# Pros and cons of online education as a measure to reduce carbon emissions in higher education in the Netherlands

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Dutch institutions of higher education have to meet stringent requirements for energy efficiency and reduction of carbon emissions imposed by the national government and through voluntary agreements on energy-efficiency. This exploratory study reports the relative contribution of student (and staff) travel to the carbon emissions of Dutch higher education institutions (HEIs) and examines the arguments for and against online education as a means to reduce the carbon impact of student travel. Data on carbon emissions using the greenhouse gas (GHG) protocol, published by HEIs, were gathered and analysed. A comparison with data from other countries is presented. It was found that the contribution of the so-called scope three emissions (travel related) to the total carbon footprint of the HEIs is between 40 and 90 percent at the Dutch HEIs that were investigated. Online education (80 percent or more digitalisation of the educational processes) greatly decreases the carbon impact of student and staff travel. A series of interviews was held with HEI professionals of online education and ICT/sustainability. The interviews were analysed using the grounded theory approach. The professionals report as pros of online education its flexibility and power to personalise educational needs of individual students and the possibility to extend the learning environment with digital media. As an argument against online education professionals mention the non-committal behaviour of students. Only a few HEI professionals recognize the connection between online education and its potential for strongly reducing carbon emissions.

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## Introduction

Under the United Nations Framework Convention on Climate Change in 2015 (the Paris agreement) 197 countries have committed themselves to keep global warming well below $2°C$ above pre-industrial levels (United Nations Framework Convention on Climate Change; URL: http://unfccc.int/2860.php). In April 2016 the European Union has ratified the Paris agreement. For the Netherlands this means a reduction of greenhouse gas (GHG) emissions of 85–95 percent in 2050 (baseline 1990) [1]. The awareness of the necessity of a responsible attitude towards the environment is growing in Dutch higher education (HE). An example of this attitude is the signing of a long-term agreement (LTA) with the government to improve energy efficiency by 30 percent from 2005 until 2020 [2,3] in 2001. Improving energy efficiency and using energy sources with less carbon emissions lead to a reduction of GHG emissions. However, a HEI may not only be held responsible for its own direct GHG emissions but also for the emissions as a consequence of its activities. One of these emission sources is student (and staff) travel. With the term student travel we designate all travelling associated with their study, such as the daily commute between student residence and their HEI, the travel between student residence and main home residence, and all other travelling for study activities, including going abroad to take courses. Transport is known to have a significant environmental impact. The Intergovernmental Panel on Climate Change (IPCC) states that 23 percent of global GHG emissions (in 2010) can be attributed to (passenger and freight) transport [4]. Given the opportunities of online education, the

current state of technology and the need for a sustainable travel policy, the choice for delivering online education for Dutch HEIs would seem logical, as stated by Perez Salgado [5]. However, up to now online education has not been widely introduced at HEIs in the Netherlands. The study presented in this article explores the following aspects:

1. the carbon emissions associated with student (and staff) travel of several Dutch HEIs,
2. the pros and cons related to implementing online education in Dutch HE, according to interviewed educational and ICT/sustainability professionals at HEIs.

This exploration consists of an analysis of reported GHG emissions from HEIs and results from in-depth interviews with HEI professionals.

The outline of this article is as follows. In the section 'Review of literature' we provide definitions and background information on reporting carbon emissions caused by student and staff travelling, and on online education. The approach (with its limitations) is explained in section 'Methods'. In section 'Results' we present several types of results: an analysis of the carbon emissions related to student travel and commute of staff of HEIs, the measures and difficulties to reduce carbon emissions for travelling, and the pros and cons of online education through an analysis of interviews held with HEI professionals. In last section, we end with a summary and conclusions, and propose suggestions for further research.

## Review of literature
### Measuring and reporting carbon emissions
One way of measuring the environmental impact an activity has on its surroundings, is to measure its carbon footprint. A definition of the carbon footprint is:'*a measure of the exclusive total amount of carbon dioxide ($CO_2$) emissions that is directly or indirectly caused by an activity or is accumulated over the life stages of a product*' [6]. Carbon dioxide is an important anthropogenic contributor to the GHGs, and often carbon dioxide equivalents ($CO_2e$) are used to express the amount of GHGs.

The Greenhouse Gas Protocol Initiative [7] is an internationally accepted GHG accounting and reporting standard for companies and organisations. It provides a guideline which companies can use to quantify and report their GHG emissions. The GHG protocol divides the emission sources into three scopes (Table 1). In Table 1 we show some examples of scope 3 emissions, including emission sources associated with student and staff travel.

According to the GHG protocol reporting on scope 3 emissions is optional. Institutions can choose which categories they wish to report on. This makes it difficult to compare scope 3 emissions across institutions.

**Table 1**

Classification of greenhouse gas emission sources based on the GHG protocol [7].

| Scope | Description [7] | Examples |
|---|---|---|
| Scope 1 | Direct emissions from sources that are owned and controlled by the institution | Heating and cooling systems, vehicles (owned by the institution) |
| Scope 2 | Indirect emissions from the generation of the purchased electricity consumed by the institution | Purchased electricity |
| Scope 3 | Other indirect emissions as a consequence of the activities of the institution, but that occur from sources not owned or not controlled by the institution | Waste, procurement, education-related student travel, commute of staff, business travel |

### Carbon emissions due to student travel
Internationally there are only a few environmental studies in which GHG-emissions of HEIs are calculated. These studies are based on the GHG protocol, so the accounting of scope 3 emission sources is optional and therefore the system boundary can be different [8,10,11•]. Studies on the environmental impact of HEIs often do not include student travel as one of the sources of carbon emissions [8–10]. Ozawa-Meida *et al.* [11•] included indirect emissions due to student and staff commute, business travel, students' trips home, and visitor travel in their calculations for a UK university. In the academic year 2008/2009 they report 300 kg $CO_2e$ emissions per student for student commute and 750 kg $CO_2e$ emissions per staff member for staff commute. The total of travel related emissions for this specific UK university is around 15 000 Ton $CO_2e$ and that is about 30 percent of the overall emissions of the university.

Townsend and Barrett [10] base their calculations of the carbon footprint of another UK university on expenditure data, that is to say: determined by the university's spending policy. They do not include travel emissions because of the complexity of gathering reliable travel data of staff and students [10]. Research from the United States (US) [12,13] seems to confirm the difficulty of obtaining reliable travel data at HEIs. Bailey and LaPoint [12] and Klein-Banai and Theis [13] state that these data have a high degree of 'inaccessible data and methodological uncertainty' [12], because 'it may be based on surveys, parking permit counts, travel vouchers and various other sources of data' [13]. Bailey and LaPoint [12] report for a US-university in 2013 550 kg $CO_2e$ emissions (per student per year) for student commute and 750 kg $CO_2e$ emissions (per staff/faculty member per year) for staff/faculty commute. It follows that comparing scope 3 emissions has to be done with great care.

Roy *et al.* [14••] and Caird *et al.* [15••] in the UK used a different approach to calculate travel emissions in a

project they called SusTEACH (Sustainability Tools for the Environmental Appraisal of the Carbon impacts of HE Teaching Models using ICTs). The carbon emissions of the HEIs were not measured or calculated according to the GHG-protocol (which includes waste, procurement, etcetera). They identified five emission sources within a course, namely student travel, ICT, paper and print, residential energy (that is: energy used by studying at home) and campus site operations. Subsequently, they calculated the carbon emissions per student per 100 study hours for each of these sources in HE courses with different levels of ICT-intensiveness. Caird et al. [15$^{\bullet\bullet}$] classified these levels in five teaching models (Section 'Online education and a classification') to examine the transformative role of ICT. Their findings are that campus-based courses (face-to-face with or without ICT-enhancement) consume considerably more energy and thus lead to high carbon emissions in comparison with distance-based courses, which are either distance or online courses. These achieve an 85 percent [14$^{\bullet\bullet}$] and 84 percent [15$^{\bullet\bullet}$] reduction of carbon emissions with respect to face-to-face courses. One of the largest contributors to the reduction is student travel [14$^{\bullet\bullet}$,15$^{\bullet\bullet}$]. In absolute travel related emission values [15$^{\bullet\bullet}$] the face-to-face model results in about 130 kg $CO_2$ and the online teaching model in about 2 kg $CO_2$ per student per 100 study hours (please note that these are expressed in terms of $CO_2$, not in $CO_2$e). To our opinion this research [14$^{\bullet\bullet}$,15$^{\bullet\bullet}$] is carried out with great transparency and accuracy. However, their calculations are not at the institutional level, but at course level (in kg $CO_2$ per 100 study hours). The reduction online education might achieve becomes even more apparent extrapolating the calculations of Caird et al. [15$^{\bullet\bullet}$] to an academic year (1200 study hours). The student travel related emission value of a face-to-face model is about 1500 kg $CO_2$ and the value of an online model about 25 kg $CO_2$ per student per year. Across teaching models (the average is calculated by Caird et al. [15$^{\bullet\bullet}$]) the student travel related emissions are about 630 kg $CO_2$ per student per year. This value is comparable to the measurements of Ozawa-Meida et al. [11$^{\bullet}$], if one adds to the commute of students also the UK based and international student travel; the 300 then increases to 480 kg $CO_2$e per student per year. Both methods (GHG protocol and SusTEACH project) used for calculating carbon emissions of student travel, either for courses or for institutions, lead to the conclusion that student travel is one of the largest carbon emitters. In addition, a positive environmental impact of online or distance education on the student travel emissions is observed.

An additional aspect that deserves attention is the travel mode. Students and staff can use different modes for travelling, such as (in descendant order regarding the amount of GHG emissions): privately owned cars, public transport (tram, underground, bus, train), (electronic) bicycle, walking. Comparing the exact GHG emissions of the travel modes has to be done with care, because this is dependent, for example, on congestion on the road, time of day, age of the car. Moreover, there are differences between countries: for example, in the Netherlands all trains run on renewable energy and therefore have no GHG emissions (since 2017). Research into the travel mode of students in the United States (US) [16], Canada [17], Australia [18] and New Zealand [19] indicates a high car-dependence of off-campus students, for example, in the US the single-occupancy car is the transport mode for 50–90 percent of off-campus students [18,20,21]. This is in strong contrast with student travel in the Netherlands. Figures from 2014 indicate that only about 10 percent of all Dutch students owned a car [22]. Since 1991 all students of HE or students older than 18 years receive a free public transport permit and as a result most students travel by public transport. In the UK at the Leeds University the main mode of transport is public transport, even if students live more than 5 miles away from the university [23]. Not only financial motives (free travel permit, paid parking) or trip characteristics (distance, time of travel) influence the travel mode choice [16]. In Australia, Kerr et al. [24] show that car dependency is influenced by psychological factors, such as behavioural intention (students' attitude, norms, ease of access) and commuting habit.

Another aspect relevant to student travel related emissions is the growing inflow of international students in HE. In the Netherlands, in 2016 there were about 42 000 international students, which is about 16 percent of all university students (VSNU [Association of Dutch Universities]; URL: http://www.vsnu.nl/f_c_internationale_studenten.html). This has an environmental effect: air travel has a significant impact in terms of carbon emissions. A case study in the UK [25] shows that eight percent of international students of all the institution's students can account for 10 percent of the institution's total carbon footprint. If the course is delivered partly online, this makes hardly any difference, because students still have to travel long distances to attend the few remaining face-to-face meetings [15$^{\bullet\bullet}$]. Another possibility for international courses is the use of virtual mobility, where students participate in international courses without travelling and this is expected to reduce carbon emissions considerably [26].

To summarise, in order to decrease the large environmental impact of student travel, one of the possibilities is to change the travel mode of students to a less carbon intensive mode of travelling. However, the travel mode choice is influenced by many factors, financial as well as psychological and in the case of international travel the alternatives are limited. Another strategy to reduce student travel emissions is the use of online education and this seems to have great potential.

## Online education and a classification

As online education is identified as enabling the reduction of carbon emissions, we will focus in this section on online education and its characteristics.

In HE the interest in online education is growing. Since 2004 the New Media Consortium (NMC) started publishing an internationally recognized annual (Horizon) report about the impact of emerging technologies on teaching and learning within learning-focused organisations. In 2012 the Horizon Report Higher Education stated: '*Education paradigms are shifting to include online learning, hybrid learning and collaborative models.*', mentioning online education for the first time as one of the trends [27].

However, it should be noted that to reduce student travel carbon emissions, it is imperative that online education literally is 'education at a distance', whereby students do not (or hardly) travel to their institution to take courses, that is, location-independent. If one would add online learning facilities on top of existing face-to-face activities instead of replacing it, the result would be an increase in the environmental impact, because of the additional energy consumed by ICT facilities for the online courses [9,28]. Furthermore, online learning is more than delivering content location-independently. According to Ally [29] the process of learning and the pedagogical approach, whilst interacting with lecturer and fellow-students, are just as important. Moore and Kearsley [30] do not speak of 'distance learning' but of 'distance education' in order to emphasize the physical distance between teaching and learning. Our definition of online education is derived from Ally [29] and Moore and Kearsley [30]:

> *Online education is distance education using the internet to create a learning environment, in which a student interacts with content, lecturer and other students during his/her learning process in order to acquire knowledge and competences.*

The extent to which online education is delivered online in a course can be used to classify the type of the course. The common term 'blended learning' is generally defined as a combination of online and face-to-face learning. However, describing it this way is vague and can be misleading [31], because as shown in Table 2, a diverse type of courses falls within this description. In the annual Sloan survey of online learning in the United States, Allen and Seaman [32•] present a classification of course delivery methods, which is shown in Table 2. In this classification blended learning is reserved for courses in which 30–79 percent is delivered online; an online course typically consists of 80–100 percent of online activities and delivery.

Caird and Lane [33•] depict a different classification in teaching models, namely Face-To-Face, ICT-Enhanced

**Table 2**

**Classification of learning courses according to Allen and Seaman [29].**

| Proportion of content delivered online | Type of course | Typical description |
|---|---|---|
| 0% | Face-to-face | Course with no online technology used. Content is delivered in writing or orally in a classroom. |
| 1–29% | Web facilitated | Course that uses web-based technology to facilitate what is essentially a face-to-face course. Uses a course management system (CMS) or web pages to post the syllabus and assignments, for example. |
| 30–79% | Blended/hybrid | Course that blends online and face-to-face delivery. Substantial proportion of the content is delivered online, typically uses online discussions, and typically has some face-to-face meetings. |
| 80+% | Online | A course where most or all of the content is delivered online. Typically has no or very few face-to-face meetings. |

Face-to-face, Distance and ICT-enhanced Distance and Online. This has the advantage that it includes distance education (print-based materials) in the classification. Although we acknowledge the value of the classification of Caird and Lane [33•], it does not clarify to what extent in the ICT-enhanced teaching model digitalisation is used to supplement rather than to substitute face-to-face teaching, and thus it does not seem to make different categories between the web-facilitated and blended/hybrid learning courses [32•]. Therefore, for the remainder of this article we follow the classification of Allen and Seaman. In contrast to web-facilitated courses, blended/hybrid educational design is more than just adding ICT enhancements to face-to-face courses. Bliuc *et al.* [31] state that it requires a fundamental redesign of the pedagogical approach, because blended education changes or extends the mode of interaction with fellow-students, lecturers and content. Garrison and Vaughan [34] add that in contrast with fully online education, in a blended learning environment students are shifting between direct (face-to-face) and ICT mediated communication.

With respect to online education, a digital learning environment (DLE) is a substantial part of the learning environment of a student. The DLE should not only support the delivery of learning materials, but the whole

process of learning in a flexible and accessible manner and should be ubiquitous [35,36]. This corresponds with the functionality a 'Next-Generation-Digital-Learning-Environment' (NGDLE) can offer. The core functionality of a NGDLE must address interoperability and integration, personalisation, learning analytics, collaboration and accessibility [35].

Almost all Dutch HEIs started to use DLEs at the beginning of the 21st century, but, according to the study of Jacobs (F Jacobs, PhD thesis, University Delft, 2013), they do not use the possibilities of ICT for learning and instructional processes to its full potential. Jacobs concludes that digitalisation in learning environments seems to be dependent on improvisation of dedicated individual lecturers and isolated projects.

## Methods

This explorative study is meant as a first orientation to identify the important issues related to the impact of online education on the mobility of students and staff. Quantitative data on GHG emissions from the HEIs were gathered and analysed. In addition, qualitative data are obtained by interviewing nine carefully selected HE professionals, and confirmed in an expert meeting with eight different (zero overlap) experts.

In the Netherlands, an HEI can be either a university or a university of applied science (UAS). A UAS has professionally oriented bachelor and master programmes, whereas a university has scientifically oriented bachelor and master programmes, with more emphasis on research. About 1/3 of the Dutch students are university students and 2/3 are UAS students. In most regions in the Netherlands there is a UAS with a wide range of study programmes serving regional students.

The carbon footprint data of the selected HEIs (Utrecht UAS, Utrecht University, Erasmus University Rotterdam, Rotterdam UAS, University of Amsterdam, Amsterdam UAS) were obtained from official internal policy documents or from official data from the website of the corresponding institution and they were discussed (if necessary) with the professionals in order to be able to assess the data. In the Netherlands several HEIs are actively pursuing a carbon reduction program. The HEIs that have undertaken a serious effort to reduce carbon emissions are still learning and although they have data to share, these are not always comparable. In addition, the data regarding student travel of the HEIs in the Netherlands are not produced with the same reliability: these are estimates based on different methods, extrapolated from travel surveys from other comparable institutions, and sometimes the source is not even mentioned.

In order to obtain information on attitudes and issues with respect to student travel and online education, semi-structured interviews were held with nationally carefully selected professionals in HEIs as the means of data-collection. The selection process was supported by SURF (the collaborative ICT organisation for Dutch education and research), that has Special Interest Groups in the areas of Green ICT and online education. The professionals work at the following HEIs: Utrecht UAS, Avans UAS, Open University of the Netherlands, Rotterdam UAS, HAN UAS, Radboud University Nijmegen. This method of semi-structured interviews is well suited for a first exploration of beliefs and motives. The interviews were analysed according to the Grounded Theory [37]. The professionals were selected on their expertise on online education and/or ICT/sustainability. The professionals with their expertise on ICT/sustainability were chosen because of their knowledge, insights, contribution and implementation of institutional policy of ICT, mobility and sustainability and their knowledge of the institutional policy towards online education. The professionals with a focus on online education are familiar with the possibilities and developments of online education in Dutch HE. The professionals were interviewed on the following topics: on the policy of ICT, mobility and sustainability, on why and to what extent and in what phase of the study online education is implemented; what impact online education has on study results; and what technological, pedagogical and organisational issues are coupled with the implementation of online education. They were asked whether the relation between online education and sustainability is recognized in the institution, especially the use of online delivery to reduce the travelling of students and staff.

Semi-structured interviews (of approximately one hour per participant) were held in March 2015. This type of interviewing gives the interviewees the opportunity to express their opinions and experiences with regard to a new area of study — the relationship between carbon emissions, mobility and online education. All nine interviews were transcribed. A qualitative, interpretivist approach to content analysis is used. As stated earlier, the interviews are analysed according to the Grounded Theory, via a series of coding processes (open, axial) using the computer program Atlas.ti. Selective coding has resulted in the categories: DLE, Staff development, Commitment of students, and Interaction. The pros and cons presented in Table 4 are derived from citations of the professionals.

In May 2015 an expert meeting (three hours) with eight experts, invited by SURF, was held, where the results were presented and critically discussed. These experts were all different persons from the interviewed professionals (zero overlap). The results reported from the interviews were confirmed during this meeting and thus the expert meeting served to corroborate the findings from the interviews.

## Results

### Scope 3 carbon emissions at Dutch HEIs

In this section we present the travel related emission data of the selected HEIs [38–40], which calculated their carbon footprint according to the GHG Protocol. In Table 3 we show percentages of scope 3 carbon emissions (student and staff travel). As stated before, the reliability of the data is not always the same and in some cases system boundaries are not completely clear (Utrecht UAS, Utrecht University, Rotterdam UAS). The values concerning student and staff travel (third column) may also include business travel. As can be seen from Table 3, the relative contribution of student commute is much higher than that of staff. Given the ratio between staff and students — for example for Avans UAS (2015) the ratio is 1:10 (staff about 3000, students about 29 000) — this is a result that one would expect.

The GHG protocol reports from these HEIs show scope 3 emission percentages relative to other emission sources. One should be aware that if the absolute carbon emissions are low (e.g. in case of the use of renewable energy) the percentage of scope 3 emissions will be higher. As can be seen in Table 3, the scope 3 emissions related to travel range from 40 percent (University Utrecht) to 91 percent (UAS Utrecht). In order to compare the Dutch GHG emissions with emissions from other countries (Section 'Carbon emissions due to student travel'), the absolute GHG emissions per person of the University of Amsterdam (UvA) and the Amsterdam UAS [5] are included in Table 3. The student commute from other countries ranges from 300 [11•] to 630 kg $CO_2$e [38] per student and staff commute from 410 [38] to 750 kg $CO_2$e [11•,12] per employee. This means that the emissions are in the same order of magnitude, across the countries from which we could gather data.

Notable is the high value of student commute of Amsterdam UAS (81 percent, 630 kg $CO_2$ e per student). An explanation might be that UAS students mostly travel by public transport or car from the region to the city where they study (they stay at their parental home), whilst university students usually live on campus or otherwise use a bicycle to travel from the campus to their rental room in the city. A UAS sustainability professional confirms this assumption: '*We also examined the modal split of our students and six percent commutes with a car and the rest with public transport, which is slightly different from the university and the assumption is that students of the UAS often stay at home with their parents longer, because the travelling distance to the institution is smaller; there are more universities of applied sciences than universities. This is also the reason for university students to rent a room in the city, where they study. ( . . . ) university students travel less with a car.*'

### Measures and difficulties to reduce scope 3 travel related emissions

In this section the results of the interviews with professionals of ICT/sustainability are presented, regarding the difficulties they encountered trying to implement measures to reduce scope 3 travel related emissions.

Almost all institutions signed the LTA (long term agreement) covenant and therefore implemented energy-efficiency measures since 2005. The LTA reports (2016) [2,3] mainly show measures which have an impact on scope 1 and 2 carbon emissions. Up to now the objective (two percent of energy reduction every year) has been achieved, but maintaining this pace will be difficult in future. A sustainability professional notes:

> '*In the beginning it was obviously simple: if you erect a new building, you suddenly make a huge step, the campus is connected to the heating network, it's easy, but now it is getting difficult. It's difficult, because LED lamps are already installed and there is already a sustainable building. The limit is reached at a certain point and then you enter the areas, where it is most difficult.( . . . ) looking at the footprint of our institution, this is student travel.*'

Most measures for reducing the carbon emissions caused by student travel, aim at making it easier for students to reach the institution by public transport. Only one

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**Table 3**

Percentages of carbon footprint of HEIs attributed to scope 3 emissions (student and staff travel) of an HEI in a specific year, calculated using the GHG protocol, as reported by HEIs. In the two columns at the right the carbon emissions ($CO_2$e emissions) for student and staff commute in kg per person per year, are shown.

| Higher educational institution | Year | Student and staff travel (total) (% of carbon footprint HEI) | Student commute (% of carbon footprint HEI) | Staff commute (% of carbon footprint HEI) | Student commute (kg $CO_2$e per student) | Staff commute (kg $CO_2$e per employee) |
|---|---|---|---|---|---|---|
| Utrecht UAS | 2014 | 91 | – | – | – | – |
| Utrecht University | 2015 | 40 | – | – | – | – |
| Amsterdam UAS | 2014 | 81 | 71.7 | 4.4 | 630 | 540 |
| University of Amsterdam | 2014 | 58 | 35.4 | 8.1 | 340 | 410 |
| Rotterdam UAS | 2011 | 85 | – | – | – | – |
| Erasmus University Rotterdam | 2011 | 70 | 50 | 10 | – | – |

–: not specified by HEIs.

professional of a specific UAS mentioned blended learning as a measure to decrease carbon emissions. However, according to the other professionals of ICT/sustainability the policy of their HEIs aims at getting the student as often as possible to the institution. They state that the general opinion in their institution is that online education should be implemented as a supplement and not as a replacement; otherwise it might be at the expense of the quality of education.

Student travel is considered difficult to change, whereas HEIs believe they can influence the commute of their staff. The commute of staff represents only a small portion of the total carbon footprint of HEIs in Amsterdam and Rotterdam (Table 3). There are incentives to get the employee from the car to a (e)bicycle. A UAS professional mentioned: '*an employee can get a subsidy to purchase an electronic bike.( . . . ) I have 3000 employees and approximately 10 employees have bought this bicycle, this is a drop in the ocean*'. In addition, the discouragement of car use through the introduction of paid parking, is mentioned, but this is a delicate topic and meets much resistance. '*According to research it is most effective to induce paid parking together with incentives, but at the moment we don't get any applause in the organisation for this measure*': according to a sustainability professional. To reduce the commute of staff by telecommuting depends in most institutions on the approval of the superior or manager. In general, it is not stimulated: '*because when a student is in need of a teacher, he can skype, but our preference is face-to-face contact to discuss something*' (said by a sustainability professional).

The results of the interviews with professionals of energy/ICT/sustainability indicate that the participating HEIs take (minor) measures to reduce scope 3 travel emissions. These measures consist of trying to change the travel mode into a less carbon-intensive one. Measures to reduce student or staff travel through online education meet resistance in the institution due to the notion (or prejudice?) that regular face-to-face contact promotes the quality of learning.

## Pros and cons of online education as a means of reducing carbon emissions

As stated earlier, one of the great advantages of online education is a substantial decrease of carbon emissions. However, this is not commonly known at Dutch HEIs [5] and, according to Jacobs (F Jacobs, PhD thesis, University Delft, 2013), Dutch HEIs seem hesitant to implement online education structurally. In order to investigate this aspect in more detail, interviews with professionals were held. The interviewees state that the majority of the courses delivered by their own institution is web-facilitated (see for the classification Table 2). The HEIs are experimenting with online and blended learning courses for reasons such as international cooperation, personalised education with large number of students, facilitating international students, and flexibility in provision of units of study. The advantage that online course delivery can lead to a reduction of the carbon footprint was new to most of the interviewed online education professionals.

The interviewees did recognize other advantages and in addition a number of concerns were mentioned about online course delivery. In Table 4 we present these in the form of pros and cons, ordered around the interaction of the student with the course content, lecturer and fellow-students. This type of ordering is chosen because typically in online education digital communication devices are used to facilitate this interaction, instead of face-to-face delivery.

### Interaction student-content
In the interaction of the student with the content (learning materials) it is essential that the student gets motivated to learn. The professionals recognize the dangers of the distractions of staying at home, but in particular, the online education professionals indicate that a balanced course design in combination with individual coaching and monitoring of the students' progress can keep these distractions away. They even state that it might lead to better learning results, if one adapts the learning materials to the needs of the student. They stress the importance of a balanced course design with a careful combination of content, didactics and technology. That would align with Ally [29] and Bliuc et al. [31] who emphasize the necessity of redesigning the pedagogical approach.

### Interaction student-lecturer
The online education professionals see minor advantages of the lecturer in the role of teaching in front of the class. According to them, the lecturer should be someone who structures the learning materials, monitors the progress, activates the student by asking the appropriate questions, and explains the content if necessary. They state that in the first year of the study the proportion between online and face-to-face contacts should be in favour of face-to-face contacts, gradually changing towards more online education when progressing in the educational program. As can be seen in Table 4 the student-lecturer interaction changes in an online environment, therefore staff training and development seem to be a crucial step in the development of online or blended education. The work of Ossiannilsson and Landgren [41] and Marshall [42] on quality enhancement of e-learning seems to confirm this.

### Interaction student–student
As for the interaction with fellow students, according to the professionals, this preferably takes place within a collaborative learning community, in which face-to-face contact is extended with online communication supported by a DLE. These comments are in line with Garrison and Vaughan [34], who created a framework of a community of inquiry 'to guide the research and practice of online learning'.

**Table 4**

Pros and cons of online education with respect to digital interaction, as reported by the interviewees (professionals). Each pro has a con mentioned next to it.

| Interaction | nr | Pros online education | Cons online education |
|---|---|---|---|
| Student–content | 1 | Challenging online (or blended) course design, which is a balanced combination of content, didactics and technology activates the student and leads to deep learning. | Non-committal behaviour of students, because of not being at the institution. |
| | 2 | Personalised education is possible by adapting the learning materials, coaching and monitoring the needs of the student. | A lack of discipline and self-dependence leads to underachievement in online education. |
| | 3 | Digital Learning Environment (DLE) and digital tools provide the means to practise a presentation multiple times and discuss the result on a forum with or without the lecturer present, time-independently. | Ineffectiveness of online communication to learn, social skills, such as presenting and discussion. |
| Student–lecturer | 4 | The lecturer becomes a moderator, activating the student instead of giving a lecture. | Less flexibility. Online interaction does not provide the means to react immediately to signals of misunderstanding and misconceptions of students. |
| | 5 | The best lecturers are online available to give a lecture. | Less positive influence on students' learning through the presence of a lecturer, teaching face-to-face. |
| | 6 | Online technology provides the means to structure the learning materials and to monitor the progress of the student. | A lack of face-to-face supervision of first-years can lead to underachievement. |
| Student–student | 7 | In a collaborative learning community students can interact with each other face-to-face as well as virtually. | Deterioration of collaboration and informal learning by not/less seeing other students face-to-face. |

Regardless of which interaction is meant the professionals emphasize the importance of the DLE: 'We like to work with a powerful and characteristic learning environment, wherein the digital learning environment is an obvious part, which organizes the learning process and facilitates co-learning and co-teaching'.

The main aspects are visualized in a conceptual model, presented in Figure 1. Education-related student travel has an impact on scope 3 carbon emissions. It can be lowered by incorporating location independency in the design of online education. Online education should be properly designed and be accompanied with a good DLE and proper staff development.

## Summary and conclusions

This study reports an analysis of the contribution of student (and staff) travel to the carbon emissions of Dutch higher education institutions (HEIs), measured according to the Greenhouse Gas Protocol [38–40]. The contribution of these so-called scope 3 travel related emissions is between 40 and 90 percent at the Dutch HEIs that were

**Figure 1**
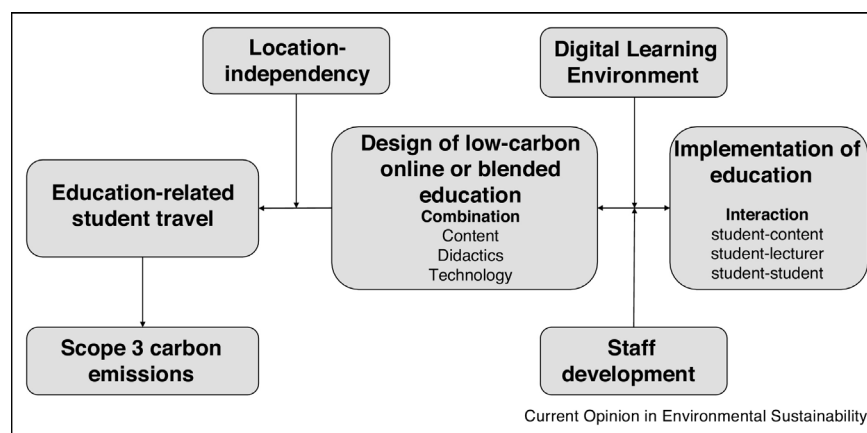


Conceptual model visualizing the relationships between online (or low carbon blended) education and scope 3 carbon emissions.

investigated. The scarce data reported from other countries (USA, UK) also show that the contribution of student travel is (very) high in the total emissions of a HEI. A comparison in detail is precarious, due to disputable data-quality [10,11•,12,13] and to national differences in travel behaviour and provisions of student housing facilities. Nevertheless, measurements in absolute values ($CO_2$e kg per student in a specific year) show that commute emissions per student in the US and UK are in the same range as in the Netherlands, namely between 300 and 630 kg $CO_2$ e.

When considering options to decrease carbon emissions due to travel, HEIs try to influence the travel mode of students and staff towards less carbon-intensive travel modes [16–19]. In the Netherlands a great amount of students travel with public transport due to the fact they receive a free travel permit from the government. In both Australia and USA the use of cars is much higher.

Secondly, this study identifies pros and cons of introducing online education in Dutch HE as a means of reducing travel related emissions. The introduction of online education allows to achieve a huge reduction in carbon emissions and could thus help HEIs to achieve their energy efficiency and sustainability goals. We examined opinions of a carefully selected group of professionals at HEIs in de field of ICT/sustainability and online education. We analysed the interviews by applying grounded theory analysis.

The professionals do not consider online education the most obvious measure to reduce travel carbon emissions, because they expect to meet resistance in their organisation, and they suspect it might deteriorate the quality of education. Measures are mostly sought in improving the accessibility of the institution to public transport, which in general is a lower carbon intensive travel mode. Most online education professionals mention as a pro of online education the opportunity to personalise education to the students' needs and to extend the learning environment with digital media. As a con they express their concern about the non-committal behaviour of students staying at home and deteriorated social processes between student and lecturer or fellow-students. In order to meet the concerns mentioned, one of the directions to look into might be low carbon blended education, since this also decreases carbon emissions, but retains some of the advantages of face-to-face education. Further research is needed to investigate the relation between the design of both online and blended courses and their carbon emissions. In order to successfully implement online education (or low-carbon blended education) as a means to reduce carbon emissions the introduction and use of the DLE and staff development are considered important factors, just as the design and implementation of the courses, which influence the amount of location-independency of the education, and thus have an impact on the student travel.

Implementing online or low carbon blended education will have high implications for many stakeholders in HE. It demands leadership of professionals, technical and pedagogical support of service departments, development of lecturers, adapted design of curricula and an active learning attitude of students.

Future research will aim at investigating in more detail scope 3 carbon emissions (also their absolute emissions, and not only their relative contribution) and at obtaining information for policy changes towards online (and low carbon blended) learning designs at several Dutch HEIs (at several levels: policy makers, professionals). An additional benefit might be an increase in awareness that student and staff travel in HE contribute substantially to carbon emissions.

## Conflict of interest
There are no conflicts of interest.

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## References and recommended reading
Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
- •• of outstanding interest

1. Vuuren DPv, Boot P, Ros J, Hof A, Elzen Md: *Wat betekent het Parijsakkoord voor het Nederlandse langetermijn-klimaatbeleid?* [What is the significance of the Paris Agreement for the Dutch Long-term Climate Policy?]. 2016:2580.

2. RVO: *MJA-Sectorrapport 2015 Hoger beroepsonderwijs*. [Multi-year Agreement Energy Use Sector Report 2015 Universities of Applied Sciences]. Netherlands Entreprise Agency; 2016. 2016/WW/157002.

3. RVO: *MJA-Sectorrapport 2015 Wetenschappelijk onderwijs*. [Multi-Year Agreement Energy Use Sector Report 2015 Universities]]. Netherlands Entreprise Agency; 2016. 26092016/WW/157005.

4. IPCC [Intergovernmental Panel on Climate Change]: *Climate Change 2014 Mitigation of Climate Change*. 2014:599-650:. ISBN 978-1-107-05821-7.

5. Pérez Salgado F: *Online onderwijs en duurzaamheid: een groene inktvlek*. [Online Education and Sustainability]. Heerlen: Open Universiteit Nederland; 2008.

6. Wiedmann T, Minx J: **A definition of 'carbon footprint'**. *Ecol Econ Res Trends* 2008, **1**:1-11.

7. WBCSD/WRI: **Setting operational boundaries**. *The Greenhouse Gas Protocol. A Corporate Accounting and Reporting Standard*. World Resources Institute and World Business Council for Sustainable Development; 2014:25-33.

8. Baboulet O, Lenzen M: **Evaluating the environmental performance of a university**. *J Clean Prod* 2010, **18**:1134-1141.

9. Robinson O, Kemp S, Williams I: **Carbon management at universities: a reality check**. *J Clean Prod* 2015, **106**:109-118.

10. Townsend J, Barrett J: **Exploring the applications of carbon footprinting towards sustainability at a UK university: reporting and decision making**. *J Clean Prod* 2015, **107**:164-176.

11. Ozawa-Meida L, Brockway P, Letten K, Davies J, Fleming P:
• **Measuring carbon performance in a UK University through a consumption-based carbon footprint: De Montfort University case study**. *J Clean Prod* 2013, **56**:185-198.
Description: a carbon footprint study of a UK university which includes measurements of the scope 3 emissions of travelling of students and staff.

12. Bailey G, LaPoint T: **Comparing greenhouse gas emissions across Texas universities**. *Sustainability* 2016, **8**:80.

13. Klein-Banai C, Theis TL: **Quantitative analysis of factors affecting greenhouse gas emissions at institutions of higher education**. *J Clean Prod* 2013, **48**:29-38.

14. Roy R, Potter S, Yarrow K: **Designing low carbon higher**
•• **education systems: environmental impacts of campus and distance learning systems**. *Int J Sustain High Educ* 2008, **9**:116-130.
Description: research into the energy-consumption and carbon emissions of distance part time courses (via printed materials and via the internet) and campus-based courses (full time and part time); a total of 20 higher education courses.

15. Caird S, Lane A, Swithenby E, Roy R, Potter S: **Design of higher**
•• **education teaching models and carbon impacts**. *Int J Sustain High Educ* 2015, **16**:96-111.
Description: research into the energy-consumption and carbon emission of distance education models compared with campus-based education models in 30 higher education courses within the SusTEACH project.

16. Zhou J: **Sustainable commute in a car-dominant city: factors affecting alternative mode choices among university students**. *Transp Res A – Policy Pract* 2012, **46**:1013-1029.

17. Whalen KE, Páez A, Carrasco JA: **Mode choice of university students commuting to school and the role of active travel**. *J Transp Geogr* 2013, **31**:132-142.

18. Hancock L, Nuttman S: **Engaging higher education institutions in the challenge of sustainability: sustainable transport as a catalyst for action**. *J Clean Prod* 2014, **62**:62-71.

19. Hopkins D, Higham J, Tapp S, Duncan T: **Academic mobility in the Anthropocene era: a comparative study of university policy at three New Zealand institutions**. *J Sustain Tour* 2016, **24**:376-397.

20. Meyerson FA, Sholly R: *Commuter Behavior and Greenhouse Gas Emissions at the University of Rhode Island*. Kingston: University of Rhode Island; 2009.

21. Gudz E, Heckathorn D, Thigpen C: *Results of the 2015–16 Campus Travel Survey*. Institute of Transportation Studies and Transportation and Parking Services University of California; 2016.

22. Centraal Bureau voor de Statistiek [Dutch Statistics Agency]. Personen in bezit van auto of motor [owners of car or motorcycle] URL: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=81844ned&D1=0-1&D2=a&D3=30&D4=l&VW=T.

23. Welch S: *University of Leeds Travel Survey*. 2015.

24. Kerr A, Lennon A, Watson B: **The call of the road: factors predicting students' car travelling intentions and behaviour**. *Transportation* 2010, **37**:1-13.

25. Davies J: **An analysis of the sustainability of different methods of delivering higher education**. *Integrative Approaches to Sustainable Development at University Level*. Springer; 2015:67-79.

26. Pérez Salgado F, de Kraker J, Boon J, Van der Klink M: **Competences for climate change education in a virtual mobility setting**. *Int J Innov Sustain Dev* 2012, **1**:53-65.

27. Johnson L, Adams S, Cummins M: **The NMC Horizon Report: 2012 Higher Education Edition**. 201: 978-0-9846601-3-1.

28. Coroama VC, Moberg Å, Hilty LM: *Dematerialization Through Electronic Media. ICT Innovations for Sustainability*. Springer; 2015:405-421.

29. Ally M: **Foundations of educational theory for online learning**. In *Theory and Practice of Online Learning*, vol 2. Edited by Anderson T . AU Press, Athabasca University; 2004:15-44.

30. Moore MG, Kearsley G: *Distance Education: A Systems View of Online Learning*. edn 3. Cengage Learning; 2011.

31. Bliuc A, Goodyear P, Ellis RA: **Research focus and methodological choices in studies into students' experiences of blended learning in higher education**. *Internet High Educ* 2007, **10**:231-244.

32. Allen IE, Seaman J: *Sizing the Opportunity: The Quality and Extent*
• *of Online Education in the United States, 2002 and 2003. Sloan Consortium (NJ1)*. 2003.
Description: the authors introduce a classification of course delivery methods. This classification makes a distinction between face-to-face, web-facilitated, blended/hybrid and online education.

33. Caird S, Lane A: **Conceptualising the role of information and**
• **communication technologies in the design of higher education teaching models used in the UK**. *Br J Educ Technol* 2015, **46**:58-70.
Description: a classification of higher education courses with regard to ICT-intensiveness. This classification is used within the SusTEACH higher education sustainability research project.

34. Garrison DR, Vaughan ND: *Blended Learning in Higher Education: Framework, Principles, and Guidelines*. John Wiley & Sons; 2008.

35. Brown M, Dehoney J, Millichap N: **The next generation digital learning environment: a report on research**. *EDUCAUSE Learning Initiative Paper*. 2015.

36. Moisey SD, Hughes JA: **Supporting the online learner**. In *Theory and Practice of Online Learning*. Edited by Anderson T. AU Press, Athabasca University; 2008:419-439.

37. Glaser BG, Strauss AL: *Grounded Theory: Strategien Qualitativer Forschung*. Bern: Huber; 1998.

38. Jonkers N, Schwarz A, van Ewijk H: *Carbon Footprint 2014 Universiteit van Amsterdam, Hogeschool van Amsterdam*. [Carbon Footprint 2014University of Amsterdam, University of Applied Sciences Amsterdam]. 2015:15110.

39. Spapens NCW: *Carbon Footprint 2014 Hogeschool Utrecht*. [Carbon Footprint 2014 University of Applied Sciences Utrecht]. 2015. 078353524:A.

40. van der Tang F: *Footprint Erasmus University Rotterdam 2011*. Erasmus University Rotterdam; 2013.

41. Ossiannilsson E, Landgren L: **Quality in e-learning – a conceptual framework based on experiences from three international benchmarking projects**. *J Comput Assist Learn* 2012, **28**:42-51.

42. Marshall S: **Improving the quality of e-learning: lessons from the eMM**. *J Comput Assist Learn* 2012, **28**:65-78.