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Design and evaluation of a sustainable blended study programme in higher education

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Introduction: Blended learning, i.e., a mix of online and in-class education, can be deployed for enhancing the educational quality and resilience in higher education (HE). It may also contribute to HE's sustainability objectives by lowering the carbon emissions of students commuting to campus. In this study, pedagogical design principles for sustainable blended learning and teaching are developed and evaluated taking into account these opportunities.

Methods: A prototype for a sustainable blended study program at a University of Applied Sciences was developed and evaluated using a form of Educational Design Research.

Results: The design stage, carried out by a team of eight lecturers, resulted in a design based on six pedagogical design principles. This design also included an effort to reduce student travel by limiting on-campus education to two days a week. The results show the effects of students' increased online learning skills and diminished travel movements on their satisfaction with the blended learning design, and their travel behaviour, which can lead towards an attitude change regarding commute and online learning. The lecturers' observations and experiences, depending on their personal preferences, contradicted (self-regulation skills) as well as confirmed (online learning experiences) the students' evaluations.

Discussion: The developed design principles are important to support a new balance between virtual and physical spaces, learning activities, moments in time and sustainability.

KEYWORDS

sustainable blended learning, student travel behaviour, design principles, higher education, attitude change

1. Introduction

Higher Education (HE) has a key responsibility in addressing the grand sustainability challenges of our time through forms of responsible research and education (Tassone et al., 2018). Colleges and universities are looking for ways to reduce their own carbon footprints and climate impact (Helmers et al., 2021; Valls-Val and Bovea, 2021) as well as taking measures for adaptation to mitigate the impact of natural disasters (Mackey et al., 2012). During the COVID-19 pandemic, most higher educational institutions (HEIs) (67%) made a rapid transition to, so-called, emergency remote teaching (Marinoni et al., 2020). Research into the

impact of this transition on the academic community in the United Kingdom showed, "a history of professional dysfunction and disturbance (…)" (Watermeyer et al., 2021, p. 638). This was, at least in part, due to deficiencies in existing infrastructure and the availability of devices for online/distance learning, and teacher training (Marinoni et al., 2020; UNESCO, 2021). Before the COVID-19 pandemic, HE showed a reluctant attitude towards using online learning (Versteijlen et al., 2017) but experiencing not only the disruptive transition but also the opportunities of online learning seems to change this attitude in one of interest (Ntim et al., 2021). Therefore, a blended learning design, allowing for both on and offline forms of instruction and learning, seems to be the way forward but careful thought must be given to how to take advantage of these opportunities, including its potential to contribute to sustainability by lowering the carbon emissions of students commuting to campus (Versteijlen et al., 2017). In HE, a large number of students travel by car or public transport to attend learning activities at their institution (Ozawa-Meida et al., 2013). According to Caird et al. (2015), distance-based HE teaching models (distance, online) achieve carbon reductions of 83 per cent in comparison with on-campus models (in-class, ICT-enhanced), largely due to student commuting (Caird et al., 2015).

When designing a blended learning configuration that may have a mitigating effect on carbon emissions by decreasing students' travel movements, the considerations underlying their decision to make a trip to campus should be considered. It seems that students make reasoned choices that depend on their attitude towards the learning activities they are supposed to attend in line with the Theory of Planned Behaviour (Ajzen and Madden, 1986; Hollett et al., 2020; Versteijlen et al., 2021). According to the Theory of Planned Behaviour (Ajzen, 1991), the student's choice to make a trip to campus derives from an intention depending on attitude, social norms and perceived behavioural control. Attitude is determined by their evaluation of the type of learning activity, the lecturer and their interest in the topic, and also, by social norms and their own perceived learning abilities (Versteijlen et al., 2021). An online learning opportunity can be an alternative option to consider. During the COVID-19 pandemic, students experienced the effects of the transition to emergency remote teaching, probably affecting their attitude towards online learning and commuting to the HEI. Van Wee et al. (2019) assume that such a trigger may cause an attitude change in what students know, feel or do. They distinguish three processes, leading to this attitude change, that is, cognitive, behavioural and affective processes (Van Wee et al., 2019). Applying this theory, the online learning experiences during the COVID-19 pandemic increased a student's knowledge about online learning advantages. These experiences (behavioural process) and increased knowledge (cognitive process) may affect their satisfaction with this type of learning (affective process). When this causes an attitude change towards online learning, it may lead to different choices regarding travelling to campus for attending in-class sessions. This study conducted an initial exploration of this potential attitude change as a result of the COVID-19 pandemic.

Whist there seem to be benefits of blended learning in realising both resilience and a lower carbon footprint, which many HEIs aspire to, a key assumption is that a blended learning study programme should maintain, or ideally improve educational quality. When considering this educational quality in terms of realisation of the learning outcomes, student satisfaction and engagement, several

empirical blended learning studies show positive results (Vaughan, 2010; Cabrera et al., 2017; Lazinski, 2017; Baranova et al., 2019; Quinn and Aarao, 2020). Still, a blended learning design is not in and by itself a guarantee for good education. Education is complex and influenced by different contextual factors. Nortvig et al. (2018) concluded, that not the blended or online design is a determinant for good education but factors such as, "educator presence in online settings, interactions between students, teachers and content, and deliberate connections between online and offline activities and between campus-related and practice-related activities" (Nortvig et al., 2018, p. 53). It seems to be essential to design blended learning carefully (Laurillard, 2013), needing a pedagogical approach that acknowledges that blended learning is more than a fusion of online and in-class learning and teaching (Vaughan, 2007; Garrison and Vaughan, 2008; Bliuc et al., 2011). Nevertheless, a detailed framework for how to design blended learning does not exist (Boelens et al., 2017). This study intends to contribute to filling this gap.

This research aims at finding directions on how to lower the environmental impact of a study programme without compromising educational quality. This aim is realised by developing and evaluating pedagogical design principles for, what we will call, a sustainable blended learning study programme and to evaluate students' travel behaviour as a result. The term 'sustainable' points to an efficient educational organisation that reduces student commute to and from campus to two days per week whilst not compromising educational quality. This objective contributes to realising Sustainable Development Goal (SDG) 13, which calls for urgent action to combat climate change, and SDG 4, which focuses on creating quality education for all. SDG 4 and 13 are part of the 2030 Agenda for Sustainable Development, adopted by 194 countries in 2015 (United Nations, 2015).

Since government restrictions due to the COVID-19 pandemic changed the blend to mainly online education, we included in the objective whether indicators could be found that experiencing mainly online learning might influence the student's attitude towards online learning and educational travel. To the best of our knowledge, this is the first empirical study to present the results of developing pedagogical design principles during the design and implementation of a sustainable blended learning study programme that not only considers pedagogical issues but also the associated student travel behaviour. By establishing an empirical foundation, this study lays the groundwork for broader application and the advancement of knowledge in future implementations.

This objective is achieved by answering the following research questions:

RQ1: How did the design team experience developing a sustainable blended learning study programme grounded in pedagogical design principles extracted from academic theory?

RQ2: How do students and lecturers evaluate learning and teaching during the implementation of the blended learning design?

RQ3: What cognitive, affective and behavioural processes can be observed while experiencing online learning, due to COVID-19 restrictions, that could lead to an attitude change in students toward educational travel and online learning?

Section 2 first introduces the methodology used to answer the research questions, followed by Section 3 presenting the results. Finally, Section 4 discusses the findings, to finish with the main conclusions.

2. Methodology

The chosen approach to study the development and implementation of sustainable blended learning and teaching is the Educational Design Research (EDR) approach. The term "Educational Design Research" was coined by McKenney and Reeves (2018). It incorporates the term 'education' to avoid confusion with design research from other fields (McKenney and Reeves, 2018). In EDR, solutions to complex real-world problems are sought and, by iteratively examining them in multiple contexts, theoretical knowledge emerges (McKenney and Reeves, 2018). We chose this methodology because of its strong connection to educational practice, contributing to more practical relevance (Van den Akker et al., 2006). In addition, EDR recognises and meets the complexity of an intervention such as the transition to blended learning and teaching. This complexity is caused by the various context variables that determine this intervention's outcome, for instance, the actions of designers, lecturers and students with their own intentions and motivations or the system policy of a HEI. In addition, EDR assumes that education evolves over time. Several iterations of research, development, testing and refinement in different contexts shape the resulting practical solution and theoretical understanding (Van den Akker et al., 2006).

In this exploratory study, we designed and evaluated one case or prototype of a sustainable blended learning unit. Our model (Figure 1), based on the generic EDR model of McKenney and Reeves (2018), shows three main stages in which the knowledge stream leads to theoretical understanding and the practice stream to a maturing intervention. The bi-directional arrows indicate that the process is iterative and flexible. RQ1 is answered in the stage 'Curriculum Design and Construction', and RQ2 and RQ3 in the stage 'Implementation and Reflection'.

2.1. Analysis and exploration

During the analysis stage, we thoroughly explored opportunities for blended learning involving various stakeholders. In the first exploration (Versteijlen et al., 2017), educational professionals (lecturers, managers and ICT service providers) of different Dutch HEIs were interviewed about the potential of online learning to decrease student travel. In the second exploration (Versteijlen et al., 2021), student travel behaviour and its connection to their learning activities were studied from the perspective of students. The findings of these two studies together with a literature review resulted in an initial draught of the design principles for sustainable blended learning. In addition, the Conversational Framework of Laurillard (2009) inspired these initial principles. This framework considers learning as an iterative process (reflection, feedback, clarification loops), linking both theory and practice, engaging students, teachers and fellow students (Laurillard, 2009).

The initial principles were tested and refined during the design and implementation of an economic business minor at Avans University of Applied Sciences (Avans UAS). A minor is a one-semester study programme on a specific subject, aimed at either broadening or deepening the study. This minor 'Public Controlling' focuses on the position of the public controller in public and non-profit organisations. The previous minor was outdated and the lecturers opted for a full redesign to a blended curriculum.

2.2. Curriculum design and construction

A team of eight educational practitioners with different backgrounds designed the minor from November 2019 to June 2020 in monthly sessions of approximately six hours. The team consisted of five content experts, that is, a minor coordinator, an educational expert and two educational ICT experts. The researcher (first author) was present at most sessions.

The minor's curriculum was designed according to the principles of constructive alignment, in which "the intended outcomes of teaching need to be stated upfront, and teaching methods and
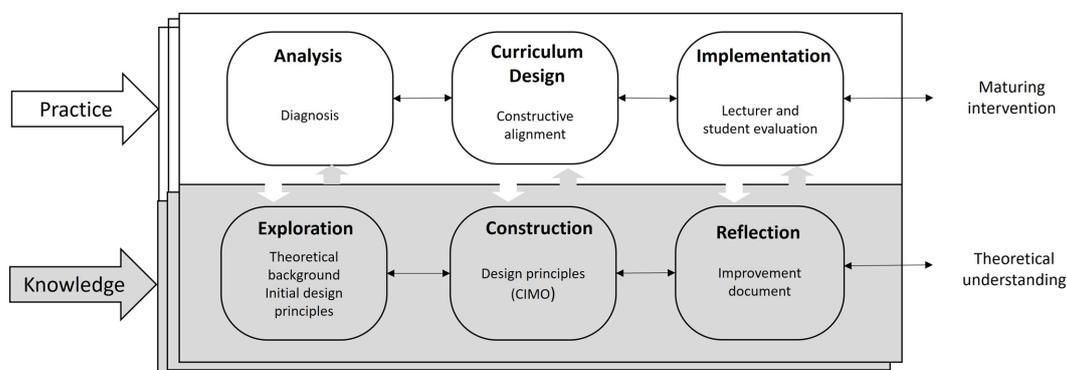
FIGURE 1
Used educational design research model. Based on McKenney and Reeves (2018).

assessments need to be aligned to what those outcomes require if they are to be met" (Biggs and Tang, 2020, p. 24).

To create a prototype, the ABC curriculum design method (Young and Perović, 2016) was used in a rapid-development workshop. The corresponding card set is based on the six learning types developed by Laurillard (2013), that is acquisition, inquiry, practice, production, discussion and collaboration. The initial design principles were partly based on the Conversational Framework of Laurillard (2013) (Section 2.1), ensuring a proper alignment between curriculum design and design principles.

During this stage, the initial design principles were further developed in dialogue with the design team. In support of this team, each principle was supplemented with context, interventions (learning activities), mechanisms that may be triggered by the interventions mentioned, and potential outcomes (extracted from academic literature). The interventions were divided between on-campus and online activities. This structure is based on CIMO logic (Context, Intervention, Mechanism, Outcome) (Denyer et al., 2008).

The design and construction phase was evaluated in June 2020 by interviewing three members of the design team, namely the coordinator, a content expert and an ICT expert. The recordings of the interviews were transcribed and analysed using Atlas.ti qualitative analysis software (version 8).

2.3. Evaluation and reflection

The minor was held from September 2020 to January 2021 and started with 26 fourth-year students of which two students quit for personal reasons. All students were between 19 and 25 years old. Nineteen students lived at their parent's homes within travelling distance from campus (Figure 2). Four minor students were enrolled originating from other colleges. The three minor lecturers were design team members. Because of the COVID-19 restrictions, on-campus education was diminished to half a day per two weeks supplemented with online activities, instead of the planned 1 or 1.5 days per week. Halfway the minor on until the end only online education was possible.

The perceptions of lecturers as well as students are incorporated in this evaluation. All three lecturers are interviewed two months after the minor. They were interviewed about their experiences with the interventions associated with the design principles during a 60-min interview with each of them. Also, some general questions were asked about strengths, challenges and possible improvements of this blended minor. The recordings of these interviews were transcribed and analysed using Atlas.ti qualitative analysis software (version 9).

The students' experiences are evaluated using a mixed research approach (Figure 3). The mixed approach is selected to enable triangulation, allowing for the verification of the in-depth observations of some students within the entire group (Creswell and Clark, 2017). In addition, a potentially changed attitude towards online learning and commuting after COVID-19 is quantitatively measured at the start because this may influence their evaluation of the blended design. For the quantitative research, the students completed two surveys with Microsoft Forms. The results are analysed with descriptive statistics techniques using IBM SPSS Statistics 28 software. Likert scales (Strongly Disagree, Disagree, Undecided, Agree, Strongly Agree) are applied to measure students' opinions. These categories are converted to numeric values 1 (strongly disagree) to 5 (strongly agree) in order

FIGURE 2
Demographic data extracted from the baseline measurement survey. **(A)** Distance from home to campus assuming the fastest road route. **(B)** Travel time during minor. **(C)** Travel mode of students (greatest distance, when using more than one travel mode) before the COVID-19 pandemic. **(D)** Intended travel mode of students (greatest distance).
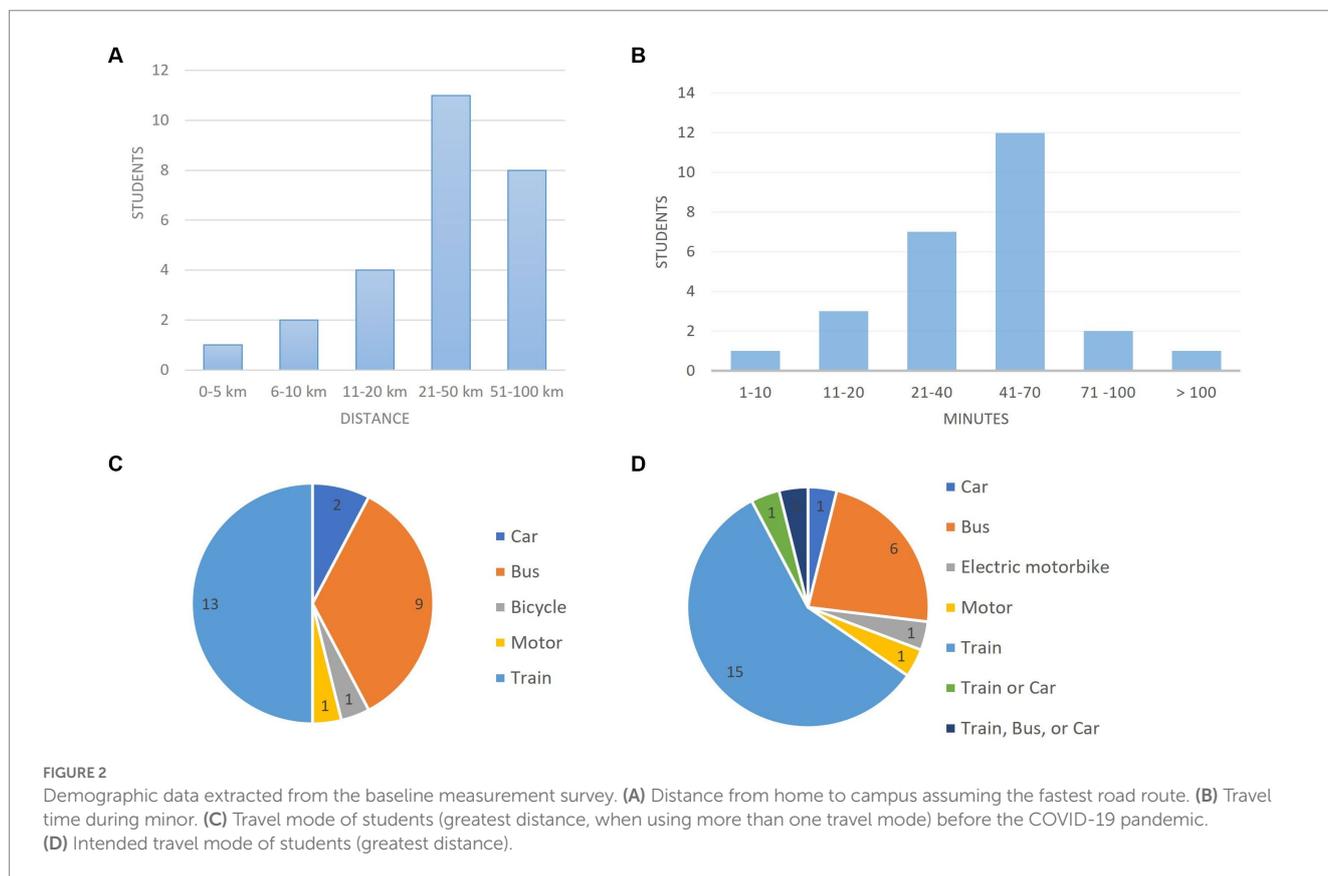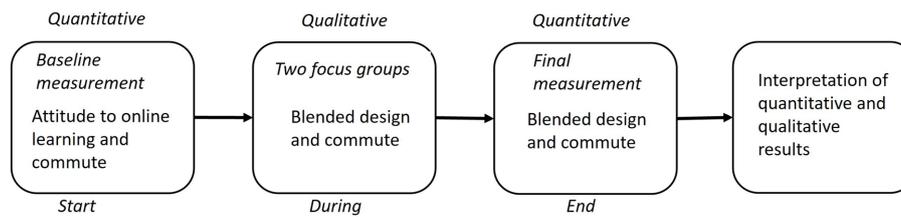
FIGURE 3
The mixed research approach to evaluating student perceptions.

to analyse the data using mean, mode and standard deviation. Other variables were measured on a nominal level, e.g., living conditions, and on a continuous level, e.g., travel time. The baseline measurement survey contains questions aiming at finding indicators about an attitude change of students towards travel choices to college or type of learning. The questions are based on the study on attitude change (Van Wee et al., 2019) and the study on student travel behaviour (Versteijlen et al., 2021), both introduced in the section Introduction. The survey questions of the final measurement were based on the results of the qualitative research (two focus groups), the Community of Inquiry Survey Instrument (draught v14) (Arbaugh et al., 2008) and the student survey questionnaire of Garrison and Vaughan (2008). These questions were divided into categories and in each category, students could add a comment on their answers. Categories, associated variables and measurement details of the surveys can be found in Supplementary material Tables 1, 2.

For the qualitative research, we organised two focus groups. In focus groups, students interact with each other and discuss their views and are thus well suited for gaining insight into their thoughts and beliefs (Stewart and Shamdasani, 2014). One focus group consisted of four male students and was organised online. The other consisted of six students (five male, one female) and took place on campus. There was no special reason to do so other than scheduling issues. The focus group meetings were led by the researcher (first author), who had no relationship with the students. Audio and video recordings were made during the session. At the beginning of the meeting, the students were asked to fill in a consent form and to provide some personal data: name, date of birth, gender, original study location, and travel mode(s) to college. They were assured that all their statements were to be treated confidentially.

The interview guide contained all the questions divided into different topics. These topics are travelling from and to the college, travelling to non-study activities and the implementation of each of the design principles. The first two topics about travel are follow-up questions to the answers given in the baseline measurement survey. The other six topics aim to establish how the students perceive the applied design principles.

The recordings of the sessions were transcribed and analysed using Atlas.ti qualitative analysis software (version 8).

All transcriptions of the qualitative data (focus groups and interviews) were analysed using the scissor-and-sort method (Stewart and Shamdasani, 2014). Fragments of text relevant to the research questions were identified and coded. These codes were ordered into code groups and assigned to categories. These categories are learning process, feedback, community feeling, interaction, discussion, acquisition, practice, collaboration, teaching, and travel. The results are incorporated into an evaluation document in which per category quotes of students and lecturers

are paraphrased, supplemented with corresponding results from the surveys. Each paraphrase has a code referring to the text fragment. This evaluation document was meant for the lecturers to improve the design of the study programme.

3. Results

The results are described according to the research questions (RQ). In Section 3.1, the design team's experiences of the process, academic support and the resulting design are presented (RQ1). The implementation of this design is evaluated according to the design principles in Section 3.2 (RQ2). Section 3.3 shows what attitude change towards educational travel and online learning could be observed amongst the minor students (RQ3).

3.1. The blended minor development

The design process followed the principles of constructive alignment where the designers begin by determining the learning goals and the associated assessments. They consulted several public sector professionals to get input for establishing learning goals. The three interviewed designers were satisfied with the concept of constructive alignment but they experienced that learning goals, assessments, and (blended) learning activities influence each other and a more iterative approach might have been more productive.

By the time, online and in-class learning activities could be added to the design, the ABC method was used in a rapid-development workshop to create a prototype (Figure 4). The facilitator remarked about this workshop:

> "At first, with the maps and the posters, as they were intended, I noticed a lot of resistance. But perhaps that depended more on the kind of persons than on the model. The team members just wanted to build the minor and this felt like a kind of unnecessary intermediate step."

The team members thought this ABC method was too complicated and theoretical. Nevertheless, they all admitted that, after depicting the results in an Excel sheet, it was useful in a later stadium.

During the sessions, the researcher observed (and this was confirmed by the ICT expert), that the designers focussed more on the design of in-class learning than on the non-scheduled online activities. The reason is the allocation of the lecturer load hours. The used
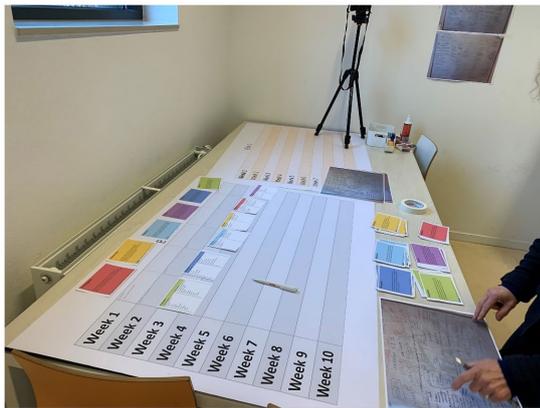
FIGURE 4
ABC method in action during a team session on March 23th 2020.

TABLE 1 Overview of the learning activities of the designed study program.

Learning activity	Associated design principle	Environment	Frequency
Introductory session	2	Online	Once
Meetings with team and tutor	1, 2, 3, 5, 6	Online or in-class	Weekly
Guest lectures	4	Online or in-class	Weekly
Workshops fellow students	4	In-class	Once per student team
Research (literature and interviews)	4, 5	Mostly online	When necessary
Peer support	1	In Teams, Comproved FeedbackFruits	When necessary
Discussion	3	In-class	4
Workshop critical thinking and integrity	4, 5	In-class and online	2

The numbers of design principles correspond to the list of design principles in 3.1.

workload model, based on traditional face-to-face education, is not suitable for allocating unscheduled online activities.

The blended minor development was supported by the creation of design principles for blended learning extracted from academic literature. The initial design principles evolved throughout the design process and resulted in design principles structured according to CIMO logic (Denyer et al., 2008) (Supplementary material, Table 3). This structuring is used, because it provided the design team with concrete implementation possibilities to meet these principles, provoked mechanisms and possible outcomes included. The design team used these principles to check the design, inspire ideas for learning activities and underpin the design choices made. The six design principles are:

1. Aiming at self-regulation in a student's learning process.
2. Fostering a sense of community.
3. Facilitating interaction and discussion amongst fellow students and with the lecturer.
4. Activating knowledge transfer.
5. Offering authentic, scaffolded and theory-based practice.
6. Collaborating for constructing a shared outcome through participation and negotiation with fellow students.

Due to COVID-19 restrictions, the online and in-class learning ratio was altered. The intention was to allocate 1.5 days per week for in-class learning activities. This became 0.5 days per two weeks. Nevertheless, the designers showed contentment with the resulting design but also reservations. The ICT expert commented on the non-scheduled online interventions in the design, depending on the lecturer and are not covered in the design. The coordinator and content expert showed concerns about theoretical knowledge acquisition. The design depends on a student's willingness to study the literature offered. Table 1 depicts an overview of the learning activities with associated design principles, environment and frequency.

3.2. Evaluating the implementation of the blended learning design

The perceptions of the lecturers and the participating students of the minor are discussed according to the design principles and

associated learning activities. The names of the students are not their real names. The lecturers are referred to as L1, L2, and L3.

3.2.1. Aiming at self-regulation in a student's learning process

Students with self-regulation skills are capable to manage their time, structure their environment, set their goals and assess their progress in attaining those goals. To be able to do so, students need to know what is expected and how they perform during the learning process. To inform the students, a study manual was available with per learning objective, explanatory text, deliverables, learning activities and a schedule over the weeks. In addition, an introductory online session was held on the minor's first day, utilising the results of a questionnaire in which students were asked about their interests, motivation, objectives and knowledge about public controlling issues. Students' performance was monitored during weekly team meetings (online and on-campus) with a lecturer present. Feedback on their progress with the assignment was provided twice per learning objective by the lecturer and also, by fellow students, using FeedBackFruits and Comproved (online tools which streamline self -, peer - and lecturer feedback).

Although the planning of activities was clearly stated in the study manual, changes due to COVID-19 occasionally confused students. The schedule, manual and rescheduling announcements contradicted each other (Table 2, A). Still, it did not interfere much with their ability to plan their learning activities (Table 2, C). Most students appreciated the extensive possibilities to study anywhere, anytime (Table 2, B). Some students found it difficult to concentrate during online lectures (Table 2, D,E).

Students (82%) were satisfied with the amount of feedback on their learning performance, especially the feedback from their

TABLE 2 Self-regulation data from the final measurement survey.

		(A)	(B)	(C)	(D)	(E)
		During the minor, there was clear communication about important deadlines and time schedules for learning activities	I appreciated the extensive possibilities to study anywhere, anytime	I had no trouble managing my own time and I submitted my assignments on time	I could concentrate well during the online guest lectures	I could concentrate well during the physical guest lectures
N	Valid	17	17	17	17	17
	Missing	0	0	0	0	0
Mean		3.12	4.24	3.88	3.35	4.06
Mode		4	4	4	4	4
Std. Deviation		0.857	0.562	0.857	0.702	0.429

lecturers during the team meetings. They had mixed feelings about the feedback from fellow students. Two observations from the focus group sessions:

"*Sometimes I felt the feedback from fellow students a bit confusing because one said A and the other one B, which were exactly contradictory, so, then I wonder, what to do?*" (Finn) and "*Sometimes you get feedback that is really useless or very superficial. Sometimes it is very good*" (Seth).

The lecturers confirm the observation of the students that the students' feedback on each other was of varying quality. A helping feature of the online feedback tool was that the lecturer could see how much time a student had spent on giving feedback.

During the online meetings, lecturers' opinions were divided on coaching the students. L1 stated that feedback during physical team meetings seems more effective than online meetings because you can see the student's body language. L2 likes, when necessary, the opportunity to easily arrange an individual online meeting with a student right after the team session. L3 could extract sufficient information from the online meetings to address undesirable behaviour and inadequate performance of students. Still, L3 also admitted to having little control over the students on days with no scheduled learning activities. L2 observes that one team did not immerse themselves in the literature given and therefore performed less well carrying out assignments.

L2: "*I didn't expect that students would not read those articles. I didn't expect that students would not discuss anything with each other. It was really a team containing five not-very-critical students. I had this other team containing four very critical students, so they did everything like a rock.*"

3.2.2. Fostering a sense of community

In a blended learning situation with less physical contact, it is a challenge to create an atmosphere amongst students safe to deliver feedback or express views. To foster a safe and social learning climate some provisions were made in the design of the minor. Students collaborated in teams of four or five members. They communicated using an online platform (Microsoft Teams) and

there were weekly team meetings with the lecturer (online and physical).

Most students appreciated the learning climate within the minor (Table 3, B) and they felt safe expressing dissenting views (Table 3, C). The blended design with physical and online meetings seems to be conducive to creating this atmosphere (Table 3, A,D).

When working in a team, most students did not experience the getting-to-know process in an online surrounding as different from a physical one. Tom stated:

"*Yes, I think it is basically the same as at college, working in a team. I think you also get to know your team online. And besides that, you already know some people and about the new team members, in other years, you only started to know them when you joined them in some team.*"

Although, Luke stated that "*I get to know a lot more about someone when meeting in real life*".

Outside their team, it is difficult to get acquainted. Finn stated, "*When you attend an online guest lecture, it says in a corner: there are 19 people present and I have no idea who they all are*".

Little was done to create a community feeling in the whole group, including lecturers, according to some participants.

Lecturer L1 finds it hard to see the student's emotions when meeting online, complicating the acquaintance process. L2 and L3 both thought that the online meetings were no barrier to getting acquainted with the students, even the contrary. In the developed design principles, some activities to promote the bonding between students were mentioned, such as organizing a virtual coffee shop, to compensate for the scarce physical meetings. However, the lecturers complained about a lack of time which prevented them to take action.

3.2.3. Facilitating interaction and discussion amongst fellow students and with the lecturer

Although the students seem reasonably satisfied with the social contact with their team members, they seem less satisfied with the amount and quality of the interaction with their fellow students as compared to physical education (Table 4, A,C). One should realise,

TABLE 3 Safe and social learning climate data from the final measurement survey.

		(A) I needed the physical meeting to get acquainted with fellow students and lecturers	(B) Getting to know my fellow students gave me a sense of belonging	(C) Expressing a different opinion did not harm the bond of trust with fellow students	(D) The Teams meetings created a bond of trust within our group
N	Valid	17	17	17	17
	Missing	0	0	0	0
Mean		3.12	3.71	3.71	3.35
Mode		4	4	4	4
Std. Deviation		1.269	0.470	0.772	0.786

TABLE 4 Interaction data from the final measurement.

		(A) Compared to the interaction experienced with fellow students in traditional (physical) education the amount of interaction increased	(B) Compared to the interaction experienced with lecturers in traditional (physical) education the amount of interaction increased	(C) Compared to the interaction experienced with fellow students in traditional (physical) education the quality of interaction improved	D Compared to the interaction experienced with lecturers in traditional (physical) education the quality of interaction improved
N	Valid	17	17	17	17
	Missing	0	0	0	0
Mean		2.53	3.12	2.94	3.06
Mode		3	4	3	3
Std. Deviation		0.874	1.054	0.827	0.899

evaluating these figures, that physical education was brought back to a minimum due to COVID-19 restrictions.

Dissatisfaction with the interaction with fellow students was not an issue in the focus group sessions. The participants evaluated Teams meetings as efficient and less distracting provided that everyone has their camera and microphone on. The participants liked the possibility of sharing their screens. For short messages and making appointments, they used WhatsApp.

Table 4, B,C show satisfaction with interaction with their lecturers. According to the participants of the focus groups the communication with the lecturers, facilitated by Microsoft Teams, was faster and more continuous.

"*They [the lecturers] are much faster and always available, say, at working hours and in college you have to walk to their working space. If he's there, then he's there, but if he's not there, then he's not there, so to speak, but then you have to come back again*" (Tom).

During an online lecture, the threshold to ask questions seems to be higher, although one participant stated:

"*But I do think: online there are also enough possibilities to have your say. you can raise your hand, you can just switch on your microphone, so the possibilities are there, but I think it also depends*

on the person whether to communicate online or only in a physical situation" (Daniel).

The design of the minor contained four in-class discussion sessions. There were no assignments made for asynchronous online discussions. On their own, only five students agreed in the final measurement that they had asynchronous discussions using the chat functionality of the online learning environment and four preferred this possibility over an in-class discussion. Still, they all felt comfortable during the in-class discussions and 13 students agreed that they were helpful to understand the opinions of others and reflect on their own. Synchronous online discussions were appreciated in small groups but not in a setting with all students (26) present.

"*On Teams, it is very easy to say nothing. For example, there was a group (…) that had prepared some nice propositions to discuss, but everyone always attends with their webcam and microphone off, and when they ask a question, few people think, oh, I'm going to switch on my microphone and I'm going to react. While if I'm in class and I ask Julia, what she is thinking, she has to react*" (Peter).

There are mixed feelings amongst lecturers about the interaction during online team meetings. During online sessions, L1 could not assess students' mental state by their body language and also thinks to be less convincing as a lecturer. The other two lecturers were quite

satisfied with the online team meetings. They experienced not much difference with physical meetings regarding interaction, even, on the contrary, there were more communication opportunities. Nevertheless, L2 noted that online interaction seems to be an additional barrier for poorly communicating students. This additional barrier to asking questions also is apparent during online (guest) lectures. Although it always seems to be the same students who ask questions regardless of the way of communication, L2 and L3 remarked.

L2 was satisfied with the discussions during the online team meetings but stated not to have time to comment on the online chat discussions of students.

3.2.4. Activating knowledge transfer

Several learning activities supported this design principle. Every week a professional from the public sector delivered a guest lecture. Some took place online, others in a physical setting. Students presented an in-class workshop for their fellow students and conducted individual and collaborative research to gather knowledge about (a problem in) the public sector. The final measurement data indicated that most students were satisfied with the amount of theoretical knowledge they gained, in particular during their research activities (Table 5, D). They were least satisfied with the workshops of their fellow students (Table 5, E).

This dissatisfaction with the workshops from their fellow students is confirmed during the focus group sessions. One of the complaints was that the six (in-class) workshops were sequentially planned, making it difficult to keep concentrated, even though the assignment was to design an interactive workshop. The result, however, was that

> "*everyone had the same format, but only slightly different content, but the format was really very overlapping and then every time, you'd be in another workshop and then, you automatically grabbed your phone for one of those Kahoots or something, you know, because that was the same thing the whole time. That just makes it less interesting*" (Tom).

Hearing the experiences of public sector professionals during the guest lectures is activating in itself and this was appreciated by the students (Table 5, B,C). The focus group participants added that the guest lectures supported their research activities. However, students and lecturers agree that an active working

format during a lecture is also important. Guest lecturers do not always have the didactical skills to engage the students and have the additional disadvantage (especially during an online lecture), of not knowing the students. Interactivity is easier to achieve during an in-class lecture than online. This may be a reason why in-class lectures were more appreciated by the students (Table 5, B,C).

L2 was less satisfied with the acquisition of knowledge by research, complaining about students not reading literature (given). As a consequence, the quality of discussions and assignments turned out to be, in some cases, inadequate.

3.2.5. Offering authentic, scaffolded, and theory-based practice

Distinctive in this minor is the cooperation with professionals from the public sector motivating the students to acquire new concepts during the guest lectures as well as to put these concepts into practice by solving real-world problems. The students appreciated working on real-world issues and to create value for the stakeholders (Table 6, B–D). This can be illustrated by a quotation from a participant of the focus group sessions who answered a question about assignments arousing curiosity:

> "*Yes, and I also think that you pay more attention to it [the assignment] because you want to deliver something really good because it actually is for a company or for someone else who is going to look at it, instead of just working on an assignment from school*" (Peter).

The minor's design intended to limit education-related travel, so students had the task to find an individual assignment in the public sector of their living area. This was less appreciated by the students (Table 6, C). In the focus group sessions, organisational and content-related reasons were mentioned. Some students found it difficult to find an appropriate assignment and some liked an assignment for a large organisation and not "for the local football club" (Tom). According to the lecturers, the student's main problems were inadequate communication skills and COVID-19 restrictions when acquiring assignments.

Because of COVID-19, in most cases, the students could not visit the organisations, they worked for. They felt this provided an incomplete picture of the organisations involved (Table 6, F).

TABLE 5 Acquisition data from the final measurement survey.

		(A)	(B)	(C)	(D)	(E)
		I gained much new theoretical knowledge about my profession during this minor	I learned much during the online guest lectures	I learned much during the in-class guest lectures	I learned much by conducting research on my own (or with the group) on new concepts	I learned much during the workshops from my fellow students
N	Valid	17	17	17	17	17
	Missing	0	0	0	0	0
Mean		3.41	3.53	3.82	4.12	2.76
Mode		4	4	4	4	2
Std. Deviation		1.004	0.624	0.529	0.697	0.903

TABLE 6 Practice data from the final measurement survey.

		(A)	(B)	(C)	(D)	(E)	(F)
		The minor assignments aroused my curiosity.	In this minor, I developed solutions that can be applied in a real-world setting	During this minor, I created value for the public sector in my living area	It motivates me to carry out tasks aimed at creating social value.	I got enough support from the lecturers to do the assignments properly.	I missed visiting the organisations involved in our project
N	Valid	17	17	17	17	17	17
	Missing	0	0	0	0	0	0
Mean		3.94	4.00	2.59	3.41	3.82	3.53
Mode		4	4	2	4	4	4
Std. Deviation		0.659	0.354	1.004	(D)	0.636	1.007

TABLE 7 Collaborating in a team.

		(A)	(B)	(C)	(D)
		I learned much from exchanging opinions and knowledge with fellow students during collaboration tasks	I am content with my contribution to collaboration tasks.	The quality of our collaboration tasks improved by collaborating both online and physically.	Involving the work field motivated us to do our collaboration tasks
N	Valid	17	17	17	17
	Missing	0	0	0	0
Mean		3.82	4.18	3.82	4.18
Mode		4	4	4	4
Std. Deviation		0.393	0.393	0.393	0.529

Data from the final measurement survey.

> "*If you visit a website, for example, you might find out what the company stands for or the company's culture, but you'll probably get a completely different answer when you would walk around in that company and ask a few employees what they really think*" (Lucas).

According to the lecturers, most students became intrinsically motivated by carrying out assignments for external public organisations. By working in the public sector, one can add societal value. This aspect was the main reason for some students to choose this minor, whilst others became inspired during the minor by the authentic assignments and the guest lectures.

3.2.6. Collaborating for constructing a shared outcome through participation and negotiation with fellow students

Developing solutions for real-life problems also seem to be motivating when collaborating in a team (Table 7, D). In this minor, a team consisted of four or five students. According to the final survey, students seem to be aware of the fact that it stimulated their learning (Table 7, A) and responsible attitude (Table 7, B). Most of them also agree on the fact that both online and physical interaction promoted the quality of their work (Table 7, C). Still, there was not much opportunity for physical collaboration due to COVID-19 regulations. According to participants of the focus group sessions, this was not much of a problem:

> "*But I have the idea that now, I do not know maybe because we are older or something, but I have the idea that now [online] is more productive than when we were at school, because then people are, yes, you are sitting somewhere and then people are walking by and so you are watching. Phones are interesting*" (Tom).

The online meetings are experienced as productive, but participants emphasise the necessity to make clear agreements on deadlines and the distribution of work. After all, everyone has their own planning whilst studying at home.

At the end of the survey, the student could evaluate the minor as a whole. Almost all students evaluated the relationship between online and in-class learning as 'enhancing' or 'relevant to' each other.

3.3. Possible attitude change towards educational travel and online learning

This section examines a possible attitude change as a result of COVID-19 regarding students' motivation to attend on-campus learning activities and choice of travel mode by considering students' cognitive, affective and behavioural processes.

3.3.1. At the start of the minor

The baseline measurement was meant to get a first indication of the attitude of the minor students towards education-related travel and online learning. They all experienced in the months preceding the start of the minor the restrictions imposed due to COVID-19. Travelling by public transport was not restricted but discouraged by the government, raising awareness of potential health risks. One of the measures was also a transition to remote emergency teaching where students gained experience with online learning methods.

To measure their knowledge of online learning activities, students were asked to mark a list of online learning activities with which they have had experience in the past. This list contained: online lecture, online practice, online question hour with a teacher (group-wise), online discussion with fellow students, online instruction video, an online individual coaching session with a teacher, online meeting with a project group, collaboration through an online platform, use of social media for study purposes, formative online knowledge test, summative online knowledge test and gamification for study purposes. Most online activities were familiar to the students, except for the use of social media (familiar for 9 students), formative knowledge test (8 students) and gamification (2 students). Table 8 shows how they experienced online learning compared to on-campus learning. The results are slightly in favour of on-campus learning, especially during collaboration activities. Still, students seem to acknowledge the online learning possibilities when looking at their preference for a mix of an on-campus and online learning model. Students showed appreciation for their online communication with lecturers and fellow students (affective process) but also missed having face-to-face contact (Table 9). When asked about their negative experiences with online learning most statements are about impaired social contact and personal attention, loneliness, and easy distraction. Almost everyone mentions 'no travel time' as a positive experience and also (not as frequently) efficiency, flexibility and easy communication possibilities.

To get an indication how the students' travel experiences during the COVID-19 pandemic affected their attitude towards a particular travel mode, they were asked to rank their reasons for choosing a travel mode before and during the COVID-19 pandemic. Before COVID-19 the rank order is 1. time, 2. money, 3. convenience, 4. flexibility, 5. reliability, 6. safety, 7. health, 8. environment. During COVID-19 it is 1. time, 2. money, 3. convenience, 4. flexibility, 5. reliability, 6. health, 7. safety, 8. environment. The only difference is

that 'health' changed positions with 'safety' during COVID-19. Still, this may be a temporary change because of the infection risks of COVID-19. The same picture arises from their open answers about positive and negative experiences with their travel mode. Travel time, costs and convenience are mentioned most frequently. "Wearing face masks" (2), delays (12) and crowded trains or busses (7) are mentioned as inconveniences of public transport. When asked about how satisfied students were with their chosen travel mode (affective process), 77.5% of the students were satisfied with their chosen travel mode. Still, only 11% would choose the same travel mode after graduation.

3.3.2. At the end of the minor

In the final measurement survey, the students were asked about the most and least efficient aspects of this blended minor. Just as at the beginning of the minor, most students mention "less travel time" as one of the most efficient aspects. Also, "online meetings" are mentioned and this differs from the earlier survey. As least efficient, they mention, amongst other things, the (online) guest lectures, interaction possibilities, and online discussions.

During the two focus group meetings and in the survey, the students were also asked about their travel experiences. At the beginning of the minor, one student intended to commute by car to the campus but in reality, five students did. Table 10 depicts to what extent COVID-19 or the blended learning model caused this behaviour. In the focus group meetings, on the question of how COVID-19 affected the travel mode choice, a student stated:

> "*Since Corona started, I haven't really travelled by public transport anymore and nowadays I commute to college by car. Also, because I only need to travel once or twice a week (…) if it was five times a week, I would travel by public transport. Otherwise, it would be too expensive*" (Lucas).

Other reasons given are: avoiding crowdedness in public transport, less travel time, more easy to borrow a car (from parents) if you need to commute occasionally. Still, the majority stated that COVID-19 made no difference regarding their travel mode choice and, in most cases, remained public transport. In the Netherlands, all students of 18 years or older receive a free public transport card and so, low travel costs were mentioned as a reason.

Triggered by the COVID-19 restrictions, cognitive, behavioural and affective processes causing a potential attitude change of students

TABLE 8 Opinions of the students about on-campus and online learning activities (baseline measurement survey).

		I learn more during an on-campus lecture than when I watch a recorded video at home	I learn more when I work on my assignments during an on-campus tutorial than completing them at home	I learn more when I collaborate with my fellow students on-campus than in an online learning environment	I think a mix of on-campus and online education is the best educational model	Online learning did not have a negative influence on my learning outcome
N	Valid	26	26	26	26	26
	Missing	0	0	0	0	0
Mean		3.54	3.42	3.62	3.81	3.15
Mode		3	3	3	4	4
Std. Deviation		1.067	1.065	0.898	0.849	1.047

TABLE 9 Satisfaction with online learning (baseline measurement survey).

		I appreciated the communication online with my fellow students.	I appreciated the communication online with my teachers.	I missed the face-to-face contact with my fellow students.	I missed the face-to-face contact with my teachers.
N	Valid	26	26	26	26
	Missing	0	0	0	0
Mean		3.23	3.69	3.85	3.58
Mode		4	4	4	4
Std. Deviation		1.070	0.618	0.925	0.809

TABLE 10 Final measurement data about preference for commuting with a car.

		Because of COVID-19, I prefer to go to college by car rather than by public transport	I prefer to go to college by car because I only have to travel to college once every few weeks
N	Valid	17	17
	Missing	0	0
Mean		3.18	3.35
Mode		2[a]	2[a]
Std. deviation		1.286	1.367

[a]Multiple modes exist. The smallest value is shown.

towards educational travel and online learning have been studied at the start and end of the minor. Students experienced the pros and cons of online and blended learning and this may change their motivation to attend classes if an online alternative is available. All students appreciated the time savings due to less travel time and a number of them also the productive and efficient online meetings. The preference for online collaboration changed throughout the minor program, with a shift from on-campus collaboration being favoured initially (as shown in Table 8) to a preference for a blended collaboration by the end of the program (as shown in Table 7, A,C), also confirmed in the focus group sessions. This shift indicates an attitude change towards online collaboration and may have an effect on their decision whether to travel to the campus for collaboration purposes.

4. Discussion and conclusion

This study's main objective was to develop and evaluate pedagogical design principles for a sustainable blended learning configuration. This only partly succeeded because the evaluation of this configuration and student travel behaviour was affected by COVID-19 restrictions. Therefore, we adapted our research design by incorporating the impact of these restrictions in our evaluation. In this section, we discuss the findings based on the three research questions and address research limitations, ending with some concluding remarks.

4.1. Experiences of the design team (Q1)

A multidisciplinary team designed the blended minor with the assistance of academic expertise. The developing team had their reservations about the constructive alignment approach. To understand the reason why one needs to know that the team members had no prior experience in designing blended learning and integrating technology. These two factors are mentioned as prerequisites for an effective blended learning design (Alammary et al., 2014). In such circumstances (inexperienced blended learning designers) a more iterative approach would probably be more effective.

A logistical issue concerns the lecturer's workload model based on traditional face-to-face education. Some blended learning interventions ask for more time commitment than acknowledged in these workload models, for instance, participation in discussion fora, regular personal approaches, and online responses to questions. This problem corresponds with previous research showing that the online experience increases the workload of lecturers due to inappropriate allocation of time (Mendieta Aguilar, 2012; Wanner and Palmer, 2015; Phillips and Phillips, 2016; Ustun and Tracey, 2020).

4.2. The implementation of the sustainable blended learning design (Q2)

The implementation of the blended minor is evaluated by studying the experiences of the students and lecturers. Six design principles were developed to serve as a basis for sustainable blended learning (Supplementary material, Table 3). All design principles proved to be relevant but their application also revealed some issues. Although the blend differed from the original planning in favour of online learning due to COVID-19 restrictions, the minor students stated that they had no trouble managing their own time and appreciated studying anywhere and anytime. Previous research confirms this appreciation but shows less belief in the former statement, that is, the self-regulation skills of the students (Hall and Villareal, 2015; Powers et al., 2016). Also, the lecturers have reservations about their students' self-regulation skills. They expected a deep learning approach (orientation towards understanding), but sometimes experienced a surface learning approach (orientation towards reproduction) of the students. This may have nothing to do with the blended context because, according to Ellis and Goodyear (2013), students' approaches to learning tend

not to differ across on-campus and online contexts. The students with a surface learning approach might have benefited from more direct feedback on their performance (online tests, quizzes) which are stimulating (Tsai, 2014).

Collaborating in a team, whilst constructing knowledge in an online learning environment, created a sense of community for the students, as confirmed by Vaughan (2010). Still, this was limited to their team. To create a community feeling amongst all minor students more actions are needed, for instance, regular online icebreakers (Keengwe, 2014, p. 90) or a virtual café (Keengwe, 2014, p. 114), but lecturers experienced a lack of time to organise this due to a failing workload model (Section 4.1). This was also a lecturer's reason for not promoting or facilitating asynchronous online discussions. These discussions provide the student with the opportunity to reflect on what has been said (or read) to make thoughtful contributions (Laurillard, 2013, p. 148). It could have been useful for stimulating students to read the literature provided, especially students with a surface learning approach, to discuss the findings, asynchronously as well as synchronously, using an online discussion board and meeting application. Pratama et al. (2020) studied the use of online meeting applications and concluded that "the video conference is proven to be more efficient, practical, and safe" (Pratama et al., 2020, p. 65), corresponding with the minor student experiences.

Although Keengwe (2014) claims that peer instruction promotes students' self-confidence and provides opportunities for reflection, the (in-class) workshops of fellow students were mostly not appreciated by the minor students. It shows that not only the content is important but also the way it is organised. That also applies to the (online and in-class) guest lectures from professionals in the public sector. These were highly relevant and therefore motivating (Laurillard, 2013) but sometimes not activating by the lack of didactical skills of professionals.

The minor students appreciated working on real-world issues and creating value for the stakeholders and, according to the lecturers, became intrinsically motivated. Previous research confirms that if an assignment is perceived as relevant by students, they become more motivated (Keller, 2008). Motivating was also the collaboration with other students working on the assignments. This is confirmed by other research (Vaughan, 2010; le Roux and Nagel, 2018; Baranova et al., 2019).

4.3. Indicators for an attitude change towards educational travel and online learning (Q3)

The findings show some indicators that the COVID-19 restrictions could have been a trigger for an attitude change in students towards commuting. Experiencing advantages of online learning such as time savings due to less travel and efficient, productive online meetings influenced their attitude towards online collaboration. This attitude change becomes even clearer when compared to the findings of the pre-COVID-19 study on student travel behaviour which showed a clear preference for on-campus collaboration (Versteijlen et al., 2021). This is in accordance with Van Wee and Witlox (2021) who state that fewer constraints regarding time and space might change the balance between the

pros and cons of making a trip and online working. However, it should be noted that during our study, students were still experiencing primarily online education and further research is needed to determine if this attitude change towards online collaboration is not temporary and influences the decision to make a trip to campus.

The reasons to choose a particular travel mode did not change much, as compared with the pre-COVID-19 student travel behaviour study (Versteijlen et al., 2021). In both studies, the students mentioned costs, time and convenience as the primary incentives. Still, in the blended learning context, an additional reason to choose a car appeared, that is, it is easier and less expensive to borrow a car (from parents) commuting occasionally. This behaviour may be temporary and does not necessarily lead to an attitude change towards a travel mode choice.

4.4. Research limitations and future research

In this design study, the pedagogical design principles are underpinned by previous research and their potential in a real-life context is explored. In EDR, the developed principles should be evaluated and refined across different real-life contexts. These contexts can differ in organisational policy, lecturers, student groups, learning subjects and so on. So, the main limitation of this study is that it is based on a single case study. The purpose of this exploratory study was to create an empirical basis for generalisation and knowledge construction in future research, in which the developed design principles can be refined across a variety of educational situations. When evaluating these design principles in a different context, it is recommended to adapt the lecturer's workload model to one that is more appropriate for blended learning (Dekeyser et al., 2014).

We chose to evaluate the blended learning study programme with student surveys, student focus groups and interviews with designers and lecturers. In this way, we were able to gain an in-depth understanding of their motivations and considerations. Nevertheless, another approach using learning analytics or observational methods would probably provide additional data and could be used to verify the opinions of the participants. In this study, a student's opinions were verified by the observations of the lecturers and fellow students.

A completely different approach might have been a context-dependent Stated Choice experiment, which asks from participants to make choices between alternatives assuming that a certain context applies (Molin, 2014). Applying this approach, students can indicate their preferences/intentions in a blended learning and a traditional learning context. An advantage of this approach is that researchers can offer more alternatives to the students. Nevertheless, it remains unclear whether students will actually make the choice they say they will. In our research, we evaluated the actual choices of both students and lecturers. Another reason for choosing EDR is its strong connection to educational practice and therefore contributing to greater practical relevance through the development of six pedagogical design principles.

As a possible environmental impact of this blended design, we focused on student travel behaviour because student travel

probably has the largest impact on the carbon footprint of a HEI. Nevertheless, there are more possible effects, such as the effect on the energy consumption of campus site operations or on student housing. Further research is recommended.

5. Concluding remarks

During one of the focus group meetings, one of the minor students stated that "blended learning is the way to go!" The minor students appreciated the freedom to make their own choices about where and when to study. Still, to ensure that this freedom does not interfere with the quality of their learning a new balance between virtual or physical spaces, learning activities, and moments in time should be created. We developed not only pedagogical design principles to support creating this balance, but we also demonstrated that experiencing online learning probably has changed the willingness of students to attend on-campus learning activities. The proposed blended learning configuration meets the student's needs to make their own choices concerning spaces, time, relations, resources and activities. In addition, its flexibility provides opportunities to organise education efficiently and sustainably.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MV was the lead researcher and author. AW and BW provided strategic advice on directions, reviewed the manuscript and provided feedback prior to submission. All authors contributed to the article and approved the submitted version.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2023.1222962/full#supplementary-material

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