Structural reduction of carbon emissions through online education in Dutch Higher Education

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Abstract

Dutch institutions of Higher Education have to meet stringent requirements for energy efficiency and reducing carbon emissions imposed by the national government. The commute of students and staff greatly contributes to the carbon footprint of a Higher Education Institution. International students in Dutch Higher Education also have a substantial impact on the environment due to air travel. Their number increases every year. The deployment and use of ICT can contribute substantially to the reduction of energy use and carbon emissions through decreasing mobility of students and staff by increasing virtualization and digitalization of educational processes.

This exploratory study examines the opportunities of online learning as a means to reduce the impact of students' traveling on the carbon footprint. The research methodology consists of a systematic review of literature and a series of interviews with experts of online learning and managers of energy, ICT and/or sustainability.

An obstacle for decreasing the carbon footprint of a Higher Education Institution using online learning are differences in opinion as expressed by professionals, regarding the quality of this form of education. Our research shows that those in favour of face-to-face education believe, that the social processes are essential for high quality education. Proponents of online learning emphasize the opportunities by focusing on the advantages for individual students – i.e. giving students more control over their own learning process. So far, only a minority have recognized that online learning can lead to decreased mobility and a reduction of carbon emissions.

Keywords

Carbon emission; carbon footprint; online education; blended learning; Dutch Higher Education; university; university of applied sciences; commute of students; business travel in Higher Education;

Introduction

At the end of the United Nations Framework Convention on Climate Change in 2015 (the Paris agreement), 196 countries have committed themselves to keep global warming well below two degrees Celsius above pre-industrial levels. On 22 April 2016 the European Union ratified the Paris agreement. For the Netherlands this means a reduction of Greenhouse Gas (GHG) emission of 85-95 percent in 2050 (baseline 1990) to keep the Paris agreement (Vuuren, Boot, Ros, Hof, & Elzen, 2016). Since 1992 the Dutch government aims at long-term agreements (LTA's) to improve energy efficiency with a large number of sectors. Almost all Dutch institutions of Higher Education (HE) signed this agreement to improve energy-efficiency by 30 percent in the period 2005 till 2020 (RVO, 2016a).

Transport has a significant environmental impact. The Intergovernmental Panel on Climate Change (IPCC) states, that 23 percent of global GHG emissions (in 2010) is attributed to transport (IPCC, 2014). In HE the commute of students appears to be one of the largest contributors to carbon emission (Bailey & LaPoint, 2016). This study explores what HE can do to contribute to achieve the Paris goals by implementing online learning as an enabler to decrease the mobility of students and staff. To measure the traveling of students and staff is complicated and therefore accuracy is not easily met, but it ranges from 40 – 80 percent of the total emission of a Higher Education Institution (HEI) (Jonker, 2015; Spapens, 2015). This percentage also involves business travel (traveling of staff apart from commuting, i.e. traveling to conferences, meetings).

The awareness about the necessity of a responsible attitude towards the environment is growing in HE. Signing the LTA covenant is an example of this attitude. Another example is the ranking of the most sustainable HEI, named 'SustainaBul' of the Dutch 'Students of Tomorrow'. In 2016 eleven of the fifteen Dutch universities and also nine universities of applied sciences took part in this contest. HE should align their mobility policy with their sustainability objectives (Hopkins, Higham, Tapp, & Duncan, 2016), i.e. promoting alternative travel modes such as public transport, cycling, walking, carpool and telecommuting (Whalen, Páez, & Carrasco, 2013; Zhou, 2012). The carbon emission caused by business travel is also dependent on the study programme, due to cultural factors like

avidity of traveling to conferences (Larsen, Pettersen, Solli, & Hertwich, 2013). However, few HEIs in the Netherlands are aware of the environmental impact of the commute of students. In the LTA-sector reports 2015 (RVO, 2016b; RVO, 2016c) reducing the commute of students is not mentioned. Only reduction of staff commute is pointed out as part of chain efficiency.

There is an additional aspect to students' commute in the Netherlands: since 1991 all students of HE or students older than eighteen get a free public transport permit. Therefore most students travel with public transport and this travel behaviour creates a capacity problem during rush hours. Another effect of this travel behaviour concerns the affordability of the current student permit by the government. This affordability is under discussion.

Studies on the environmental impact of HEIs mostly do not include the commute of students as one of the sources of the HEIs carbon emissions. And if so, the solution is sought in influencing the travel mode choice for students (Whalen et al., 2013; Zhou, 2012), not in decreasing the commute of students. An exception is the SusTEACH project in the United Kingdom (Caird, Swithenby, & Lane, 2015). This project not only shows that the commute of students and staff greatly contributes to the carbon footprint of a HE institution, it also indicates that distance-based HE models (online courses) achieve significant carbon reductions (83 percent), if compared with campus-based HE models (face-to-face courses) (Caird, Lane, Swithenby, Roy, & Potter, 2015; Roy, Potter, Yarrow, & Smith, 2005). It proves, that the deployment and use of Information and Communication Technology (ICT) can contribute substantially to the objective to decrease mobility through virtualization and digitalization of educational processes.

In 2004 the New Media Consortium(NMC) starts publishing an internationally recognised annual (Horizon) report about the impact of emerging technologies on teaching and learning within learning-focused organisations. In 2012 the Horizon Report Higher Education states : "*Education paradigms are shifting to include online learning, hybrid learning and collaborative models.*", noticing it as one of the trends (Johnson, Adams, & Cummins, 2012). To reduce the commute of students, it is imperative, that online also means education at a distance. If one adds online learning on top of existing activities instead of replacing it, the result is an increase in the environmental impact, because of the energy consumed by ICT facilities (Coroama, Moberg, & Hilty, 2015; Robinson, Kemp, & Williams, 2015).

Given the current state of technology and the need for a sustainable travel policy, the choice to make education partly location-independent by providing it online, seems logical, but is not widely accepted. There are several studies about the carbon footprint of a HEI and several studies about the impact of online learning. However, there is hardly any awareness about a possible causality between them. Therefore further research is necessary. This study is an exploration and a starting point to bridge this gap by exploring the Dutch situation with regard to the environmental impact of traveling in HE and the development of online education. A systematic review of international literature and Dutch reports are described in Review of literature. In Results the findings of in-depth interviews with managers of energy, ICT and/or sustainability and experts of online learning are presented.

Method

The research methodology is twofold: a systematic review of literature and a series of in–depth interviews. The participants of the interviews are:

- Experts of online education: they are aware of the possibilities and developments of online education in Dutch HE
- Managers of energy, ICT and/or sustainability: the HE policy of mobility and sustainability is prepared and implemented by these managers. Moreover they organize the technical support of ICT-related needs in education. Therefore they are very much aware of the policy of the HEI towards online education.

The participants, their institutions and the category (University or University of Applied Sciences[UAS]) are presented in table 1.

Institution	Category	Participant
University of Applied Sciences Utrecht	UAS	Online education expert
		Manager of sustainable business
Avans University of Applied Sciences	UAS	Online education expert
Open University of the Netherlands	University	Online education expert
		Online education expert
University of Applied Sciences Rotterdam	UAS	Manager of ICT/sustainability
University of Applied Sciences Arnhem Nijmegen	UAS	Manager of sustainability
		Manager of ICT
Radboud University Nijmegen	University	Manager of energy

Table 1 Participants of the in-depth interviews of this study

The mix is in favour of the UsAS, because the carbon footprint caused by mobility is a bigger issue in these institutions.
Semi-structured interviews were selected as the means of data-collection and based on a questionnaire for business- and one for educational stakeholders (Appendix B). This method is chosen, because it is well suited for a first exploration of beliefs and motives. It gives the participants the opportunity to express their opinions and experiences with regard to a new area of study, namely the relationship between mobility and online education. All nine interviews (except one) were transcribed. One interview is not recorded, but the resulting text is approved by the interviewee. A representative of a governmental taskforce (Taskforce Beter Benutten Onderwijs en Openbaar Vervoer) is consulted about the consequences of the commute of students for public transport and governmental policy.
This study is meant as a first survey to identify the important issues of the impact of online education on the mobility of students and staff. Future research should involve more HEIs and also involve the experiences of internal stakeholders like teachers, students and educational managers as well as external stakeholders like the government and industry.
A qualitative, interpretivist approach to content analysis was used as it allows for comparisons to be undertaken between different scientific articles and perspectives of the participants. The data (literature and interviews) are analysed according to the Grounded Theory (Glaser & Strauss, 1998). In appendix C network views visualize the results of the analysis.
The carbon footprint data of universities and UsAS were obtained from the website of the corresponding institution.

Review of literature

Monitoring carbon emission

A way of getting to know the environmental impact one has on its surroundings, is to measure one's carbon footprint. A definition of the carbon footprint is *:" a measure of the exclusive total amount of carbon dioxide emissions that is directly or indirectly caused by an activity or is accumulated over the life stages of a product."* (Wiedmann & Minx, 2008). Carbon dioxide is one of the greenhouse gases, but is also the main attributor, especially when talking about transportation emissions (fossil fuel use). Almost all Dutch HEI measurements of the ecological footprint aim at carbon dioxide instead of greenhouse gas. Therefore it is acceptable to use in this study the term 'carbon footprint'.

The Greenhouse Gas Protocol Initiative is an internationally accepted greenhouse gas accounting and reporting standard. It provides a guide which companies can use to quantify and report their Greenhouse Gas (GHG) emissions. Emission sources are defined into three scopes (table 2).

Scope	Description	Example
Scope 1	Direct emissions from sources that are owned and controlled by the institution	Boilers, 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 occur from sources not owned or controlled by the institution	Waste, commute of students and staff, business travel, residential heating caused by studying at home

Table 2: Definition of greenhouse gas emissions sources (WBCSD/WRI, 2014)

Measurements of the carbon footprint of HEIs show that scope 3 emissions account for approximately 80% of the footprint (Larsen et al., 2013; Ozawa-Meida, Brockway, Letten, Davies, & Fleming, 2013). This is an estimate, because scope 3 emissions are difficult to calculate. They have a high degree of inaccessible data and methodological uncertainty (Bailey & LaPoint, 2016). Obtaining reliable data concerning the commute of students is difficult, because "it may be based on surveys, parking permit counts, travel vouchers and various other sources of data" (Klein-Banai & Theis, 2013). Also ambiguity in system boundaries is a key issue (Townsend & Barrett, 2015), i.e. it may or may not include residential heating caused by studying at home. The SusTEACH project included student's commute and residential heating in their measurements of carbon emission, in contrast to the measurements of James Townsend (Townsend & Barrett, 2015). He based his calculations of the carbon footprint on expenditure data, that is to say: determined by the university spending policy. The commute of students is a private activity and was therefore excluded from the carbon footprint. According to Leticia Ozawa-Meida the focus of GHG reporting is shifting from direct emissions to indirect emissions of an organisation and further development of scope 3 accounting can be expected (Ozawa-Meida et al., 2013).

Carbon emission of traveling of students and staff in the Netherlands

In the Netherlands there are a few public HEI reports based on the Greenhouse Gas Protocol, which give scope 3 percentages relative to other emission sources. In table 3 percentages of the proportion of the commute of students and staff in the carbon footprint -originated from these HEI reports - are presented. The commute of students is in most cases not separated from the commute of staff. Given the ratio of students and staff - i.e. Avans UAS (2015): students 28.763 , staff 2.754 - it is likely, that most of the commutes' emissions is caused by the students (confirmed by calculations of the University of Amsterdam and the UAS of Amsterdam).

Higher Educational Institute	Year	Commute of students and staff (% of carbon footprint)	Commute of students (% of carbon footprint)	Commute of staff (% of carbon footprint)
UAS Utrecht	2014	91	-	-
University Utrecht	2015	40	-	-
UAS Amsterdam	2014	76	71,7	4,4
University of Amsterdam	2014	43	35,4	8,1
UAS Rotterdam	2011	85	-	-
University Leiden	2014	23	-	-

Table 3: Percentages of the proportion of the carbon footprint (scope 1,2,3) of a HEI regarding the commute of students and staff with the corresponding year of measurement

The commuting data are not very reliable: they are estimates, based on different methods, extrapolated from mobility surveys of other comparable institutes, or the source is not mentioned at all. Besides that, the percentages describe the emission sources of the carbon footprint relative to each other. For example, if the emissions, caused by use of energy, are low - in case of the usage of renewable energy - the emission percentage, caused by commute, is larger. Still it does give an indication of the magnitude and it confirms the percentage of 80 percent, mentioned earlier.

In the Netherlands every student of HE gets a public transport permit free of charge (for weekdays or for the weekend). To get an idea of the modal split of transport of Dutch students table 4 presents percentages about the travel behaviour of the students, having a public transport permit. A traffic user is a pedestrian or a user (driver or passenger) of a vehicle. Traffic use is derived from the proportion of students, making at least one translocation on the day of survey.

Students with public transport permit	Traffic user(%)	Use of public transport(%)
Free of charge during weekdays	83,7	37
Free of charge during weekends	93,6	25,7

Table 4: Traffic using students (making at least one translocation on the day of survey) in 2014 (Centraal Bureau voor Statistiek[CBS], 2016)

In 2014 10,5 percent of all students owned a car (Centraal Bureau voor Statistiek[CBS], 2015). The modal split is an indicator for the environmental impact of traveling. These percentages indicate that a large proportion of students walks or cycles to the institute. These walking and cycling students are mostly university students. The percentages of the commute of students and staff of universities and UsAS differ in magnitude, especially the percentages of the HEIs in Amsterdam (table 3). The situation is comparable, still the percentage of students' commute of the UAS doubles the percentage of the university in Amsterdam. In the Netherlands 28 percent of university students (with study grant) lives at their parent's home, while 57 percent of UAS students lives at home. (2012-2013) (Dienst Uitvoering Onderwijs[DUO], 2015).

HE in the Netherlands stimulates the inflow of international students. In 2015 there were 36.711 international students. That is 14 percent of all university students (Vereniging van Universiteiten[VSNU], 2016). But it has a (environmental) downside: air travel has a significant impact in terms of carbon emission. A case study in the United Kingdom shows that 8 percent international students of all the institution's students can account for 10 percent of the institution's total carbon footprint (Davies, 2015). Air travel is also a contributor, looking into business travel especially at universities. Developing research collaborations and attending conferences comes with an environmental cost (Hopkins et al., 2016). Business travel accounts for 13,1 percent of the carbon footprint of the University of Amsterdam and 19 percent of the footprint of the Wageningen University.

Online education

In order to decrease the student's commute, it is imperative to make part of the education location-independent. This means: the student is not tied to a certain location to get an education and therefore is not obliged to travel. This location-independence can be achieved by "the use of the internet to access learning materials; to interact with the content, instructor, and other learners; and to obtain support during the learning process, in order to acquire knowledge, to construct personal meaning, and to grow from the learning experience". In this definition of online learning of Mohamed Ally (Ally, 2004) it is apparent, that online learning is more than delivering learning materials online: the process of learning and the pedagogical approach are just as important. To take benefit of online learning to decrease commuting, the emphasis on learning at a distance is required. Michael Moore does not speak of 'distance learning' but of 'distance education' in order to emphasize the physical distance between teaching and learning (Moore & Kearsley, 2011). Combined, it leads to our definition:

Online education is distance education, where the internet is used to create a learning environment, in which a student interacts with content, teacher and other students during his/hers learning process in order to acquire knowledge and ability.

The use of online education in HE can be divided according to the proportion of content delivered online. The common term 'blended learning' is generally defined as a combination of online and face-to-face learning. This definition is vague and can be misleading (Bliuc, Goodyear, & Ellis, 2007). In the annual Sloan survey of online learning in the United States I. Elaine Allen and Jeff Seaman presented a definition of course delivery methods (Allen & Seaman, 2003). Table 5 shows this classification.

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 to 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 to 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 face-to-face meetings

Table 5 Classification of online learning (Allen & Seaman, 2003).

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With respect to online education, a digital learning environment (DLE) is a substantial part of the learning environment of a student. The DLE not only supports the delivery of learning materials, but the whole process of learning in a flexible and accessible manner and is readily available, when needed (Moisey & Hughes, 2008) (Brown, Dehoney, & Millichap, 2015). 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, accessibility.

Almost all Dutch HEIs started to use DLEs at the beginning of the 21st century, but they do not use the possibilities of ICT for primary learning and instructional processes to its full potential (Jacobs, 2013). In the Netherlands the digitalisation in learning environments is dependent of improvisation of dedicated individual teachers and isolated projects (Jacobs, 2013). The Open University of the Netherlands is an exception; it started systematic online education in 2014. Dutch HE needs an integrated approach towards the use of new technology in the learning environment: "e-Learning initiatives are guided by institutional strategies and operational plans" (Marshall, 2012). The challenge lies in opening up new methods of education with the use of new technology

One of the core functionalities of a NGDLE is learning analytics. The Society for Learning Analytics Research defined learning analytics in the call for papers of the first international Conference on Learning Analytics and Knowledge (LAK 2011): "Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs"**.** With a tool for learning analytics a teacher can act upon the differential outcomes of the students and adapt the learning materials to the needs of the individual student (Sclater, Peasgood, & Mullan, 2016).

Learning analytics is still in an early stage of development (Sclater et al., 2016). Institutions are interested, but it is not a top priority in most HEIs, according to the outcome of a survey of EDUCAUSE among their member institutions (Arroway, Morgan, O'Keefe, & Yanosky, 2015). Data-quality concerns, system-integration difficulties, lack of institutional policy and faculty culture of resistance, are mentioned as possible causes.

Research questions

The main questions to be answered by professionals in Dutch Higher Education (in the semi-structured interviews) will be:

1. What measures have been taken to decrease the scope 3 emissions of transport in Dutch Higher Education?
2. What are the challenges and obstacles in the implementation of online education in order to decrease the scope 3 emissions of transport in Dutch Higher Education?

Results

Decreasing scope 3 emissions of transport in Dutch Higher Education

In the Netherlands a number of HEIs (Rotterdam, Utrecht, Amsterdam) calculated their carbon footprint according to the Greenhouse Gas Protocol. There are also institutions that only consider energy usage of their own buildings (Nijmegen) or only register the emissions produced by their own employees and buildings (TU Eindhoven, University Wageningen). Almost all institutions signed the LTA covenant and therefore implemented energy-efficient measures since 2005. Up till now the objectives (two percent of energy reduction every year) have been achieved, but maintaining this pace will be more difficult in future. A sustainability manager of an UAS noted: "*in the beginning it was obviously simple: if you set down a new building, you suddenly make a huge step, the campus is connected to the heating network, 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 come to the areas where it is most difficult.*"

The areas, where it is most difficult, are the indirect emissions of scope 3, especially the emissions caused by traveling. According to the percentages mentioned in table 3 the emissions caused by students' commute is much higher at an UAS than at an university. UAS students mostly travel by public transport or car from the region to the city where they study, while university students often go by bike from the campus or their rental room in the city. A manager of sustainable business noted: "*We also examined the modal split of our students and 6 % commutes with a car and the rest with public transport, which is slightly different from the university and the assumption is that UAS students stay at home with their parents longer, because the travelling distance to the institution is smaller; there are more UsAS than universities. Also the reason for university students to rent a room in the city, where they study. (…) university students travel less with a car. We think, living at home gives an easy opportunity to borrow the car of your mother*"

Solutions for bringing down the carbon emission caused by students' commute are mostly sought in making it easier to reach the institution by public transport. Only the manager of sustainable business of the UAS Utrecht mentioned blended learning as a solution to decrease the mobility. The policy of most Dutch HEIs aims at getting the student as much as possible to the institution: "*Online education only as a supplement and not as replacement, otherwise the quality of education deteriorates*".

Student's commute is considered a given reality, whereas HEIs believe they can influence the commute of their staff. The commute of staff only occupies a small portion of the carbon footprint. The modal split of HEIs in Amsterdam and Utrecht shows that approximately a quarter of the academic staff commutes by car (Jonker, 2015; Spapens, 2015). There are incentives to get the employee from the car to a (e)bike. A manager of UAS noted: "*an employee can get a subsidy to purchase an electronic bike.(…) I have 3000 employees and approximately 10 employees have bought this bike, this is a drop in the ocean*". Also paid parking permits are mentioned, but this is a sensitive 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" : a*ccording to a manager of sustainable business. To reduce mobility of staff by working from home and telecommuting depends in most institutions of the approval of the concerning superior. It is not stimulated: "*because when a student is in need for a teacher; he can skype, but the preference is face-to-face contact to discuss something*" (sustainability manager of UAS)

The challenges and obstacles in the implementation of online education in Dutch Higher Education

In order to decrease students' commute, it is essential that online course delivery also means location-independent delivery. The notion, that this can lead to a reduction of the carbon footprint was new to the interviewed online learning experts. The Open University of the Netherlands is an example of an institution which offers almost all courses online. The majority of the courses delivered by the surveyed institutions is web-facilitated (classification in table 5). They are experimenting with blended

and online learning for reasons such as international cooperation, personalised education with large number of students, facilitating international, working or ill students, efficiency (generic courses).
A project with organisational support and part of an institutional strategy is the implementation of blended learning, accompanied by an evolving DLE (HUbl) at the Educational department of the UAS of Utrecht. According to the project leader of blended learning: *"We have an institutional program on education innovation (…) a growing number of people deliver education in a blended form and the reason is, we created 14 design criteria, which education must meet. One of these is the possibility to deliver the course in blended form"*. The importance of an integrated approach becomes apparent, comparing this project with an isolated project of a MOOC at Avans UAS. A lack of policy means no educational and limited technical support and no training of teachers, according to an organizer of this MOOC.

In view of their policy most Dutch educational managers believe, that the physical environment of the institution and face–to-face contact with the teacher promotes learning and establishes an essential part of the learning environment of a student. This fear of lack of commitment of the students, while studying at home, is an obstacle with regard to implementing online education. In table 6 a resume of these negative opinions according to the interviewees can be found. Next to it: the positive reactions of other interviewees, who contradict these opinions (Appendix 1: table 2).

Student characteristic	**Against online education** (mostly of interviewed managers)	**In favour of online education** (interviewed experts of online education)
Attendance	School attendance promotes learning and quality of education.	Challenging online course design activates the student. In combination with face-to-face sessions it results in deep learning.
Ability	The student needs an extra ability to succeed in online education, namely discipline.	Personalised education is possible by adapting the learning materials and coaching to the needs of the student.
Non-committal behaviour	Online learning contributes to the laziness of the student. It can also result in despondency by lack of help from fellow students.	Postponing behaviour of the student has less to do with online learning as with the freedom to determine one's own pace. Good coaching and monitoring is required.
Study phase	First-years need more face-to-face supervision.	First-years need a lot of structure and good coaching, how to cope with online learning.

Table 6 Resume of negative and positive reactions of interviewees about the learning commitment of students in online education.

Experts of online learning believe, in contrast to the managers, that online education can lead to activation of the student and a better quality of education, if certain conditions are met. In table 7 a resume of the opinions of online education experts with regard to these conditions are presented (Appendix 1: table 1,2,4).

Condition	**According to interviewed online education experts**
Digital Learning Environment(DLE)	The core functionality of a Next-Generation-Digital-Learning-Environment should be present in the DLE. Preferably the DLE evolves with the wishes of the designers of education.
Staff development	Online education starts with a professionalization course for teachers in which didactical concepts in relation to technology and content will be dealt with.
Course design	Blended education solves communication issues and it leads to deep learning
Personalisation	The teacher should monitor the progress of a student with learning analytics and adapt the offering of learning materials and coaching of this student accordingly

Table 7 Resume of the opinions of interviewed online education experts about conditions to be met by online education

These conditions are the challenges Higher Education has to face in order to implement online education while maintaining quality. Online education experts believe in blended education, where the blend of face-to-face and online and the amount of coaching and monitoring is adapted to study phase and target students. With regard to target students: full-time students have different needs than part-time students, who combine in most cases work with study.

Conclusion

The measured carbon footprint of Dutch HEIs indicates a large proportion of carbon emissions due to traveling of students and staff. There are only few institutions, that measure the indirect emissions of the commute of students. The accuracy of the measurements is disputable, because data-quality is difficult to determine. Still the percentages in the carbon footprint reports caused by traveling of students and staff do not contradict each other or contradict international research. The range of the percentages of the commute of students and staff in the carbon footprint is 23 percent (university) to 91 percent (university of applied sciences). It is unclear if air travel by students from foreign countries is included in the measurements. International research shows, that 8 percent international students accounts for approximately 10% of the carbon footprint of the institution. The environmental impact of air travel is also evident from the percentages due to business travel, i.e. attending international conferences. Up till 19 percent is measured at a university. Measuring scope 3 emissions is complicated. Not in the least because of the costs and difficulties to gather data, but also because of the ambiguity of system boundaries. Some institutions exclude the commute of students from their measurements and none of the institutions include residential heating caused by studying at home. A national standard or protocol is needed in order to compare the carbon footprint of the HEIs to be able to draw conclusions for improvement. In the United Kingdom in 2012 the Higher Education Funding Council for England (HEFCE) started with helping the HE sector to measure scope 3 carbon emissions through supplying definitions and good practice guidance (Higher Education Funding Council for England [HEFCE] , 2012).

An improvement in decreasing the emissions caused by student's commute is possible by implementing online education. In the Netherlands there is little awareness about the causality between online education and reducing the carbon footprint of the organisation. In most cases online education is used as a supplement rather than a replacement of face-to-face education. Concerns about the quality of online education, especially fear of non-committal behaviour of students, is an obstacle to change this policy and implement the necessary investments to facilitate online education. For HE a form of blended education seems to have the best opportunities to deal with the concerns of the educational managers AND at the same time decrease the commute of students. Institutional leadership is necessary to organise technical and pedagogical support and the professional development of staff.

Challenges to meet for Dutch HE with respect to blended education:

- Most HEIs need a change or adaptation of their Digital Learning Environment. This DLE must support the pedagogical concepts of online education and meet the requirements of the Next-Generation-Digital-Learning-Environment.
- Staff development is necessary to interweave technology with pedagogical and content knowledge.
- Implementation of learning analytics is needed to assure quality and good returns of education. It supports personalised learning.
- Design of blended education, which activates the student, results in deep learning and decreases the commute of the students.

Implementing blended education has high implications for many stakeholders in HE. It demands leadership of managers, technical and pedagogical support of service departments, development of teachers, adapted design of curricula and an active learning attitude of students. Therefore a systemic approach is needed, while modelling blended education. The reward is flexibility for students to choose their own pathway through education, personalised education in spite of growing numbers of students, affiliation with pervasive computing behaviour of students and last but certainly not least, a structural reduction of carbon emission to keep the global warming well below two degrees Celcius.

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Appendix A: Analysis of interviews about online education

O: Online education expert
M: Manager of energy, ICT and/or sustainability

The numbers refer to the participant

Table 1: Digital Learning Environment

Characteristic	Expert	Examples of citations
Interoperability and integration	O4	"At this moment we are developing our own DLE and in addition Collaborate is still used as a Virtual Classroom tool"
	O1	"We are thinking about the possibilities to integrate serious gaming to the HUbl or tools to learn social skills using a webcam"
	O1	"Continual there are new implementations. The beauty of it is: it is not finished. We already have a list of things, we also want to have."
Collaboration	O4	"We use social media, because the communication department insists, but we do not use it on a structural basis in a course. A course has its base in the DLO"
	O1	"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"
	O1	"the chat environment, we call 'forum' is connected to social media. Which social media is dependent on the course design of the teacher"
	O1	"We think it is important, talking about online, starting a discourse between students and teachers and also among students. A forum where students can discuss topics with or without a teacher present"
	O2	"In fact the environment must facilitate online learning. All interactions with the learning material, fellow students and teachers should be realized with the learning environment"
Accessibility	O1	The HUbl is designed with more image material. We have a special video team"
Learning analytics	O1	"Still one of those things on our wish list (…) The HUbl exchanging content with other tools. (…) a way to make personalised education possible. Which student works in what way? What works well for her/him"
	O2	"it is not applied in a large scale, but more and more. I know, there are a lot of organisations, who apply learning analytics in a relatively small scale."

Table 2: Staff development

Characteristic	Expert	Examples of citations
Technological	O4	"First a training course with the tool "
	O3	"It is important not to have fear for camera's"
Pedagogical	O1	"First a professionalization course, meant for explaining the didactical concept (…) What does it mean for the didactical models"
	O1	"The role of the student and teacher changes (…) it asks for a different way of teaching, because the role of the teacher changes to a great extent into the role of a moderator"
	O1	"the TPACK model assumes, that every teacher has to have content knowledge, has to have didactical knowledge and as we say, has to have also technologic knowledge"

Table 3: Commitment of students

Characteristic	Expert	Examples of citations
Attendance	M1	"(…) the UAS says: if the students are inside the university building, then there is chance, they start learning. If they come a day less, I know they do anything except learning"

	M2	"if you do not stimulate the students to be there by scheduling (…), they do not do their thing (…) You have to get them inside the school building"
	M3	"the board encourages students to come to the campus. They think the quality of education improves, if the students get more face-to-face education"
	O3	"it is difficult to explain, but students hanging out together inside the building is also a part of it (…) it is, I think, important for team building and therefore also for the results of the group."
Ability	O4	"First I think the social environment of a full-time university is much better for a young student and second every part-time student has to have both IQ and discipline"
	O1	"Sometimes face-to-face, sometimes individualistic. That is dependent on course design or on what the student needs. Our aim is personalised learning"
Non-committal attitude	O4	"if the students don't know how the tool works they just get together and work it out. It is often something very small and then you can forward again, but our students (OU) sit separately at home, messing with such a tool and that causes in some cases study delay and despondency"
	O4	"(...) because the student stays lazily in bed and watches a movie, where a teacher talks about some things (…) then the question is whether it yields something."
	O2	"That postponing behaviour has less to do with online learning as with the freedom to determine your own pace. So for example, if you structure online learning, deliver it with good coaching and monitor the progress of the student and act upon it, if necessary, then it makes no difference to the returns of education."
Activating student	O1	"we say, because it places the student in a activating role (…) and thus the return is higher."
	O1	"Pyramid of Bloom (…) we try to reach higher levels. That is relevant for co-learning and deep learning"
	O2	"Not only leads it to more effective learning but also often to more efficient learning or learning with more fun, when you offer the learning material in the form of a game (…) For younger student this is very stimulating"
Study phase	O2	"Look, if the students have a wrong picture of online learning and they get their education in a unstructured way/environment with a lot of freedom and coming right from high school, there is a chance they are not coping. But if you start with paying attention to the working of online learning and next you offer much structure and much coaching and gradually bringing this down, there is chance everything turns out well"
	O1	"What to do with students? We easily say activating students, but if a student don't want to be activated. (…) some students who are young, 18 years old, they don't get it, while an older student in the 4th year understands why he studies (…) it develops over the years that someone is studying"
Part-time	O4	"The students like it very much to get online education, because of the fact it is very efficient not having to travel a long distance. The alternative is attendance in the evening or on Saturday"

Table 4: Communication

Between	Expert	Examples of citations
Student – teacher Student - student	O4	"live face-to-face education is more clever, more real, more presence, more interaction between people, more community spirit, more peer pressure, all social processes improve, while live. Also collaborating with other people, offers much more commitment seeing each other live on a regular basis. (…) It is not at the expense of content quality "
Student - teacher	O3	"(…) sitting at home while talking to a group of students (…) with the right equipment (…) it gives a feeling of togetherness (…) He can ask

		questions , I can react, he sees me, the only thing is, he cannot touch me.”
	O2	“As a teacher switching is easier, interaction is direct, so you can properly assess what the student needs at that time”
Student-student	O1	Question: Do students need seeing each other? “Yes, that remains the same. I don’t belief in totally online, all happening through that thing (…) it really needs each other.“ (online and face-to-face)
	O3	“but the bonding and coming together is also important”
Student – learning material	O2	“there are tools to learn social skills. (…) you get an assignment, you carry out this assignment in front of your webcam, when, after checking, you are pleased with the result, you send it to the teacher, otherwise you do it again, as much as it takes to get a good result”

Appendix B: Questionnaires

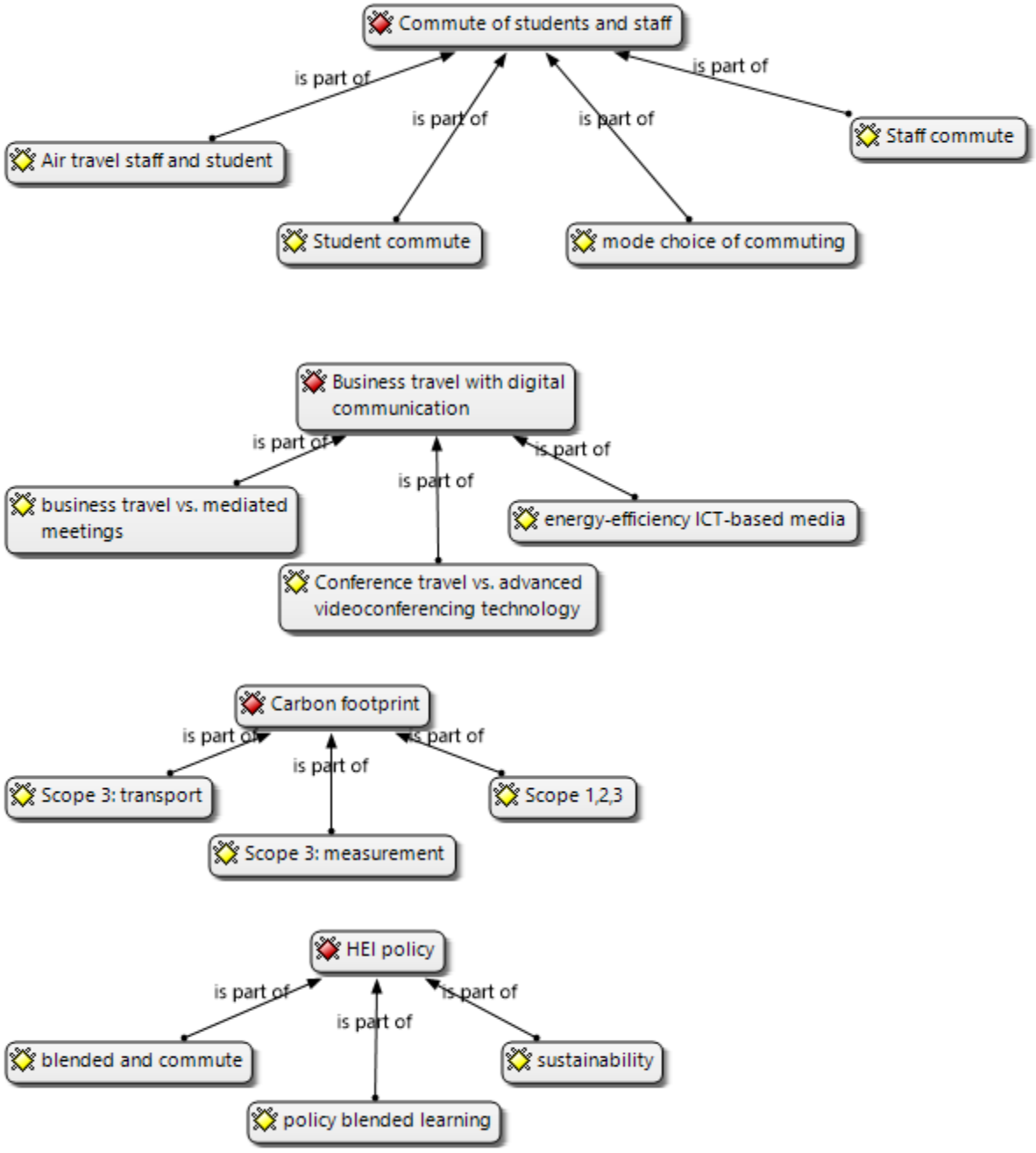
Subjects for online education experts

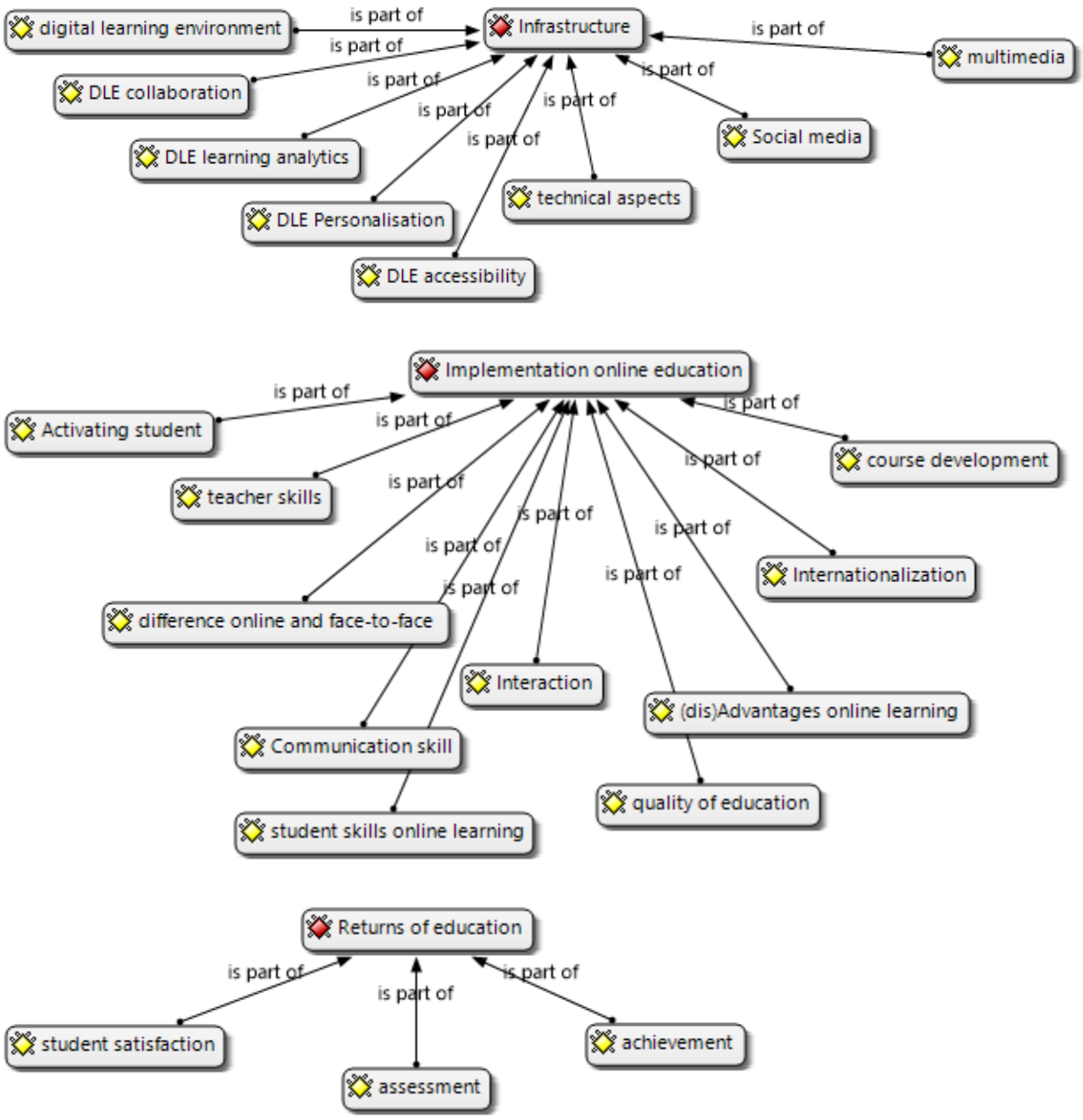
1. In which amount online education is provided (structural/ incidental)
2. What is the influence of branch or phase of study?
3. What were the reasons to implement online education (financial, educational, sustainable)
4. Is a part of the education still face-to-face? For which reason?
5. Which part of education is best delivered online and which face-to-face?
6. What is the role of social media with regard to collaboration.
7. What are the experiences? (Contentment of students or teachers, study results)
8. How labour-intensive is the design and delivery of online courses?
9. Are study results of online courses compared with similar face-to-face courses?
10. How is examination implemented? If on a distance: what about prevention of fraud?
11. Is a teacher or student in need of special skills in terms of online education?
12. Which Digital Learning Environment is used?
13. Are there technological obstacles while delivering online courses?
14. Is the relation between online education and sustainability recognized in the institution, especially using online delivery in order to reduce the commute of students and staff?
15. Is online education provided as a replacement or as a supplement of face-to-face education.
16. Is learning analytics applied with online education?

Subjects for managers of energy, ICT and/or sustainability

1. What is the policy of the institution with regard to carbon reduction?
2. Is the carbon footprint of the institution measured?
   In case of affirmative answer: Which aspects are included?
   In case of negative response: What are the reasons for not measuring?
3. What is the policy of the institution to regulate traveling of students and staff?
4. What is the modal split of commute of students and staff?
5. What is the policy of the institution regarding the decrease of traveling by car?
6. Are there stimulating measures to travel by bike or public transport?
7. Are there measures to decrease the commute of students?
8. Is the relation between online education and sustainability recognized in the institution, especially using online delivery in order to reduce the commute of students and staff?

Appendix C: Network views of the analysis of literature and interviews




digital learning environment
is part of
Infrastructure
is part of
multimedia
DLE collaboration
is part of
is part of
is part of
is part of
Social media
DLE learning analytics
is part of
technical aspects
DLE Personalisation
DLE accessibility
Implementation online education
is part of
Activating student
is part of
is part of
course development
teacher skills
is part of
is part of
is part of
is part of
Internationalization
is part of
difference online and face-to-face
Interaction
(dis)Advantages online learning
Communication skill
quality of education
student skills online learning
Returns of education
is part of
is part of
is part of
student satisfaction
achievement
assessment

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