

Review

Beyond the COVID-19 Pandemic: Can Online Teaching Reduce the Carbon Footprint of the Internationalisation of UK Higher Education?

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Abstract: The COVID-19 pandemic has been a learning curve for Higher Education Institutions (HEIs) in devising and delivering teaching online. This transition has enabled HEIs to continue teaching students, especially international students, who were restricted to travel to their countries of study. In the UK, approximately 20% of the student cohort are international students. The pandemic resulted in a drop in international student recruitment, which generated concerns about a potentially alarming economic crisis in the UK HE sector. However, COVID-19 measures have also been portrayed as a significant contributor to reducing global CO₂ emissions. Thus, the question arises: can online teaching reduce the carbon footprint of the internationalisation of education? This paper reviews online teaching as a potential solution to reduce carbon footprint and increase access to HE, whilst maintaining high student performance in HE within the remits of internationalisation.

Keywords: online learning; sustainability; internationalisation; carbon footprint; higher education



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1. Introduction

The COVID-19 pandemic has been a major challenge and learning opportunity for the global Higher Education (HE) sector. The interventions implemented to curb the spread of the disease has created several socioeconomic impacts including a disruption to normal teaching processes which has driven Higher Education Institutions (HEIs) around the world to adopt new teaching styles to cope with the pandemic [1]. Most universities have been called to deliver online teaching, including practical courses, which has been a learning curve for both staff and students [2]. The transition from in-person to remote learning added additional stressors to teachers in their personal and professional lives due to increasing professional demands and instability across the sector [3]. Moreover, the pandemic has had significant implications on how to deliver teaching to overseas students. This was particularly evident in the UK HEIs, where international students make up 22% of the total student population (2019/20) [4].

Teaching methods have drastically shifted online, demanding extensive training and innovation in remote learning practices, following the Quality Assurance (QA) guidelines [5]. Due to the government's COVID-19 regulations, both domestic and international students were prevented from traveling to their universities. Although this was reported to have impacted on the HEI income, after having multiple remote teaching and assessment periods, improvements have been reported in the overall academic outcome of students [6]. At the same time, with international students travelling less, remote learning has been signified as an important contributor to a reduction in the overall CO₂ emissions of HE teaching practices [7]. This can also be supported by increasing evidence showing a reduction of both commercial flights and their CO₂ emissions by >40% in 2020 [8,9]. Existing research has indeed underlined that raising awareness of climate change through the internationalisation of curriculum is not enough to deem the internationalisation of education

as sustainable, particularly due to its high environmental cost [10]. Therefore, in this paper, we will explore the potential of online teaching to contribute to the decarbonisation of higher education, by particularly focusing on aspects of travel.

2. What Is “Internationalisation”?

Internationalisation in HE is regarded as “the intentional process of integrating an international, intercultural or global dimension into the purpose, functions and delivery of post-secondary education, in order to enhance the quality of education and research for all students and staff, and to make a meaningful contribution to society” [11]. Internationalisation of HE can therefore involve the integration of many different aspects, including knowledge transfer, intercultural learning, international cooperation and communication between institutions, scholars and students and the physical mobility of students and staff across countries. This, as Teichler identifies [12], can enable a greater appreciation of diverse cultures, creating an increasingly globalised and interconnected world.

In the UK context, international students are described as students whose permanent residence prior to commencing their studies are in countries in the European Union (EU) or outside the EU [13]. International students make up a diverse group culturally, socially, geographically, as well as in terms of their tuition fees. Only in 2014–2015, international students paid an estimated GBP 13.8 billion in tuition fees and accommodation to UK universities and generated GBP 25.8 billion in gross output in the UK [14]. As of 2018–2019, there were roughly 485,645 international students in the UK which accounted for 20.7% of the student population [15]. Maintaining a cohort of international students is important, not only in economic terms, but also for fostering the internationalisation of the UK HEI sector through processes of ‘intercultural dialogue’ that, as studies also show [16], can be based on and value international students’ ‘cultural capital’.

Internationalisation has a significant impact on both domestic and international students’ personal development, in terms of both academic as well as broader transferrable skills. For example, as Mellors-Bourne et al. noted (2013), an expected impact of international study is that international students change and grow as individuals through on-campus activities and interacting with the host country society [17]. However, internationalisation can also enhance the experiences of local students as well as international ones: by enabling them all to make international contacts, understand as well as gain greater appreciation of diverse cultures, becoming citizens of an increasingly globalised and interconnected world. According to Leask (2015), such processes of cultural and linguistic diversity can contribute to internationalising HEI curricula, resulting in a broader diversification of the teaching materials and the benefits this may entail for both domestic and international students [18].

However, internationalising HE through an internationalisation of student cohorts has also been discussed in relation to its potential contribution to an overall increase in the sector’s carbon emissions, with an emphasis given to air travel. This has been particularly evident during the COVID-19 pandemic lockdowns, where a significant reduction in overall CO₂ was observed due to a decrease in the number of global flights [8,9]. Therefore, despite the positive contribution of education and learning, also as a separate Sustainable Development Goal as well as an element related to the broader Sustainable Development agenda [19,20], the internationalisation of education can be thought of as a factor increasing the sector’s overall carbon footprint, particularly with regard to the high-carbon travel patterns associated with it.

3. Carbon Footprint of International Students’ Travel

Research shows that carbon emissions from international students’ air travel are rising rapidly within the past fourteen years [21], carrying significant environmental sustainability implications for universities that aim to reduce their overall carbon emissions [21]. China, India, US, Hong Kong (Special Administrative Region) and Malaysia are the top 5 non-EU countries of origin of international students in the UK. Table 1 shows that the

estimated carbon footprint generated per person per flight from these countries of origin is significantly high. For example, a one-way flight from Malaysia to the UK generated an estimated carbon footprint of 1.8 tons of CO₂. However, a limitation to this is that not all international students from these countries will be departing from these airports and the formula does not take into account the domestic travel that international students have to take [22]. Furthermore, the estimated carbon footprint was calculated for a direct flight route on a one-way economy class ticket and so it does not take into consideration multiple leg journeys, business/first class travel and return journeys, which might also entail that the actual carbon footprint per student per flight can be greater than the estimated one. On the contrary, this calculation already helps us understand the size of the carbon footprint implicated within the existing patterns of the internationalisation of the UK's HEIs teaching.

Table 1. Estimated carbon footprint per person per flight from the top five non-EU countries of origin. Airports with the most international traffic in the countries of origin were used as the starting point and the estimated carbon footprint was calculated in tons of CO₂ using the formula created by [22] from a direct flight route to Heathrow Airport on a one-way economy class ticket.

Country of Origin	Direct Flight Route to the UK on a One-Way Economy Class Ticket (IATA Code)	Estimated Carbon Footprint (Tons of CO ₂)
China	PEK to LHR	1.3
India	DEL to LHR	1.1
USA	JFK to LHR	0.9
Hong Kong	HKG to LHR	1.6
Malaysia	KUL to LHR	1.8

Therefore, as the UK HE sector has witnessed a growth in international student numbers, this can only have direct implications in further increasing the carbon footprint of the UK's Higher Education sector. Moreover, the literature suggests that HEIs often downplay the extent to which they are embedded in and dependent upon unsustainable practices, with the greenhouse gas emissions associated with international student movement rising faster than their overall emissions [23]. To combat the effects of climate change and the energy crisis, educational leaders should be at the forefront of investing in sustainable and environmentally friendly research and teaching practices to maintain high standard, research-led teaching and learning for both local and international students that could be delivered online in the coming years [24]. As HEIs strive to be low-carbon, Shields also finds [23], the larger issue of maintaining global connections and long-distance travel is one of the most difficult challenges for their successful response to climate change. Hence, potential alternatives need to be identified, researched and implemented along with updating sustainability policies of the UK government and HE sector, in order to mitigate the high carbon footprint of international students' travel.

4. Current Sustainability Policies and Limitations

The United Nations Educational, Scientific and Cultural Organisations (UNESCO) have set up a United Nations (UN) decade of education for sustainable development which sought to mobilise educational resources across the world to help create a more sustainable future [25]. Its main goal was to integrate the principles, values and practices of sustainable development in all aspects of education and learning [25]. Furthermore, The Sustainable Development Goals (SDGs) Accord report in 2020, which is endorsed by the UN, paints a promising picture of embedding UN SDGs in universities around the world. Apart from SDG4 particularly focusing on ensuring quality education for all, education, and particularly higher education, is acknowledged as the key for driving change towards ensuring sustainable development. Findings show that the awareness of SDGs in universities is steadily increasing with almost 90% of those reporting to have started implementing SDGs within their institution and over 68% of institutions have stated that SDGs are a strategic priority that will be included imminently in the institution's overar-

ching strategy [26]. The rise in international students has been supported roughly with increased advocacy for sustainable development in HE through the UN and institutions such as CANIE (Climate Action Network for International Educators) [27]. For example, the Greening Universities toolkit which was conceived in partnership with UN agencies and leading universities provides insights into developing a green/sustainable campus by implementing infrastructural, managerial and operational considerations [27]. For example, in the UK, Bournemouth University has set up an ESD Community of Practice with faculty which has uncovered excellent practice and promoted greater collaboration [26]. Newcastle University has established an SDG committee that reports directly to the University Executive Board to bring more structure and coherence to the SDG agendas [26].

According to the UK Research and Innovation (UKRI) and Office for Students, a strategy and action plan was produced for the HE sector which provided a framework for sustainable development relevant to areas of carbon management, curriculum, student engagement and community outreach [25]. The COP26 (26th UN Climate Change Conference of the Parties) Universities Network Briefing established key messages for HEIs to achieve net zero emissions. These include establishing principles to justify which emissions can and cannot be offset, standardising emission reporting across the sector and more consistent reporting of travel emissions [28]. HEIs are important actors in investing and reinforcing sustainable development plans that can decrease the overall carbon footprint of both individuals and institutions. Additionally, as Le Quéré et al. (2020) noted, the COVID-19 pandemic can provide an interesting framework for influencing future decarbonisation policies, also with regard to HEIs and their internationalisation strategies.

As stated in their carbon management strategies, plans and reports [29], the Higher Education Funding Council for England (HEFCE) acknowledges the potential contradictory relationship between sustainable development and internationalisation agendas. For them, reducing emissions of student and staff travel is key; however, they do not offer any solutions or recommendations beyond providing guidance on how to measure those emissions [29]. A study by Dvorak et al., (2011) has provided solutions such as rigorous environmental rating and review of HE courses (especially study abroad programmes) becoming standard practice and involving environmental education in all programmes [30]. However, the authors further stated that the HE sector has made very few (if any) changes to account for the environmental impacts associated with international student air travel [30]. Another study by Fawcett agrees with this finding, stating that there is little evidence that the HE sector has begun to acknowledge the impact that current levels of recruitment of international students has on the climate [21]. Moreover, Hale et al. (2013) suggest that the sustainability agendas for educational travel may lag behind the sustainability agendas in other aspects of HE (such as carbon management) due to the relatively little information provided on travel practices from established databases [31]. More recently, Wynes et al. (2019) observed that no relationship was found between academic productivity (including green academics active in sustainable research) and air travel. These air travel emissions were caused by international conferences and workshops and were found to be associated with seniority in academic positions (e.g., professors) [32]. While these articles and reports all identify this emerging challenge with regard to educational travel, there is not much research from a UK perspective identifying individual and institutional responses. Therefore, investigating the effectiveness of alternatives such as online learning is an interesting possibility to be further explored and more widely adopted in a post-pandemic HEI teaching context.

5. Lessons from COVID-19

The COVID-19 pandemic has opened up new opportunities for reducing the carbon footprint of the internationalisation of HE teaching [33]. The closure of campuses and introduction of government guidelines brought about new challenges for the HE sector to deliver quality education online [5]. The transition to online teaching has been introduced as a necessary response to COVID-19, with its own opportunities and challenges [34]. For

example, recent studies have shown that online teaching has improved student assessment scores when compared to pre-COVID times [6], a fact that also shows promise for the possibility of a more permanent wider-scale shift in post-pandemic times. COVID-19 enabled a speeding up of experimentation with diverse online strategies and further refinement of these practices in accordance with Quality Assurance guidelines [35]. For example, in the study by Dost et al. (2020) with medical students, the development and introduction of online educational platforms have allowed students to access education and training from a wider community of professionals [36]. There has been a reported rise in external resources and teaching programmes such as Osmosis and BiteMedicine which allowed many teaching sessions to be available to medical students across the country [36]. This is especially important in the medical field where face-to-face teaching is a crucial aspect that is needed to ensure the relevant skills are taught.

A main lesson that COVID-19 has taught everyone is the impact that air travel has had on the overall carbon footprint of HE. It is estimated that commercial flights decreased by >40% in 2020 compared to 2019, leading to an equivalent decrease in its carbon emissions [8]. This can be observed by the number of visas issued. For instance, the percentage of visa issuance to non-EU students in the second and third quartiles of 2020 decreased by 99% and 53%, respectively, compared with 2019 [37]. This change is largely attributed to the national lockdowns being implemented across different countries as well as the government advice to reduce all non-essential travels, including international students' travels, resorting to new modes of online teaching. Considering the potential positive environmental implications of such practices, it is interesting to explore the possibility of online teaching also as part of a more blended mode of teaching at the aftermath of the COVID-19 pandemic. Therefore, the remainder of the paper focuses on online teaching as an alternative post-pandemic educational strategy that contributes to the decarbonisation of the UK's highly internationalised HE sector.

6. Online Teaching as an Alternative

In the pre-COVID-19 era, delivery of teaching for most HEIs largely meant conventional in-person, place-based methods, such as didactic lectures, seminars and workshops. This created an environment where key skills can be easily taught, and students can engage with each other. The pandemic provided a platform for teaching to transition online due to the social distancing guidelines and national lockdowns. However, it also opened up new possibilities for decreasing the sector's carbon footprint and therefore its overall environmental impact [38]. Spain's International University of La Rioja (UNIR) is an example of a university that adopts an online teaching model. UNIR is an online university that promotes HE using different approaches such as online classrooms, virtual campuses and personalised master classes. Benefits acknowledged include increased learning opportunities for students across diverse geographical areas and the convenience of flexible, self-paced learning [39]. The possibility of online breakout rooms has also been acknowledged as a substitute for more proximate student interactions, while maintaining good levels of students' engagement [40]. Although transitioning teaching methods, such as laboratory experiments in STEM, online poses challenges to students in terms of performing hands-on tasks, several advantages can also be observed. For example, online laboratory sessions can enable students to explore reactions that are too expensive or too dangerous to perform in person [39]. Furthermore, online teaching practices, similar to the conventional methods, have also been witnessed to allow for research-led, evidence-based, problem-based and technology-enhanced teaching to be delivered, also enabling higher order thinking such as evaluation and creativity [2,41]. Nevertheless, online teaching bypasses challenges with room space, health and safety matters and allows students with learning differences to attend and engage discussions without social anxieties and difficulties [42,43]. In addition, as studies above noted, most of these online laboratories run with minimal waste and carbon footprint as compared to a face-to-face teaching model. Hence, online teaching programmes, such as this delivered by UNIR, carry their own potential for contributing to

a less carbon-intensive HEI model, especially considering the low energy intensity levels of online platforms, currently estimated to be between 1.1% and 1.9% of the total global energy consumption [39]. In universities such as Coventry, a new concept known as collaborative online international learning (COIL) has been implemented during the pandemic [44]. COIL enables students from different countries to work on one common project. It can also be used to create virtual simulations and, if used strategically, it is envisioned to support active and effective learning experiences [44].

To determine the effectiveness of an online teaching model in terms of total emissions produced, comparisons to a traditional face-to-face model have also been made. In a study by Caird et al. (2015), an environmental assessment of campus-based and distance-based HE courses was conducted. The results were converted to average CO₂ emissions and normalised to per student per 100 study hours which are presented in the Figure below (Figure 1) [7]. The analysis revealed striking differences in the carbon emissions from both online and face-to-face teaching models. For instance, face-to-face learning produced four-fold more travel emissions compared to online learning showing that any course-related travel made during the study period significantly contributed to carbon emissions. In this study, the student travel data were weighted to represent the proportions of UK-domiciled and overseas students. On average, the total CO₂ emissions produced by the online teaching model was significantly less than the face-to-face model (Figure 1), hence showing the sustainability benefits of using online teaching in HE courses. In a country like the UK, taking into account factors such as residential energy consumption, campus expenses and travel between the university and residence, an online teaching model could contribute to an estimated 83% reduction of the total carbon footprint per student [7]. Of course, this study does not consider the potential carbon footprint of home learning, which also goes beyond the remits of this study and its focus on the impact of students' travel to campus for educational purposes. Additionally, the study has not considered that a lot of campus-based practices are already transitioning to digitisation of learning materials, which already suggests the digitisation of aspects of campus-based teaching. However, if the above hypothesis focusing on the carbon footprint related to student travel is considered and extended to the number of HE students in the UK in 2018/19, online teaching appears to carry the potential to reduce the carbon footprint of HE, particularly this associated with student travel, which is the focus of this study. According to a study conducted by Li, Tan and Rackes [45], by assessing 2,751,865 students [46] with an energy consumption of 3.84 tons of CO₂ per student, a total consumption of 10,567,161.6 tons of CO₂ can be attributed to the total carbon emissions produced by students from the HE sector in the UK in 2020/21. By applying the estimated 83% emission reduction as mentioned previously, it can be affirmed that 8,770,744.128 tonnes of CO₂ can be saved by adopting an online teaching model alone. Li, Tan and Rackes noted that 20% of the average CO₂ consumption is attributed to transportation, of which half is due to hometown travelling, a fact that highlights the impact of travel on carbon emissions and the importance of mitigating its effects [45].

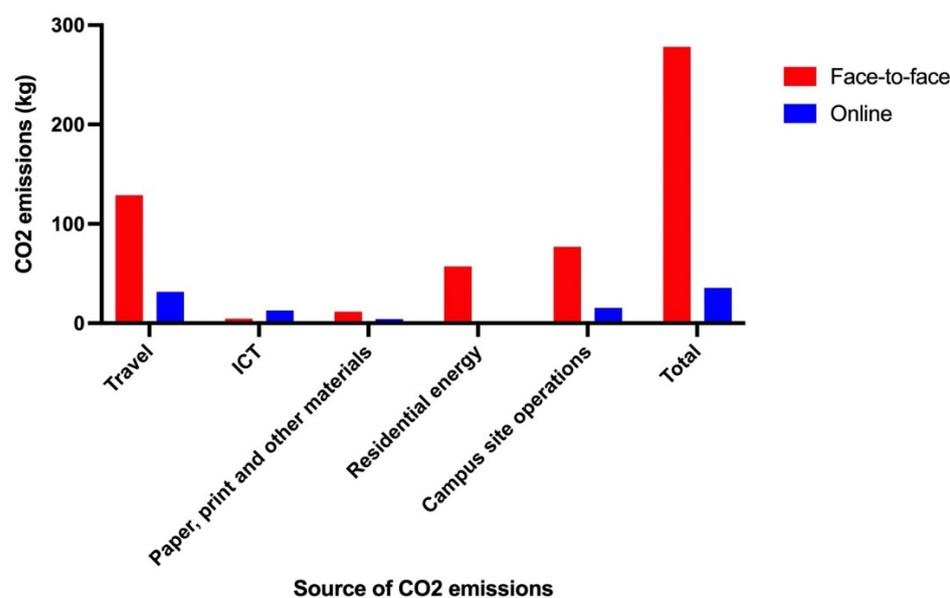


Figure 1. Average CO₂ emissions of face-to-face and online teaching models. Results from the environmental assessment of face-to-face and online teaching model is converted to average CO₂ emissions (kg) and normalised to per student per 100 study hours. Modified from: [7].

7. Performance of Students in the Online Teaching Model

Considering student performance is a very important parameter to consider when reinforcing new significantly different, albeit more sustainable, teaching models such as online teaching. A recent study conducted by Gonzalez et al. (2020), analysed the effects of COVID-19 on the autonomous learning performance of students in HE. The study consisted of a sample size of 458 students from three different subjects at Universidad Autónoma de Madrid in Spain. The results showed that there is a significant positive effect ($p < 0.05$) of the COVID-19 confinement on students' performance (Figure 2). This, as claimed by Gonzalez et al. (2020), was largely attributed to a change in students' learning strategies to a more continuous habit, improving efficiency [6]. Another example of this has also been shown in India where students gained higher marks in online assessments and open book examinations, thus suggesting an alternative mode of examination that enhances the quality of education whilst maintaining a lower carbon footprint [47]. Comparative analyses of student performance during online learning versus face-to-face prior to the pandemic has also been conducted with the results revealing no significant difference in student performance between online and face-to-face learners [48]. Moreover, studies by Almendingen et al. (2021) revealed that students seemed to adapt quickly to the sudden shift in online learning due to the pandemic and research by Clark et al. (2021) indicated that online learning improved student academic results by 0.22 of a standard deviation [49,50]. Knowing there is no significant difference in performance coupled with the ability of students to adapt between the two different modes can entice HEIs to make the gradual shift towards an online teaching model to improve the environmental impact of the sector associated with its high travel carbon footprint [50].

However, a survey conducted as part of Kaczmarek et al.'s study (2020) found that both students and faculty felt that distance learning had decreased student engagement and participation and increased burnout [51]. Technological issues, home life distractions and the COVID-19 pandemic are some of the factors that led to the perception of degraded student learning. Transitioning teaching methods, such as laboratory experiments in STEM, to being online was also identified as posing significant challenges as students were not able to perform hands-on tasks and learn to actively collaborate and work in teams [52]. Distance learning, especially amongst young students across all subjects, can pose a challenge in

terms of developing key transferable skills such as collaboration, communication and public speaking, which could, in turn, carry further employability implications.

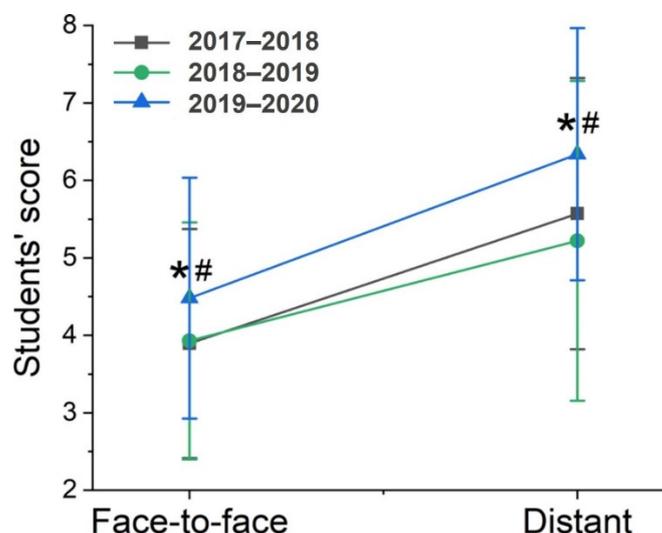


Figure 2. Students' scores in the face-to-face period and in the online learning period. Data is presented for the 3 academic courses (2017/2018 and 2018/2019 being the control group and 2019/2020 the experimental group) as mean \pm SD. Symbols indicate statistically significant differences ($p < 0.05$) between course 2019/2020 and 2017/2018 (*), 2019/2020 and 2018/2019 (#) or between the period before and after the confinement during the same course. Adapted from [6].

These are all some very valid concerns to be considered and mitigated in a future post-COVID online teaching context, also acknowledging the potential limitations of some skills (such as those related to specific STEM subjects) to be obtained online. Of course, Kaczmarek et al.'s (2020) study was based on a small sample ($n = 39$), which is also smaller than this of the study conducted by Gonzalez et al. (2020) ($n = 458$). However, the findings that Kaczmarek et al. (2020) stated should not be disregarded as one of the main challenges associated with online learning is maintaining good levels of student engagement [42]. Studies have also shown that there are many barriers to the adoption and implementation of online teaching in medical schools. A cross-sectional survey of medical students highlighted that online learning was less effective in the practical aspects of teaching suggesting the need for some face-to-face learning [53]. However, a study by Stoehr et al. (2021) indicated that 84% out of 3286 medical students found online learning to provide greater learning flexibility and higher attendance of courses [54]. One avenue that can be explored further is the use of virtual reality (VR) in medical training. This can be applied in areas such as anatomy teaching, surgical procedures, and key medical techniques through implementing 3D visualisations in virtual world scenarios [55]. Furthermore, Imperial College London implemented virtual patient-focused teaching which led to increasing students' clinical reasoning skills and diagnostic thought process [56]. This suggests that online learning could still play an important role in the teaching of medical students as well as other students in the future.

8. Impact of the COVID-19 Pandemic on UK Higher Education and Sustainability Policies

The COVID-19 pandemic has raised significant challenges to the HE sector. This is also manifested in the estimated sector-wide loss of £2.6 billion in tuition fees for 2021 [57], an increase in student claims seeking a refund on tuition fees, as well as loss of income from unutilised student accommodation of about £395 M [57]. As a consequence of global lockdown, there has been a concern that international student recruitment levels would be lower at future recruitment cycles, with online teaching already appearing as a new option. As Kaufman and Chapman report [57], universities have been under pressure from students to confirm program delivery methods and teachings to avoid student deferrals. To

compensate for this loss, online learning has become a possibility, which, in the context of our study, can reduce international student travel, while at the same time, widening access of the UK's HE to a broader spectrum of international students who may otherwise not be flexible enough or in a position to study in the UK.

A survey conducted by Gutterer et al. (2020) investigated international student perceptions of COVID-19 and its impact on their study plans [58]. Results show that students were more concerned about shorter term COVID-19 disruptions, such as travel restrictions and financial issues. A total of 35% of the respondents reported that they would change their study plans to the UK due to the virus outbreak [58]. A fact which also aligns with the observed fall in the numbers of foreign and overseas students' in the majority of universities, potentially having a negative impact in the post-pandemic times [59].

Due to the COVID-19 confinement and lockdowns, there has been a temporary reduction in daily global CO₂ emissions by 17% [9]. The HE sector must envisage this as an opportunity to foster further decarbonisation of HEI practices [60]. In order to do this, various sustainability policies need to be put in place, such as creating more educational and training opportunities for staff, more specifically on the environmental impact of travel carbon emissions, and the possibilities opened around online teaching. At an institutional level, carbon management plans can play a key role in helping set out clear goals and practices when it comes to reducing carbon emissions. HEFCE has been active at encouraging universities to play their part in meeting national carbon reduction targets and have therefore adopted targets of reducing direct carbon emissions (scope 1 and scope 2) by 43% by 2020 and 83% by 2050 from their 2005 baseline [38].

9. Conclusions

Internationalisation of HEIs and the recruitment of international students have significant impacts on HE and its current high carbon footprint. Internationalisation in HE can be environmentally unsustainable, with lessons about climate change not deemed enough to engender more sustainable practices within and beyond classrooms. As discussed in our paper, identifying effective carbon emission reduction strategies is key, especially in countries like the UK, whose HEIs rely on a large cohort of international students. Additionally, educational travel can be a key parameter towards that, especially considering existing evidence of the high carbon footprint of international travel including educational travel [8,37]. It is within this context, that our study focused on online teaching as a potential way forward that can contribute to the decarbonisation of the internationalisation of the UK's Higher Education. The COVID-19 pandemic has provided impetus for such an exploration, especially considering the changing educational landscape around online teaching as a response to COVID-19 travel restrictions. Therefore, in our study, we wanted to explore whether online teaching can contribute to a reduction in emissions due to a reduction in international students' travel.

As discussed in our paper, the challenge here remains, can this happen while maintaining or even improving levels of student engagement and performance? We have looked at a number of studies providing evidence to the possibilities and limitations of that. On the one hand, as observed, there is an increasing number of studies showing that students' performance has not been adversely affected by online teaching practices, especially as evidenced in their assessments records and results [6,49,50]. However, the same cannot be said about student engagement, especially when considering particular subjects, such as STEM studies [51,52]. Therefore, as we propose above, further adjustments may be needed to maintain students' engagement while enhancing students' performance. The use of international branched campuses can be an alternative for accomplishing this goal. This means students can be taught the UK HE curriculum in a potentially less carbon-intensive way while maintaining the positive aspects of a more socially proximate mode of in-person teaching which has been successfully demonstrated by some UK HEIs [61]. Of course, here, considering the effects of the COVID-19 pandemic is also important. An online teaching model because of the COVID-19 pandemic can have its own challenges,

for example with regard to (re)creating a community of students and scholars online [62]. However, experiences such as COIL have shown some promise in bridging this gap [44]. With regard to STEM subjects, some aspects of in-person, place-based teaching need to be maintained, a fact that may also apply to other lab-based disciplines. In such cases, online learning practices should not be completely removed but rather embedded into the future curricula to create a more flexible, hybrid approach that will be needed to counteract potential limitations of an online teaching model.

Online teaching has shown to be a steppingstone towards a low-carbon future, although experimentation is essential for developing and addressing the challenges associated with it. The post-COVID context has opened up this space for experimentation and learning to be done. It has helped mainstream some of the pathways that some universities have already been developing around online teaching, and has enabled these discussions to also enter the agenda of HEI decarbonisation, a key issue for both universities and the society more broadly [63]. However, as also discussed in this study, developing appropriate institutional policy frameworks can be key at setting both targets as well as training opportunities for decarbonisation [38].

In conclusion, the internationalisation of the UK's HEIs has been impacting the environment; however, this study has highlighted the importance and potential of online teaching in mitigating the high carbon footprint, a trade off that is important to balance as well as address at a policy and practice level. This study is envisioned to shed more light on this emerging field of educational practices taking place online, and the possibilities that can be opened up in moving towards a more decarbonised future for the current highly internationalised HE systems, in the UK and beyond.

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