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An Inter-University CBL Course and Its Reception by the Student Body: Reflections and Lessons Learned (in Times of COVID-19)

Paolo De Stefani[1†] *and Ling Han*[2*†]

[1] Department of Political Sciences, Law and International Studies, Università degli Studi di Padova, Padua, Italy, [2] Centro di Ateneo per i Diritti Umani "Antonio Papisca", Università degli Studi di Padova, Padua, Italy

The COVID-19 pandemic and the consequent restrictive measures adopted by the countries have significantly reduced the capacity of higher education institutions to carry out innovative international teaching and learning activities. This paper provides a short reconstruction of how the seven European universities, members of the Arqus Alliance, handled this challenge. During 2020–21, that is, in full pandemic, the Arqus partners redesigned and implemented a trans-European challenge-based learning (CBL) project involving university students from many disciplinary fields, including social sciences and natural sciences, focused on climate change-related risks in European cities and areas. Based on this experience, a contingent conceptualization of CBL is proposed, comprising eight characteristics, whose effectiveness is then tested against data provided by students who participated in the courses. In this context, the results of a Likert questionnaire distributed to students from participating universities will be discussed. The analysis is meant to provide a deeper understanding of CBL not only as a pedagogical tool for a specific output, but also as a broader learning experience generating outcomes for teachers who plan and deliver CBL activities, and for the beneficiaries of such activities. In other words, the article aims to highlight some enabling and inhibiting factors of "strategic CBL"—this latter expression is supposed to capture the process of designing and implementing a CBL activity as a CBL practice in itself.

Keywords: challenge-based learning, higher education pedagogy, COVID-19 pandemic, blended learning, interdisciplinary education, interuniversity cooperation, student-led learning

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***Correspondence:**
Ling Han
ling.han@unipd.it

*These authors have contributed equally to this work

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INTRODUCTION

The COVID-19 pandemic has caused immeasurable damage around the world. In addition to causing a traumatic loss of human lives, it has impacted—and continues to affect at the time of writing—societies and socioeconomic systems worldwide. Higher education institutions are no exception. In response to the global health crisis, states have adopted lockdown and social distancing measures that have directly conditioned, among other things, the teaching and learning experience of millions.

In 2020 and 2021, almost all higher education institutions have closed their premises and suspended campus activities. Online learning has mainly replaced face-to-face classes (Amemado, 2020; Marinoni and van't Land, 2020; Marinoni et al., 2020; Schleicher, 2020). International student

mobility, a key feature in most European universities, has also been negatively affected (Rumbley, 2020, p. 10–13). While physical mobility has been suspended, "virtual mobility" has boomed, and collaborative online learning alternatives have been offered, where possible (Marinoni et al., 2020, p. 11).

Against this background, the seven European Universities of the Arqus Alliance (of which some details are provided in the next section) handled the challenge of pursuing their commitment to implement a Challenge-Based Learning (CBL) programme, originally meant to involve about 40 students from all parts of Europe in both face-to-face and online activities, during the COVID-19 pandemic. Instead of simply canceling the scheduled activities, the universities took up the challenge and moved the programme almost entirely online. The programme was adapted to an unpredictable scenario of travel bans, a sudden and generalized shift to digital learning platforms, and logistic uncertainties.

This paper provides a short reconstruction of how the CBL programme was implemented. The main objective, however, is not to report on the educational and practical restyling imposed by the Coronavirus crisis, rather to reflect on what this experience can teach in terms of conceptualizing CBL. Indeed, the need to radically rethink the CBL programme prompted the course designers to interrogate themselves and undergo a thorough reflection on the limits and potentialities of this methodology. The implementation of the CBL programme was in itself a CBL experience. Hence, the relevance of the work carried out in these circumstances, at least for those who were more directly involved in the making: teachers, learners, tutors, and stakeholders alike.

In general, the objective of the article is to highlight the enabling and inhibiting factors of "strategic CBL." With this expression, we refer to the process of designing and implementing a CBL activity as a CBL practice in itself. The specific "challenge", to which the Arqus program described in these pages responded, was that of establishing an international CBL program in higher education, in seven European universities, highly interdisciplinary, at a time of the Coronavirus pandemic. Any CBL programme is likely to be conceived as a "challenge." For this reason, we suggest to use the expression "strategic CBL" to describe a wider metacognitive approach required to capture the systemic transformative potentials that CBL encapsulates.

BACKGROUND: THE CHALLENGE OF THE COVID-19 PANDEMIC ON INTERNATIONAL MOBILITY

In Europe, international mobility has been a fundamental catalyzer of academic and scientific excellence for centuries. The EU Erasmus+ program of interuniversity exchange for students, lecturers and staff, and its predecessor, the Erasmus programme, have supported the mobility of more than 10 million students since 1987 (European Commission, 2021, p. 18). The European Education Area (EEA) project, launched in 2018 and featuring, among others, the European Universities Initiative, is also based on mobility and transborder cooperation as drivers of learning and excellence in research. Since student and staff mobility has been almost impossible during 2020 and most of 2021, transnational cooperation projects between universities have inevitably scaled down.

It can be said that higher education institutions and staff had to undertake a collective challenge-based learning journey. In response to the health emergency and the multifaceted social challenge caused by the pandemic, they have developed existing or brand new digital and organizational tools to adapt their plans and patterns to a disruptive event.

Digital learning, or e-learning, has been on the political agenda of the European Commission since the dawn of the new millennium (European Commission, 2001; Salajan, 2007; Salajan and Roumell, 2016; Zalite and Zvirbule, 2020). EU institutions could quickly adapt to the emergency induced by the pandemic (Marinoni et al., 2020; Rumbley, 2020), arguably, thanks to the progress made in digital education over the past decades. The COVID-19 crisis has accelerated the digital shift in teaching and learning, particularly in higher education (European Commission, 2020). The move of classrooms from campus to virtual space has been relatively smooth. It took advantage of software and platforms such as Zoom, Moodle, Teams, Kaltura Meet, and many others that private and public high education institutions managed to secure to scholars and the student body.

The reflection on the e-learning shift in higher education is not new. It may be maintained that faculty and staff in higher education institutions have had a relatively long time to ponder the benefits and weaknesses of distance teaching and respond to e-learning instruction challenges (Perrotta and Bohan, 2020). Students, instead, had very little time to adapt to the new learning environment.

Whereas, knowledge and information conventionally transferred by professors in traditional classrooms could continue to be imparted by means of online classes, either in synchronous or asynchronous mode, through online e-conference platforms, non-traditional learning faced a more severe challenge in migrating online. The virtual experience can hardly replace laboratory work, study trips, interactive workshops, learning-by-experience programs, etc. More generally, any kind of group work cannot shift to a virtual mode without losing critical cognitive dimensions.

The risk was that, because of the pandemic, some of the most engaging initiatives planned by the Arqus Alliance—one of the seventeen European Universities alliances funded by the EU Commission for the years 2019–2021 in the framework of the EEA—were to be abandoned or severely downsized.

A RETROSPECTIVE VIEW ON THE ARQUS COLLABORATIVE CBL PROGRAMME 2021 AND A TENTATIVE CONCEPTUALIZATION OF CBL

This section provides a short description of the CBL program that a working group within the Arqus Alliance (Arqus) designed and implemented in the academic year 2020–2021. The task itself was

a CBL experience, as the original programme had to be adjusted to respond to the "grand challenge" posed by the COVID-19 pandemic in the respective European countries. In particular, a separate paragraph is dedicated to the experience at the University of Padova. The unplanned experience of conducting an almost entirely online CBL programme has suggested the formulation of a situational and contingent definition of CBL (section Conceptualization. A situational definition of Challenge-based learning and research design), which, in sections Testing the CBL approach and Findings and discussion, will be tested against the opinions about their experience expressed by some participating students.

The Arqus Collaborative Challenge-Based Programme 2021

The Arqus Alliance is a partnership between the universities of Granada, Bergen, Graz, Leipzig, Lyon, Padova, and Vilnius, supported by the European Commission under the European Universities Initiative for the years 2019–2022.

The European Universities Initiative was launched after the 2017 Gothenburg summit with the aim of creating "bottom-up networks of universities throughout the EU which will enable students to obtain a degree by combining studies in several EU countries and contribute to the international competitiveness of European universities" (European Commission, 2018). Arqus started operating in 2019 on six substantive Action Lines (AL) (AL 1 was dedicated to governance and budget coordination): Widening Access, Inclusion and Diversity (AL2); Student-centred Frameworks for Quality Learning (AL3); Multilingual & Multicultural University (AL4); Entrepreneurial University and Regional Engagement (AL5); Research Support and Early Stage Researcher Development (AL6); Engaged European Citizens (AL7) (Arqus Alliance, 2021a).

CBL-like activities have been planned in the framework of many ALs. In particular, an "Arqus collaborative challenge-based programme" was planned in AL7, under the supervision of the University of Bergen. The objective was to establish, starting from 2021, a collaborative interdisciplinary course where students were "challenged" to investigate "the risks of climate change—from landslides to sea-level rise—and the role of institutions and citizens addressing these risks" (Arqus Alliance, 2021b). The course was intended to include a kick-off winter school in Bergen and follow-up activities in each university during the summer semester (from March to June 2021).

The train-the-trainers seminar was scheduled for the summer of 2020, the subject of which was to jointly develop the content and methodology of the Winter school. Six participants per partner university, selected among senior BA and MA students in multiple courses, should have participated in the Winter School to learn about climate risks facing European cities and how these risks might be governed. In addition to attending disciplinary seminars in Geology, Social Sciences, Biology, Physics, etc., the students were supposed to participate in workshops to acquire practical skills on mapping the climate risks in their cities, interpreting climate data, practicing interdisciplinary collaboration and scenario building (four quadrant-scenario frameworks). After the Winter School, each university had to organize a credit-bearing follow-up activity during the summer semester, with the possibility of involving additional students. Such activity was designed as a challenge-based learning project focusing on a climate-change-related topic proposed by experts/lecturers or identified by the students themselves. Finally, the whole programme was to be concluded with an academic conference, organized and led by students and hosted in one of the annual conferences of the Arqus Alliance, which would have provided a space to discuss and disseminate the results of the programme.

As it gradually became necessary due to the spread of Coronavirus infection, all aspects of the programme except the topic "Climate Change" had to be recast.

The train-the-trainers seminar was postponed and eventually conducted entirely online in October 2020, and the Winter School (February 18–22, 2021) was also held remotely. Students from different universities only had the opportunity to cooperate and interact with each other and with the lecturers and tutors on the Zoom platform or using other collaborative software. However, in some locations students could meet in person in the university premises.

The transfer of lectures to the online mode went quite smoothly, as students at the seven universities had become familiar with distance classes since the two previous semesters. Lectures were held online in the form of Zoom webinars, allowing the six participants from each university to interact directly with speakers, while a wider audience could occasionally attend the lectures without direct interaction. This made it possible to meet the requests of some universities who wished to offer Winter School content to a wider audience. The lecture recordings were made available on the Arqus Moodle platform (provided by the University of Graz) for any further asynchronous usage.

Conducting interactive workshops online across the seven universities proved to be a more difficult task. Facilitators had to be recruited at each university to support the local student teams in their assignments. For online cross-university interaction, some collaboration software and apps were used on which facilitators received *ad hoc* training before the beginning of the Winter School, namely Miro and Google Jamboard. Interaction on collaborative tasks (mapping the risks, scenario building, etc.) took place essentially within the local teams, some of whom had the chance to meet in person, while the others could only meet virtually.

After the Winter School, the CBL activities were organized locally, adopting different approaches and schemes, depending on the choices and opportunities available in the partner universities. The CBL approach was maintained as an overall feature, although the practical implementation modes could not be discussed in detail, and the coordination among the seven partners was relatively loose. This was only partly due to the Covid-19 emergency. In fact, coping with the diversity between the academic calendars and schedules, course structures, and the number of students and teachers involved in the seven universities proved to be harder than expected.

The CBL features—described in the subsequent sections of this paper—not only require engaged students to identify and

tackle, from a multidisciplinary standpoint, a concrete and localized "grand challenge" which in this case is associated with climate change and its societal impact. They also require students to conduct research in cooperation with non-academic actors, who can be data or challenge providers, stakeholders providing feedback regarding the relevance of the output, beneficiaries of projects, or the target of communication and dissemination actions, etc.

During the summer semester of the academic year 2020–21, local teams in each university, generally divided into sub-teams, worked on "climate risk challenges" and attended additional courses or seminars to support them in identifying and developing a suitable project, with the assistance of tutors and academic staff. As already noticed, attempts to organize on a regular basis joint inter-university virtual meetings and peer review exercises were only partially successful, due to the mismatch of the respective academic schedules and, more generally, the still disruptive impact of the Coronavirus on the involved institutions and persons.

Considering the diversity in the academic calendars and the variety in size, membership, and form of academic supervision, the results of the CBL exercise were hardly comparable across the partner institutes. Some teams elaborated on research papers seeking to meet the standards required by academic journals; others focused on research-based projects to be submitted to local government authorities or institutions, business operators or non-profit entities for implementation or further development.

Eventually, to assess students' performances, a joint seminar was convened under the leadership of the coordinating university of Bergen in June 2021. Representatives of the local student teams summarized the main results of the work conducted at the respective universities and received feedback from lecturers of the coordinating university, academics from the other universities, and their peers. The overall evaluation was that the quality of the students' output was remarkably high, as was the degree of satisfaction of the students. At the respective universities, students were assessed and marked, based on the research outputs submitted.

The CBL Programme at the University of Padova

Unlike some partner universities in the Arqus Alliance, where the same group of students participated in both the Winter School and the following summer semester activities, the University of Padova organized its summer semester CBL course involving a broader group of fourteen master's students to join the six who participated in the Winter School. The Padova course included lectures and seminars conducted in dual mode (in class with physical attendance, but also open to virtual participation via Zoom, the synchronous meetings being recorded and made available for asynchronous consultation on Moodle), and two study excursions to Venice and its lagoon, which lies at about 30 km from the city of Padova. The topic of the CBL course organized in Padova was indeed "Rethinking Climate Risk: The Venice Paradigm." This was intended as an expansion of the workshops proposed in the Winter School and focused on mapping climate risk at the local scale. The overall design of the course and its CBL features were inspired by an "Industry Community Project" course, jointly implemented by the University of Padova and the University of Sydney in previous years (University of Padova, 2019).

The 20 participants made up three interdisciplinary groups. Each group worked on a project they selected and related to the risks of climate change that impact the fragile physical and social environment of Venice and its lagoon. The six students who had participated in the Winter School were expected to act as leaders or moderators of the groups. The activity unfolded from mid-April to mid-May 2021. The five modules addressed in the lectures and seminars comprised a wide range of subjects, namely: The Venice lagoon: morphological characteristics, hydrodynamics of the lagoon system, man-made changes; The regulatory framework: "International Disaster Law," the role of agencies, institutions, and local communities; The perception of the climate problem and its consequences in city governance; The psychological effects in environmental emergencies; and The role of voluntary work, with specific reference to civil society associations operating in the city of Venice.

Each module lasted one week and consisted of 6–8 hours of morning lectures held in a blended teaching model. Workshops organized by trainers and self-organized group work were held in the afternoon or in the evening. The units were designed to provide multidisciplinary content on climate risk, from local and international perspectives, engaging scholars, practitioners, activists, and representatives of the business sector.

Two study trips to the city of Venice and the Venice lagoon, respectively, were planned to be carried out at the beginning of the course; however, due to restrictions during the pandemic, they were postponed to May, and the students had the opportunity to meet a wide panel of stakeholders, including NGOs, local institutions, cultural groups, business operators working in climate risk mitigation, and visit the natural and historical environment of the city and the surrounding wetland, including the technological facilities installed to control the tidal flows in the lagoon (the MOSE plant). Students then completed their research project in mid-June 2021. The elaborated projects included an educational toolkit for high schools to introduce teenagers to the risks related to climate change in the Venice lagoon; a project to launch a start-up promoting sustainable tourism in the wetlands of the north Adriatic Sea; and an analysis of the natural and social challenges of Venice city and its lagoon and ongoing resilience and adaptation projects.

CONCEPTUALIZATION. A SITUATIONAL DEFINITION OF CHALLENGE-BASED LEARNING AND RESEARCH DESIGN

In this section, we propose a definition of CBL based on an analysis of existing definitions and elaborating from the Arqus joint experience. The Arqus journey into the notion and practice of CBL started by identifying a "grand challenge," namely global warming, as the topic to be addressed through a joint CBL program. Consequently, before presenting the idea of CBL that

we eventually developed—and now try to conceptualize—this section also presents a short discussion of the notion of "grand challenges." In both cases, our purpose is not to propose a comprehensive theoretical foundation of the terms, but to retrospectively elucidate the rationale that oriented the design and implementation of the educational activities. Therefore, the provided definitions should be considered as eminently context-dependent, conditioned by the specific circumstances and expectations associated with the Arqus project. Keywords such as "international," "EU dimension," "European societies," "European citizens," "multi/interdisciplinarity," "environmental rights," "university social responsibility," etc., along with "responding to the Coronavirus pandemic" and "building a more resilient Europe" were among the most important drivers.

Grand Challenges

The notion and practice of CBL are generally associated with the concept of "societal challenges," also referred to as "grand challenges" or "wicked problems." This approach definitely fits the task of building a contingent, context-sensitive conceptualization of CBL at a historical moment characterized by the sudden emergence of a "grand challenge," that is, the coronavirus pandemic and its early aftermath.

Various articles in the literature have been addressing the slippery concepts of "grand challenges," "societal challenges," or "wicked problems" (Camillus, 2008; Malmqvist et al., 2015; Hicks, 2016; Kaldewey, 2018). These notions were first articulated in academic works but then gradually incorporated into the language of political entities and policymakers. Indeed, the overall concept seems to situate in a space where scientific and political spheres, descriptive and performative languages, ontology and epistemology somehow overlap.

The "grand challenge" language in science emerged in the United States during the 1980s (Hicks, 2016) and became predominant after 2000, largely replacing the cognate formula of "wicked problem," popularized since the 1970s. After the 2007–2008 financial crisis and its social and political repercussions, "societal challenges" or "grand challenges" have also become prominent in Europe among scientists and policymakers (Daimer et al., 2014). The "Europe 2020 Strategy" of the EU Commission conceptualized societal challenges as major concerns shared by all the EU citizens in the long term, which required smart, innovative and inclusive growth strategies (European Commission, 2010).

An element that seems to be associated with the shift from "(wicked) problems" to "(grand) challenges" is a more positive attitude *toward* the related risks, an attitude arguably borrowed from the rhetoric of sports (Kaldewey, 2018, p. 177–118). Indeed, the semantics of "challenge", compared to "problem", seems to convey the idea that the struggle is conducted not only against an external, objective, and factual obstacle situated out there in nature, but also inexorably incumbent on the human actor (be it a scientist, a policymaker, a citizen, a consumer, or a businessman). In the idea of "challenge," the actor and the "matter of concern" are instead entangled in a single knot. A challenge has to be accepted and ties together the actor and the risk associated with a certain situation. Moreover, in a challenge, there is always a winner and a loser. If an actor takes on a challenge, this means that there are prospects to successfully tame and control the associated risk.

In this sense, a "grand challenge" appears less disrupting than a "wicked problem," because it refers to issues of concern that the actor has pregauged, preframed and eventually elicited, among others, to be tackled effectively. Success, in this case, should not be interpreted as if the winner could "solve" or "dissolve" the situation of concern and radically eliminate the associated risk, as in a zero-sum game. Rather, successfully taking up a challenge means achieving an upgrade to a higher level of the game, passing to another scenario, and being ready for a further challenge. The virtually "infinite" chain of challenges and game levels tempers the apparently "optimistic" sport-inspired concept of "grand challenges." Similarly, the elicited nature of the challenge, that is, the fact that it is framed and shaped by the human actor to fit their agency, "selected" among the many potential issues based on criteria that look at least obscure and unpredictable, does not ensure that accessing any upper level of the game constitutes, in fact, an effective "progress."

In summary, "wicked problems" or "grand challenges" are critical social issues for which there are not only a lack of simple solutions, but even no solutions at all, as they are inherently and socially complex, ever-evolving, and coevolving along with the actors that frame them and the "solutions" applied to them. Global warming (or climate change), sustainable development, armed conflicts, and the nuclear race are some examples of "grand challenges" that share the mentioned characteristics. Dealing with a pandemic like the one caused by COVID-19 may well also be a "wicked problem" of this type. Their "wicked" character is also linked to the disputable status of the surrounding "problems." Far from being objective and natural "facts", "wicked problems" and "grand challenges" are the subject of social construction and can also disappear as "problems" or "challenges" due to a change in the subjacent narrative.

Thus, a (societal) challenge-based learning (CBL) experience is proposed as a constructive approach that education agencies and institutions, in general, can adopt to navigate a situation of concern characterized as a "grand challenge" or "societal challenge" and the multiple uncertain scenarios disclosed. By practicing CBL, participants of all ages develop the competencies and skills required to play, challenge after challenge, the game of life (Isidori, 2010) and exercise their citizenship.

Defining CBL

A seminal definition of CBL was proposed by Apple Inc. (Nichols and Cator, 2008, p. 1) when it launched the very idea of CBL (in bolds, the keywords identified in Leijon et al. (2021, , p. 4):

> *"Challenge Based Learning is an engaging* ***multidisciplinary*** *approach to* ***teaching and learning*** *that encourages students to leverage the* ***technology*** *they use in their daily lives to solve* ***real-world problems****. Challenge Based Learning is* ***collaborative*** *and hands-on, asking students to work with peers, teachers, and experts in their* ***communities*** *and around the world to* ***ask*** *good*

questions, develop deeper ***subject area knowledge****, accept and* ***solve challenges****,* ***take action****, and* ***share*** *their experience."*

Another useful and more pointed definition (Malmqvist et al., 2015, p. 90) describes CBL as (emphasis added by the authors):

"a learning experience in which learning takes place through the identification, analysis and design of a solution to a ***sociotechnical problem****. The learning experience is typically* ***multidisciplinary****, takes place in an* ***international context*** *and aims to find* ***collaboratively*** *developed* ***solutions*** *that are environmentally, socially and economically sustainable."*

These two definitions share many characteristics while differing from each other in describing the scope of the learning experience. The reference to "real-world problems" in the first definition seems to detach CBL from the "grand challenges," which, according to the constructivist approach adopted in this article, are neither "problems," nor "real-world" *facts* that learners and teachers assume as a given. The latter definition can be taken as fitting a CBL program that addresses "societal challenges" such as the one pursued by Arqus AL 7.

The reference to technology is unsurprisingly central in the definition of Apple. In fact, CBL was introduced as a learning and teaching process designed for high schools and universities in the domain of computer science and software engineering (Nichols et al., 2016; Tang and Chow, 2020; Leijon et al., 2021), and the practice has been heavily supported by high-tech companies. In many cases, the apparatus that most of the time CBL projects are invited to elaborate is software or apps. This can be easily inferred by visiting the website of the Challenge Institute (a spin-off of the work made by Apple Inc. in the field of CBL), created to disseminate the practice in colleges, high schools, etc. (Challenge Based Learning - Take Action Make a Difference, 2021; The Challenge Institute, 2021). In the context of the Arqus Alliance program described here, the role of technologies was not so overwhelming, despite the fact that the chosen topic (climate change) and the modality of interaction (distance learning) were heavily influenced by computer technology. The technological limb, in our situational definition of CBL, needs to be downsized.

The emphasis on technology may be related to the additional characteristic of CBL of "solving challenges." In fact, both definitions refer to a "solution" to a "real-world problem" or a "sociotechnical problem" as the expected outcome of the learning process. However, as discussed above, "grand challenges" are not likely to be "solved"—although they incorporate an "optimistic" narrative that promotes agency and encourages playing the game.

Another feature of CBL is the emphasis on multidisciplinarity, which may evolve toward interdisciplinarity. Despite praising multidisciplinarity, the definition of Nichols & Cator identifies the development of "deeper subject area knowledge" as one of the key goals of a CBL experience. However, the relationship between a multidisciplinary approach and the focus on subject area knowledge is not entirely clear. Indeed, CBL experiences are generally carried out with students from a specific major, usually in computer science or engineering, who address a limited set of specific facets connected to a societal challenge, most of the time likely to be addressed using the scientific and technological tools that learners can handle, for example, innovative computing (Binder et al., 2017). Multidisciplinary knowledge is integrated in a second phase and does not appear deeply embedded in the CBL design as a crucial outcome. A literature review covering academic articles discussing the definition and application of CBL in third-level education institutions found that non-STEM (Science, Technology, Mathematics) publications were virtually absent (Gallagher and Savage, 2020, p. 6). Among the CBL experiences reported in the literature, we can mention the "Global Challenges in Engineering" course at the University of Western Australia (Baillie et al., 2015) and "The Green Challenge" course at the Technical University of Denmark (Hussmann et al., 2010). Particularly relevant for our case is the case presented in the work of Gunnarsson and Swartz (2021), as it refers to a comprehensive project aimed at including a CBL frame in engineering courses within a consortium established under the same European Universities programme as for Arqus. CBL involving students from different disciplines on a common and sufficiently multifaceted theme may include the "Challenge Lab" at Chalmers University of Technology (Holmberg, 2014, p. 98). In rare cases, CBL was applied in social science and pedagogy (see, e.g., Cruger, 2018); the most common field is engineering (Leijon et al., 2021, p. 3), and innovation is a key feature.

The "knowledge" that CBL contributes to developing is not only in the cognitive realm, but also includes moral attitudes and virtues such as empathy, solidarity, and civism. The first definition appears to value the cognitive and performative output of CBL, despite its final mentions of "take action" and "share [the] experience." The latter expressions apparently refer to the specific scope of the chosen "challenge," and not to a wider form of civic involvement, which seems to transcend the provided definition. Quite differently, the definition elaborated by Malmqvist and others emphasizes the qualitative characteristics of the outputs, which suits better CBL within the Arqus framework. In fact, the Arqus agenda is explicit in mentioning the Sustainable Development Goals (SDG) and targets as fundamental terms of reference in its Vision and Core Values documents (Arqus Alliance, 2021c).

The other characteristics of CBL mentioned in both definitions, namely the collaborative configuration, the involvement of experts from the community or a broader field, the action-oriented pattern and the sharing component (communication, especially to the concerned community, dissemination, and feedback), as inherent in any project, are all fully relevant in connection with the Arqus experience.

In light of the above discussion, in this article, CBL is conceived as a learning framework that allows participants (university students, working in teams and assisted by scholars as facilitators or coaches) to navigate local and global "societal challenges" identified autonomously or responding to a challenge provider, while gaining multi/inter-disciplinary awareness and cultivating disciplinary knowledge and professional and social skills. CBL allows to develop concrete and feasible sociotechnical projects, based on a scientifically controlled research pattern and in dialogue with local and global stakeholders, that integrate a technological

TABLE 1 | Students responses ($N = 26$).

Items/statements	Disagree*	Neutral**	Agree***
1. I increased substantive and methodological knowledge in my main field of study.	6	9	11
2. I increased my ability to formulate complex problems in a critical and independent way.	6	6	14
3. I increased my ability to plan, conduct, and finalize a research project.	6	1	19
4. I appreciated that we could address grand challenges of concern for the global society.	1	1	24
5. I found my main field of study allowed me to fully grasp the topics addressed in lectures and workshops I attended.	5	5	16
6. Lectures, workshops, and our research project used mainly tools and knowledge from fields different from my main area of study.	7	6	13
7. I think my field of study does address current societal and environmental problems	4	2	20
8. The research/project I worked on can actually have an impact in a real-world scenario.	2	5	19
9. Information and ideas provided by non-academics (experts, speakers, stakeholders, etc.) were important for the development of our research project.	3	6	17
10. The findings of our research led me to question some attitudes/ideas that I had prior to starting the project.	7	5	14
11. The most relevant feature of this learning experience were lectures and related discussions.	11	7	7
12. The most relevant feature of this learning experience was applying and developing research and development tools, such as software and apps, Internet-based tools, etc.	5	9	11
13. The most relevant feature in this learning experience was interacting with my peers from other universities' research groups.	6	7	13
14. What I most appreciated was learning and applying research methods and procedures.	3	7	16
15. Our research project could not have been carried out without the input of all team members.	8	3	15
16. I enjoyed working with colleagues in my group.	2	5	19
17. I enjoyed working in English in most activities.	1	2	22
18. I enjoyed drafting and editing the final research output.	5	6	15
19. I have greater confidence in doing scientific research.	6	4	16
20. I feel I could lead a team in similar situations.	1	4	21
21. I believe that complex issues such as climate change and environmental degradation can be tackled constructively.	1	0	25

Disagree = the number of respondents who selected 1 (I totally disagree) and 2 (I disagree).
**Neutral = the number of respondents who selected 3 (I am neutral).*
***Agree = the number of respondents who selected 4 (I agree) and 5 (I totally agree).*

component and are likely to be communicated, implemented and disseminated, producing effects compatible with the SDG agenda.

To sum up, CBL in the Arqus programme is a student/learner-led undertaking, in which actors from different sectors and with different goals are involved, with the aim of developing a *dispositif* (apparatus) to tackle an intractable "grand challenge." The learning experience is multidisciplinary and interdisciplinary. The technological element is not necessarily included in the outcome, but is nonetheless inherent, at least as much as necessary for communication and dissemination. In fact, any research that aims to have a practical impact in a physical or social domain has a technological component.

TESTING THE CBL APPROACH

Based on the conceptual framework elaborated within the Arqus program, at the end of the collaborative experience, a reflective inquiry, in the form of a Likert questionnaire, was made, with the purpose of testing whether the key elements of a CBL experience were actually remarked on and appreciated by the students. Indeed, no student participating in the Winter School and in the spring semester might be considered familiar with CBL methods. Neither was the CBL character of the planned activities particularly emphasized by the proponents—due to the same reasons sketched above: on the one hand, the novelty and peculiarity of the multi-university and multidisciplinary scenario and, on the other, the impact of the pandemic that caused the methodological attention of teachers and learners to focus predominantly on e-learning. Therefore, the questionnaire gave the opportunity to test whether the organizers succeeded in establishing a meaningful CBL program, that is, whether the contingent definition proposed above captured the actual practice not only in the expectations of the proponents, but also in the evaluation of the students.

Methodology of the Survey

The investigation was carried out using a qualitative approach with mixed elements. It mainly qualifies as action research, since the authors were directly involved in designing and implementing what was the object of the survey and used the research output for curriculum development purposes,

and possibly to generalize CBL practice (Gibbs et al., 2017).

Student opinions were collected using a self-assessment questionnaire with a Likert scale along with some open-ended questions. Analysis of the responses to the questionnaire was carried out in light of discussions, comments, and suggestions that the authors had over the months with lecturers, students, and stakeholders. The comments also take into account the evaluation of the CBL outputs.

By filling in the questionnaire, the students provided a self-assessment about their previous preparation, experience during the programme, and learning outcomes. The assumption is that from their answers, it is possible to infer whether the students perceived and appreciated the key features of CBL as conceptualized in the previous section and operationalized over the unfolding of the Arqus AL 7 program.

The main body of the questionnaire consisted of 21 Likert scale questions belonging to eight areas developed from the definition and main characteristics of CBL as summarized at the end of section Conceptualization. The eight characteristics were as follows:

1) tackling societal challenges,
2) inter-disciplinarity,
3) engaging stakeholders,
4) internationalization,
5) applying research skills,
6) teamworking and developing interpersonal skills,
7) active learning, and
8) using technology.

The eight CBL characteristics were embedded in one or more questions of the student questionnaire. Based on their assumed semantic implication with one or more of the CBL characteristics, the items in the questionnaire were weighted (from 0.1 to 1) to reflect their heuristic value with regard to one or more criteria. In fact, not only single items were measuring more than one CBL characteristics, but the latter also may have some elements in common. For example, "internationalization," "teamwork and interpersonal skills," and "active learning approach" share a social and communicative dimension; similarly, "using technology" and "engaging stakeholders" are entangled with "applying research skills."

Three final open-ended questions invited students to comment on the organization of the program, in particular the inter-university collaboration, one aspect that admittedly needed improvements and on which the comments and suggestions of students were considered of relevance. These items were mainly for internal review and are not discussed in this paper.

The questionnaire was distributed online to all participants at the end of all activities of the Arqus 2021 programme (June 2021). There were 26 respondents out of a potential target of 56. The low participation in the survey could be partially explained by the fact that, in some universities, most of the summer semester activities ended well before June.

Finally, it must be taken into account that the questionnaire was conceived and construed having as a privileged term of reference for the CBL activities carried out at the University of Padova, which the authors of this article could directly follow and get direct experience from. Some parts of the questionnaire may not have adequately reflected the student experience in other universities, and this may have affected the response rate.

Considering that the recorded elements of the CBL are interconnected and that there was a low number of respondents, a qualitative analysis method was adopted, using at times quantitative data to control the interpretation of some conclusions.

The Likert Scale Questionnaire and Its Interpretation

The student questionnaire consisted of 21 statements (items) that the students had to comment on using a five-point Likert scale, from 1 ("strongly disagree") to 5 ("strongly agree"). On each item of the questionnaire, the respective rate of "disagree" (the number of people who selected the minimum scores of 1 and 2), of "neutral" (the number of people who selected 3), and of "agree" (the number of respondents who selected 4 and 5) was calculated (see **Table 1**).

Based on the responses of the students, we then calculated two values for each of the eight characteristics of the CBL—the "negative" and the "positive." The "negative" value represents the sum of the "disagrees" received, multiplied by the respective weight (from 0.1 to 1) assigned to the items on the Likert scale associated with the given feature—the higher the negative value, the lower the level of student reception of CBL features. On the same token, "positive" scores represent the level of successful reception of the CBL "philosophy," and the result of the "agrees" score multiplied by the coefficient assigned to the respective item. In the cases of items 5 and 11, negative and positive scores are inverted. Thus, the "neutral" values were discarded, as their contribution to our research question was negligible; however, they will be used in the interpretation of some results.

The CBL features that received a positive score $\geq$15.6 (i.e., those receiving an "agreement" from at least 60% of the respondents) are considered acknowledged and shared by the students, while those valued with negative scores >15.6 (60% of "disagrees") are considered failed—that CBL characteristic was not perceived as such by the students. The results in between shall be interpreted case by case.

The first characteristic of the CBL—"Tackling societal challenges"—was tested by Items 2 (weight [w] = 0.2), 4 (w = 0.4), 7 (w = 0.1), and 21 (w = 0.3). This general feature of the CBL has been checked in questions distributed randomly in the list, in order to avoid standardized responses.

Items 1 (w = 0.1), 5 (w = 0.4), 6 (w = 0.3), and 7 (w = 0.2) have been used to measure the second quality: "Multi/Inter-disciplinarity." Some elements directly address students' experience in interdisciplinary learning, while others aim to improve disciplinary knowledge and skills, the acquisition

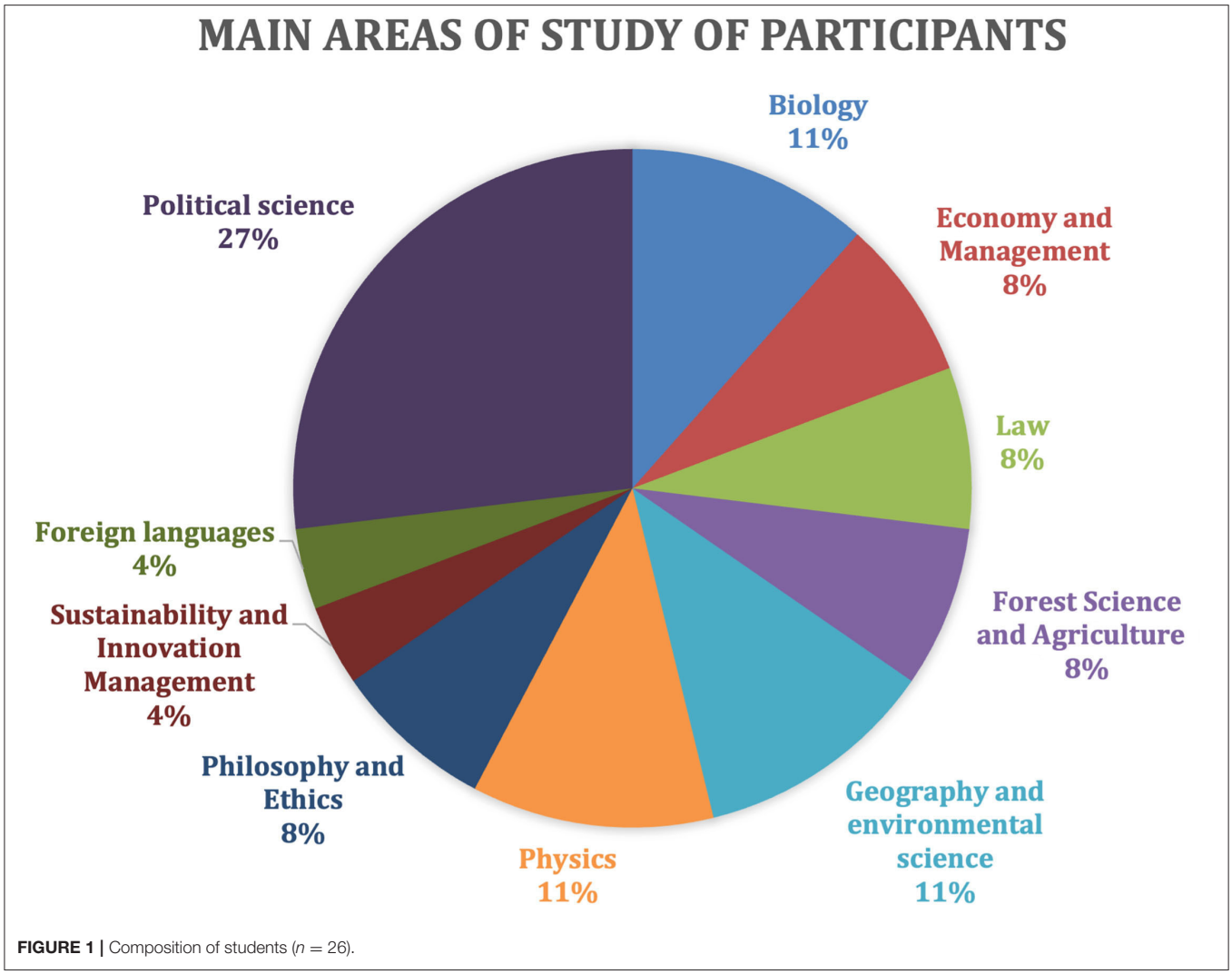

FIGURE 1 | Composition of students ($n = 26$).

of which should not be secondary in an interdisciplinary curriculum. In fact, interdisciplinary knowledge cannot be seen to be incompatible with deepening knowledge in a given disciplinary field.

Item 9 ($w = 1$) was the only one that measured the CBL characteristic of "Engaging stakeholders." In this case, the issue is directly addressed, and the respondents are invited to appreciate the role of non-academic contributors as challenge-provider or in any other roles they played.

Statements 13 ($w = 0.6$) and 17 ($w = 0.4$) have been associated with "Internationalization." Both items were designed to indirectly address the issue via inquiries about interuniversity interactions and English as the working language (no participant student had English as the mother tongue).

The feature "Applying research skills" was present, to different degrees, in a series of items: 2 ($w = 0.2$), 3 ($w = 0.2$), 8 ($w = 0.2$), 9 ($w = 0.1$) 14 ($w = 0.1$), 18 ($w = 0.1$), and 19 ($w = 0.1$). The statements were supposed to control various aspects of the characteristic, including critical thinking, planning, conducting and implementing scientific research, and developing interpersonal and personal skills related to the ability to research. The particular relevance of this dimension was often reiterated at the Arqus AL 7 meetings and looks appropriate for a program developed in academic institutions and involving prevalently master's students.

Items 13 ($w = 0.4$), 15 ($w = 0.2$), 16 ($w = 0.2$), and 20 ($w = 0.2$) were associated with "Teamwork." Some statements directly recall student experiences, while others require commenting on one's own experience in connection with the collective dimension of the work done.

Statements 10 ($w = 0.3$), 11 ($w = 0.2$), 12 ($w = 0.1$), 13 ($w = 0.2$), 14 ($w = 0.1$), and 19 ($w = 0.1$) were used to measure the CBL characteristic synthesized as "Active learning style." Two arguably mutually exclusive statements (11 and 14) were used as controllers to assess the level of attention of the respondents and to check whether the student-centered and research-led style of the CBL design was recognized and valued.

The last characteristic—"Using technology"—was measured by questions 12 ($w = 0.6$) and 18 ($w = 0.4$), whose focus was on using existing technology (software applications based on

TABLE 2 | Measuring the reception of CBL features in the 2021 Arqus Collaboratory Programme (max = 26).

CBL characteristics	Negative score	Positive score
1. Tackling societal challenges	2.3	21.9
2. Inter-disciplinarity	9.9	11
3. Engaging stakeholders	3	17
4. Internationalization	4	16.6
5. Applying research skills	4.5	16.8
6. Teamworking and interpersonal skills	4.6	16.2
7. Active learning approach	6.3	12.9
8. Technology	5	12.6

the Internet) in the implementation of teaching and learning activities, rather than on the design and implementation of new technology.

FINDINGS AND DISCUSSION

The profiles of the 26 (out of 56) respondents from the seven partner universities are summarized in **Figure 1**. They were graduate and undergraduate students in the final year from 10 main areas of study. The number of students in natural sciences (12) is slightly lower than that in social sciences (14). The composition of the student body indicates that technological innovation could hardly be the core of this CBL programme.

Generally speaking, the CBL concept was shown to be shared by students. As **Table 2** shows, five out of eight criteria have positive scores over the 15.6 threshold. While the positive scores of three criteria (2-inter-disciplinarity, 7-active learning approach, and 8-technology) were below the threshold, the corresponding negative scores were also much lower than the failure threshold, meaning that although these three criteria were not successfully perceived by students, it was neither a typical failure.

Therefore, it is fair to conclude that the CBL features developed in designing the Arqus CBL collaboratory program have been "grasped" by the students involved in such activities. The CBL concept was shown to be generally shared.

In the following paragraphs, the CBL characteristics will be commented on separately in light of the score received.

Tackling Societal Challenges

This was the most widely shared CBL characteristic in the Arqus programme, having received the highest positive score (21.9) and the lowest negative score (2.3). It was tested on Questions 2 (weight [w] = 0.2), 4 ($w = 0.4$), 7 ($w = 0.1$), and 21 ($w = 0.3$). After attending the course, almost all participants thought that "societal challenges" could be tackled constructively. Although the activities at each university addressed climate risk issues at the local level, the students were clearly aware of the links between local issues and "grand challenges" that affect global society. The vast majority of the students stated that they were already familiar with the societal and environmental issues dealt with in this programme, since such topics were also addressed in their main area of study, and that they now feel prepared to tackle such complex issues constructively. We can infer that participants have seized the nexus between grand challenges on the one hand, and local risks and responses thereto on the other.

Inter-disciplinarity

In all universities, the scheduled Arqus activities adopted a more or less intense interdisciplinary approach. Interdisciplinarity characterized the program design, student selection, methods, assessment, and outputs. This item was measured by items 1 ($w = 0.1$), 5 ($w = 0.4$), 6 ($w = 0.3$), and 7 ($w = 0.2$). It is one of the few criteria for which the positive score (11) did not reach the 15.6 threshold. However, an analysis of each item shows that this CBL feature was not actually missed. Twenty out of 26 students from all disciplines confirmed that their field of study already addressed climate issues, which means that a bit of interdisciplinarity was incorporated into their previous academic careers. When participating in the Arqus activities, the students felt challenged by the new topics they were confronted with and supported by the disciplinary knowledge they already had acquired in their own fields of study. This is consistent with an interdisciplinary activity that allows one to acknowledge the value of one's own competences while realizing the intrinsic limits of any discipline. The result of the responses to this set of items seems to confirm that interdisciplinarity is not opposed to the acquisition of disciplinary knowledge and skills.

Engaging Stakeholders

This feature was measured with one explicit question: statement 9 ($w = 1$). In total, 17 students recognized the value of engaging stakeholders in the development of their research project. Different stakeholders, including NGOs, local authorities, and experts in the field, participated in both winter school lectures and local summer semester CBL courses. For example, in the 5-week Padua course, students had the opportunity to dialogue with people working in the field of disaster and emergency risk mitigation and response, both at the local and international levels, with a focus on natural events affecting the Venice environment. The students interacted and cooperated not only with their fellow colleagues, but also with stakeholders who had different or even conflicting interests and points of view. In fact, two out of three projects developed by student teams in Padua were designed to address socio-cultural rifts in local communities about environmental risks associated with climate warming.

Internationalization

In tackling societal challenges, the international dimension is an essential facet. The overall Arqus program was designed to enhance the education of critically engaged European and global citizens who are able and willing to contribute to a multicultural, multilingual, and inclusive Europe which is open to the world and to better respond to the grand societal challenges of the twenty-first century in Europe and beyond. The Winter School tackled the theme of Rethinking Climate Risk from a multilevel

perspective, while each university discussed the topic focusing on each city.

We tested this characteristic of CBL using two indirect variables, items 13 ($w = 0.6$) and 17 ($w = 0.4$), on cross-university cooperation, respectively, and the use of English as a medium language. The positive score is 16.6, above the 15.6 pass mark. Half of the participants considered the interuniversity activities to be among the most relevant features of this learning experience. Almost all of the students enjoyed working in English in most of the activities, although English is not the official language at any of the seven universities. Students apparently are not only aware of the importance of internationalization in tackling societal challenges but are also willing to work and collaborate along trajectories and networks that transcend the local one.

Applied Research Skills

In this item, we measured whether students developed the skills to conduct independently applied research, using a project or academic paper as the final output. When carrying out an applied research project, skills are needed in the following four components: defining the research scope, making a comprehensive plan, implementing and monitoring the plan (data collection and analysis, design, management procedures), and reporting (Bickman and Rog, 2009, p. 3). Many projects involved a substantial dimension of social action, with a component of civic and educational activism. Therefore, they were trying to induce some socio-cultural change and provide a concrete, localized response to the "grand challenges." As mentioned above, the assessment of the work of the student teams carried out in the overall CBL experience focused essentially on these results. They were evaluated on the basis of their inherent scientific and logical consistency, rather than their implementation since the Arqus course lasted only one semester and there was not enough time to assess their follow-up.

Measured by items 2 ($w = 0.2$), 3 ($w = 0.2$), 8 ($w = 0.2$), 9 ($w = 0.1$), 14 ($w = 0.1$), 18 ($w = 0.1$), and 19 ($w = 0.1$), this characteristic of the CBL with student opinions gives a positive score of 16.8. Slightly more than half (14) of the students thought that they had increased their ability to articulate a complex issue in a critical and independent way, while 6 students felt the opposite. Regarding carrying out a research project, more students gave positive feedback. Most of them (19 respondents) believed that their ability to plan, undertake, and complete a research project improved, while the number of those who thought negatively remained at 6. Most of the students stated that they asked experts and other stakeholders for advice while developing the projects, and these external actors were considered to provide important input. Again, the majority of the participants enjoyed the process of conducting research, drafting, and editing the research output. After attending this program, 18 students stated that they felt more confident in conducting scientific research. Unfortunately, the students had little time to implement their projects; however, most of them were confident that their evidence-based proposals had the capacity to have an impact in a real-world scenario.

Teamwork and Interpersonal Skills

Although many regular higher education activities can develop teamwork abilities, this is a key feature of CBL. In the Arqus CBL projects, students interacted and cooperated not only with their colleagues at their home university but also with participants from other partner universities, trainers, and external actors.

The feedback of this CBL characteristic showed a positive score of 16.2. It was measured by questions 13 ($w = 0.4$), 15 ($w = 0.2$), 16 ($w = 0.2$), and 20 ($w = 0.2$). The vast majority of the respondents felt that they could be team leaders in a similar research project. They enjoyed working with the members of their group despite some disagreements. The interaction with peers at other universities was not felt as a distinct feature of their experience: Only half of the respondents gave positive feedback. Indeed, this was a relatively underperforming part of the overall CBL design. Many students commented that they wished they had had more opportunities to interact or meet in person peers at the partner universities. It can be inferred that the relatively low rating of this aspect did not necessarily mean that interuniversity cooperation was considered irrelevant by the students but simply reflected the fact that this facet of the programme was not implemented as planned.

Active Learning Approach

One of the main features that distinguish CBL from other pedagogical methods, and align it with constructivist learner-centred methods, is the importance placed on the student agency as co-responsibility in knowledge creation (Schreurs and Dumbraveanu, 2014, p. 37). Instead of passively attending lectures, students are called to be the driving force in setting the research frame and delivering the learning outcomes. Prior disciplinary knowledge and skills are used and improved through the CBL experience, in which students acknowledge the "societal challenge," specify a research question, conduct research, propose a response, develop a project, and then implement such project. Was this learning design perceived and appreciated by participants?

By asking for four mutually exclusive items (11–14), students were required to evaluate the learning efficacy of the three main learning methods used during the courses, namely lectures and related discussions (item 11, $w = 0.2$), designing and developing evidence-based research (items 12, 14 and 19, each weighing 0.1), and interuniversity peer interactions (items 13, $w = 0.2$). The picture resulting from the students' responses is not clear, perhaps due to some limits in the way the Likert chart was conceived and supplied. The students identified lectures (that is a "passive" learning method) and "applying and developing research and development tools" (supposedly a "learner-centred" methodology) as equally relevant, each being the most relevant feature in their learning experience for 11 respondents. Half of the respondents indicated that the most relevant feature was interactions with peers from other universities. Sixteen students considered applying research procedures as the key in their

learning experience and stated that they became more confident in doing research. In other words, some respondents did not notice the mutually exclusive character of some statements and simply expressed their appreciation for the different components of the course.

This aspect of the CBL design cannot be considered clearly endorsed by student opinions. However, it seems that they did not perceive the facts of being exposed to a variety of learning methods as negatively affecting their learning experience, as would be the case if the number of negative feedbacks had exceeded the positive ones. Furthermore, looking at the result of item 10 ($w = 0.3$), we may see that for more than half of the participants, the course challenged their prior understanding of the issues at stake, which means that it triggered a reflective and critical thinking process, which is at the core of learner-centred methods.

Technology

The last CBL feature to test is technology. As noted above, developing innovative technological responses ("solutions") to real-world challenges was a key element in the original CBL conceptualization. However, the Arqus CBL collaborative programme was designed to engage students in their capacity as European citizens faced with the societal challenge of climate change, instead of as high-tech developers. Rather than providing technological and engineering solutions to global warming, students, with their diverse academic backgrounds, worked together to develop learning outcomes in the form of academic articles. The latter's contents were either research-based studies, or research-based projects of socio-cultural action, in both cases aimed at promoting the agency of European citizens. Therefore, when measuring this CBL feature, the focus was not on technology innovation, but on whether and how technology application was an asset in learning outcomes, under the assumption that the call for technology is evidence of a significant degree of attention devoted to actual implementation of responses to the "societal challenge," since without the medium of technology (or technology as a medium), any practical relevance is excluded.

As expected, this feature did not receive high scores. Measured by two interrelated questions—items 12 ($w = 0.6$) and 18 ($w = 0.4$)—which largely refer to the kind of computer and Internet-based software tools that most students are familiar with, the positive score in this feature is 13.2. Less than half (11) of the students found that applying and developing technological tools was the most relevant feature of this learning experience. However, this did not mean that technology was irrelevant in Arqus CBL courses and in their learning outcomes. In particular, more than half (15) of the participants enjoyed editing and drafting the research output. Such activity resulted in producing and commenting, on some online platforms, presentations edited using some software such as Google Slides, Prezi, etc. professionally. Although some students were unfamiliar with basic technology for online teaching and learning, most of the participants took them as valuable tools necessary to communicate and disseminate their content not only within the academic system, but more largely in the "real world" scenario envisaged in their research outputs.

LESSONS LEARNED

Although the overall result of the CBL concept designed in the Arqus programme was proven to be in line with the assessment of the students and, therefore, shared by the latter, some critical points emerged throughout the development of the overall project, comprising the curriculum design phase, the preparation and delivery of the Winter School, the organization and implementation of the summer semester courses, and in the final moments of assessment and self-reflection.

The primary limitations on which improvements should be made lie mainly in the organizational aspect. As anticipated in the previous section, the whole process and in particular the inter-university experiences, including workshops, peer review of research reports, and eventual informal student meetings, planned for the first six months of 2021, were hampered by the restrictive measures on traveling and physical gathering due to the pandemic. Online discussions were sometimes difficult due to technical issues or connection lags. No matter how well-designed they are, distance learning tools cannot be compared with the face-to-face experience. In this regard, there was little that could be done by lecturers, tutors, and students.

Another obstacle to inter-university cooperation and student collaboration, which could be mitigated with a smarter design and appropriate preparation, is the sheer differences in schedules and course calendars between universities. Students did not fully participate in common activities (and did not fully participate in our survey) not only because of the misalignment in schedules, but also due to conflicts between the CBL courses and other classes, exams, internships, etc. that students had to attend in their respective institutions. Indeed, the misalignment of calendars has proved to be a rather intractable issue that makes inter-university cooperation at the structural scale a very time-consuming and frustrating undertaking. A CBL initiative requires a good synchronization of actions, in order not to penalize participant students and avoid the "anything goes" attitude that sometimes accompanies journeys in innovative learning environments (Hipkins et al., 2018, p. 85).

Due to the difficulties in synchronizing common activities, it seems important for the success of a similar inter-university initiative to secure the cooperation of students and their strong association in the undertaking. This can take the form of a special role to be assigned to the selected students participating in the Winter School as team leaders or moderators in the framework of the local CBL courses. Feedback from students participating in the 2021 CBL programme showed that the connection between the Winter School and the summer semester courses carried out at the university could be improved. Students trained and tasked to be moderators and mediators between Arqus coordinators and the teaching staff and learners of the partner universities can provide consistency and convergence among the different courses, facilitate formal and informal exchanges among students, and improve communication flow.

Student participation is also crucial in the assessment process. The latter should be operationalized as a framework providing quick and punctual feedback to students, rather than as a once-for-all evaluation and marking of outputs. The Arqus experience only partially met this target, though. For the reasons illustrated above, formal evaluation focused on sub-team output, while the peer review exercise and other forms of interaction were unfortunately curtailed, and feedback from lecturers, tutors and stakeholders was not provided systematically and timely.

More generally, it seems important to underline the student-centred nature of CBL projects. This involves the appropriate participation of the learners at all stages of the process. The methodological and metacognitive outputs of participating in a CBL experience can only be achieved and consolidated by associating learners and teachers—and partner institutions and individuals as appropriate—in a transparent fashion, without mixing the roles' responsibility.

Detaching ourselves from the strict consideration of the survey's results and adopting the viewpoint of co-designers and teachers/tutors involved in the 2021 Arqus CBL programme, another obvious flaw that affects its implementation in all the seven partner universities regards the dissemination and implementation phase. While students were required to develop a research-based project that involves local stakeholders and is likely to have a social impact in terms of promoting active citizenship, they were not given substantial resources, including time or academic space, to share with a broader audience or to implement, with a given target, their projects. In other words, a CBL program should also encompass the potential follow-ups of the CBL program itself and provide space to support, if appropriate and sustainable, the projects developed in such a framework.

CONCLUSION

This article provided a reconstruction, based on the experience of the authors, of a CBL programme carried out in the framework of the inter-university Arqus Alliance in 2020–21. As a result of an embryonic action-based research (Fontan and Bussière, 2019, p. 79), this article aimed to shed light on a specific path to "strategic CBL," highlighting the enabling and inhibiting factors that can influence the process of designing and implementing a highly interdisciplinary international CBL program in higher education.

The first two sections the peculiar characteristics of this programme, carried out simultaneously in seven European universities in 2020–21, that is, while a major societal challenge was taking place in the world, namely the COVID-19 pandemic. Based on a qualitative analysis of data collected from 26 students with a Likert scale questionnaire as explained in section testing the CBL approach, a detailed discussion of the results and findings was presented in sections findings and discussion and lessons learned. The survey aimed to test whether the conceptualization of the CBL experience as explicitly and implicitly operationalized by the programme designers (and discussed in section Conceptualization) was grasped by the students and reflected in their opinions concerning their learning experience. The reflection is offered as a contribution to broadening the discussion of this relatively new teaching and learning approach.

In conclusion, it may be stressed that, in addition to the characteristics that were identified above to describe the Arqus approach to CBL, *flexibility* and *adaptability* should be added as overarching features. Taking into account the complexity of the "societal challenge" tackled (climate risks) and the uncertainties of factors that have influenced the unfolding of the project (the pandemic), all actors in this CBL experience (Arqus coordinators, university teachers and staff involved, students, partners, and stakeholders) had to adapt their planning, research and teaching roles according to the changing scenario and practical conditions, while maintaining the overall objective firmly. Without this flexibility, in plans and in human resources, this Arqus CBL programme could hardly have taken place.

Among the characteristics discussed in the article, multidisciplinarity and interdisciplinarity are the ones that the Arqus CBL experience has developed well beyond the examples of CBL presented in literature and implemented in higher education. Students and scholars from a wide spectrum of disciplines, from natural sciences to social sciences, and the humanities, contributed to the curricula. Experts from a variety of fields participated as resource persons and counterparts. Indeed, the multidisciplinary and interdisciplinary design was a facet of its flexibility, allowing students to bypass structural and contingent limits and constraints and develop viable projects.

As in "classic" CBL, mainly aimed at students in computer science and engineering, technology has also proved to be an indispensable tool throughout the program and for the progress of research-based projects. It also helped retrospectively to catch up with some of the shortcomings of the programme, namely the limited space devoted to interuniversity cooperation (curtailed by the pandemic but also due to the differences in schedule and course organization among the partner universities) and to the follow-up of student projects.

To improve the CBL experience within an interuniversity framework such as Arqus, a key pragmatic measure appears to be greater participation as co-creators at the appropriate level, of students, the driving force of CBL. Students should have more space to identify the "societal challenges" to address and contribute to the design of courses and activities and their evaluation. The importance of including learners in the epistemic CBL scheme is probably the most significant lesson learned.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2022.853699/full#supplementary-material

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