hands-on activities in seminars, workshops or working groups.

The predominance of content-based learning raises the question of the place of ESD in these courses. Is it about imparting classical geographical knowledge, or are the courses consciously part of ESD? ESD should be an integral part of teacher training.

> *The idea is that pupils feel they are an integral part of the functioning of the world: that they are not isolated from it but are part of it. (EUROGEO3)*

5.2. Skills in the intended or implemented curriculum

We have examined the objectives set by the teachers or the curriculum for these courses. In addition to the theoretical content, the aim is to develop skills in document analysis, data processing and mapping, as shown in Table 5.

Table 5. Skills worked (interview corpus)

Skills	Number of quotations
Analysing_document	31
Reading_text	1
Data_analysis	8
Data_collection	8
Data_management	3
Data_synthesis	3
Reading_map	13
Spatial_analysis	4
Analysing_map	4
Creating_map	3
Assessment_ methodology	1
Collaborative_work	1

In addition to these general skills, specific vocational skills such as urban planning and curriculum design were explored. Three main types of objectives are directly related to education for sustainable development. The first type of objective relates to spatial thinking, the second type aims to develop critical thinking and the third category aims to encourage students to think about the future. This is illustrated in Figure 6. The data from the interviews and the curriculum analysis are consistent.

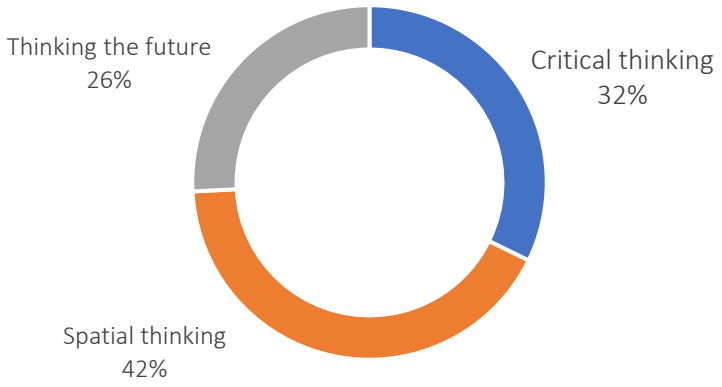

Figure 6. ESD skills (curriculum corpus)

The identified learning objectives were primarily skills-based. Soft skills and life skills were rarely mentioned in the curricula analysed or in the interviews conducted. Some academics focused exclusively on disciplinary content and did not see it as their task to get students to think about these issues or change their behaviour:

> *I start with L1, the goal is to first understand the system, i.e. the relationships that exist between the different climate parameters. […] Students must know that by putting their finger on the globe on the planisphere, they should have in mind the sequence of the different mechanisms, the different factors that will give rise to a climate. If we get to that point, that's great. (UPC1)*

Other teachers focus on spatial analysis:

> *We don't teach a geography course, so these are journalist students and I teach a quick introduction to GIS with open-source mapping software. And here's the data they to use. And then they create a map and they all go, "Wow, it's amazing". And then they sort of turn over the worksheet. And on the other side, it tells them how to manipulate that map to create the opposite story, to tell a contrasting story around that data. (EUROGEO1)*

Other academics focus on critical thinking, while some teachers adopt a forward-looking approach:

> *We focus on monitoring the environment, monitoring the planet with satellite imagery with photos. Students can see through the map or from a satellite image that is interactive, navigate to see the relief, see pictures and see points, and on these points, they can open images with what has happened in those exact places. It is unbelievable how easy it is for them to navigate. (NTUA4)*

This bi-lateral approach reflects the geographical perception:

> *In this way, the students understand and predict why there would be a flood, for example. We create conscientious citizens, because seeing and understanding the results marks them and for someone who does not have knowledge of geosciences to understand the ways in which an area will be flooded, for example, it is quite something. (NTUA1)*

> *So, the work in the laboratory. Using geographic information systems and modelling the parameters, we will answer the question of what will happen and also a big and powerful part of our teaching is the field work as geoscientists. Our real laboratory is the field, and we try to integrate it as much as possible into the lives of our students. Through collecting, analysing and mapping the quantitative and qualitative attributes of the geographical space, by means of specific tools, methods and technologies, students enhance the spatial thinking they need to form the groundwork for dealing with these problems, thus raising their awareness and readiness to act. (NTUA1)*

Conversely, other academics have explicitly designed their courses to sensitise students to sustainable change, as the following extract shows. Often these are teacher educators.

> *So, first of all, I think it is very important to take into account environmental and sustainable development issues in geography education (…) For example, for sustainable development goals, or very often in geography teacher education, you show something from school, and this always concerns human and environmental interactions. I think this is also how environmental and sustainable development questions enter teacher education classes. (UHH1)*

These findings highlight challenges that are discussed in the following section.

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5.3. Blended learning

With the exception of courses offered by UNED, a distance learning university, none of the curricula examined mention distance learning. However, many digital tools are mentioned, as can be seen in Figure 7.

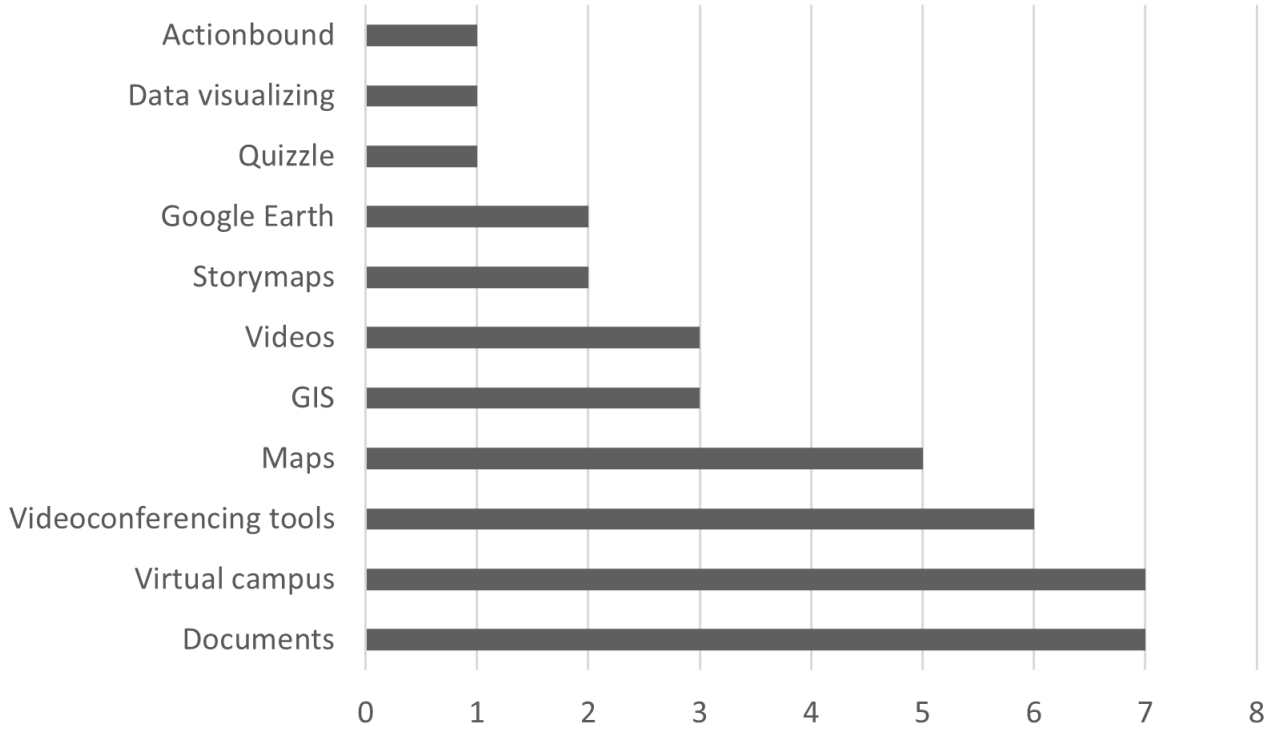

Figure 7. Digital tools mentioned in curricula

In addition to classical geography tools such as maps, documents or GIS, digital teaching tools such as virtual campuses (Moodle, Claroline, etc.) and tools used in virtual learning environments such as StoryMaps or Google Earth are also used.

> *We then do a specific session where we look at teaching with GIS and we take a case study where we look virtually at how they can bring a place into that classroom, but they do not collect data or anything. It's more about how it is done. (EUROGEO1)*

Nevertheless, the majority of academics do not seem to have engaged in blended learning practices after COVID-19:

> *When I was online all the time last year because of COVID, I felt that when I met my trainees at the end of the course on a field trip, many of them had not engaged in the remote teaching that they probably should have. (EUROGEO2)*

The interviews even underline a certain distrust of blended learning, which is seen as online lectures via Zoom or Teams. Academics point to the cumbersome and inefficient nature of online conferencing tools for interacting with students:

> *I had to use the blended learning methodology during COVID because there was no other choice last year. I certainly don't like it. My vocation is face-to-face. I think it loses a lot of impact, it loses all the power of the interaction between students and between students and teachers. (UNED2)*

> *Talking in front of my screen and when there is an audience, if it is in real-time, it can work. But if we are asynchronous, personally that does not suit me. I've never done it, but I'd be uncomfortable with that. (UPC2)*

However, some teachers have found that blended learning improves the learning curve during COVID-19. Despite this, the terms e-learning, blended learning and distance learning, including virtual field trips, did not make sense to some, highlighting academics' lack of training in this area.

> *Interviewer: And you haven't used virtual field trips yet?*

> *Interviewee: (...) I wondered what that was? So, what is meant by that? (pause) So I uh. That means (pause) well I don't know. I don't know this term. (UHH5).*

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Are you asking me about blend-learning? Are you asking me about the integration of tools, virtual journeys, and so on …? (UNED1)

The virtual field trip is considered an interesting complement to the real field trip, but not a substitute:

And with excursions it's, I mean, I don't know, when I'm on Google Earth and I'm driving through Greece, it's just not the same as when I'm on site for a week. The virtual experience is somehow not comparable (…) On the other hand, for example, when we used these Story Maps instead of writing a term paper, I thought it was quite good. Because it's also something that I think you can somehow pass on to others. (NTUA 5)

So, I would say that for me it would be good to combine the positive aspects of both forms. It's the mix that makes it. Online tools and meeting in person. (UHH3)

I try to make sure that what is in the Story Map is not what I am telling in the field; it is a complementary material. (UNED1)

6. Discussion and conclusions

The aim of this study was to gain a better understanding of how global change is integrated into the three dimensions of the curriculum: the intended, the implemented and the achieved curriculum (Keeves, 1992). In addition, a further aim was to determine whether the pandemic had promoted the development of blended learning on global change. Four findings emerged from the interviews and curriculum analysis. First, in integrating global environmental issues, there is a wide range of existing concepts in the curricula, some of which are frequently used, such as environment, climate change and sustainability, along with related educational concepts such as education for sustainable development (ESD). Secondly, the most widely used learning approach for global change topics is content-based learning. Thirdly, in terms of skills to be developed, document analysis, data processing and working with maps are particularly emphasised in the curricula or in the interviews. Fourth, there is a wide range of tools used in blended learning. A distinction can be made between general tools (e.g. video conferencing tools) and subject-specific tools (e.g. GIS).

ESD has so far only been used selectively in geography courses at universities with a focus on environmental topics, as Brundiers et al. (2021) describe. The curricula studied showed a diversity of approaches, with some intended and implemented curricula playing a central role for ESD, as described by Barth and Rieckmann (2016). This is especially true for teacher education, where the implementation of ESD has already been demonstrated in other studies (Sprenger & Nienaber, 2017). On the other hand, there are many courses in geography curricula that deal with sustainability or environmental issues, but these courses are primarily addressed through the prism of disciplinary content or skills, including spatial thinking, thinking about the future and critical thinking. However, interdisciplinary, transversal or cross-cutting approaches are not absent from the stated practice of the academics interviewed. In summary, while course content may provide insights that could help educate students about sustainable development, courses are not always designed and delivered in line with these insights, except in teacher education where students need to be prepared to implement ESD in their classrooms.

Global change is one of the least used concepts, as Van der Pluijm (2006) also shows. Blended learning could be an approach to developing new curriculum structures and content to teach students about sustainable development, especially global change. The majority of teachers interviewed said that they had not changed their teaching practices after the pandemic. The abrupt shift to distance learning during the lockdown led to misconceptions about blended learning and a strong desire to return to face-to-face contact with students. Academics pointed out the challenge they faced in terms of technological issues (Davies et al., 2013). In addition, teachers are sometimes not well trained in pedagogy in general and in the use of blended learning in particular. The challenge, then, is to incentivise and enable university teachers to design a blended learning course that offers innovative teaching approaches, including greater motivation to teach sustainable development and global change (Akyol & Garrison, 2011). Secondly, blended learning is an interesting lever for developing curricula that address the challenges of global change in a transversal way at the university level. Blended learning makes it possible to overcome the organisational and systemic constraints (e.g. cost, timing and location) of courses that apply to multiple programmes. In the eyes of the interviewees, virtual field trips are an interesting tool to teach students about sustainability. Virtual field trips (France & Haigh, 2018; Friess et al., 2016; Lindau & Finger, 2012) could be a way to develop blended learning in the context of ESD (Leininger-Frézal & Sprenger, 2022). A virtual field trip is a multimedia teaching and learning environment that provides the opportunity to explore geographical areas in a virtual, multimedia and interactive way (free translation from Schmidt et al., 2012, p. 145). Virtual field trips have already been used in higher education as part of ESD (Leininger-Frézal & Sprenger, 2022). The results showed that this approach is fruitful both in terms of student acceptance and learning success. Virtual field trips could be a lever to develop blended learning courses in ESD. However, there might be a gap between the benefits of virtual field trips in a blended learning environment and the actual expertise required to use and teach these pedagogical approaches in higher education. This practically results in the need to train higher education teachers. The European project V-Global is working to fill this gap by developing a transnational MOOC to train academics to incorporate blended learning courses on global change into the curriculum in order to have a practical impact on global change higher education and contribute to the achievement of the SDGs.

This study has a wide scope and opens up possibilities for the implementation of ESD in higher education. It provides a case study that offers examples of different facets of the global change curriculum in selected European universities. This is an interesting and novel perspective on teaching practice and the issues involved in developing a global change curriculum at the higher education level. As de Miguel Gonzales (2019) notes, global challenges require global approaches, and this study is a step in that direction. However, there are at least two potential limitations to the findings of this study.

The first limitation concerns the five selected universities, which serve as exemplary case studies and not as a representative sample. Only selective results within the universities are collected, so no conclusive statement can be made about a particularly effective approach for the institution as a whole, as Bauer et al. (2021), Singer-Brodowski et al. (2019) and Sterling (2004) describe.

The second limitation is that the study is based on curricula and teacher-reported practices, rather than classroom observations. These are different facets of the curriculum (Keeves, 1992) that may agree, but there may also be a wide gap between what teachers say they do and what

they actually do in practice. Despite these limitations, this research can be seen as a first step towards transnational approaches, such as in MOOCs, to enhance the teaching of global change in higher education by incorporating virtual field trips and blended learning teaching environments.

Institutional Review Board Statement: Not applicable. The study did not require ethical approval.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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