Of study enthusiasts and homebirds: students' everyday mobility and sustainability dilemmas in online higher education

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Abstract

Purpose – Online education enables location-independent learning, potentially providing university students with more flexible study programs and reducing traffic-related CO_2 emissions. This paper aims to examine whether online education can contribute to university-related sustainable everyday mobility, with particular consideration given to aspects of social sustainability and potential rebound effects. Specifically, it explores sustainability dilemmas that arise from conflicting social and ecological effects.

Design/methodology/approach – Drawing on qualitative data from mobility diaries and extensive semistructured interviews ($n = 26$) collected at Osnabrück University of Applied Sciences in Germany, this study deploys thematic analysis and a typification approach to analyze and classify students' daily practices related to studying, mobility and dwelling, which may be impacted by online education.

Findings – The study identifies six distinct student types with diverse practices in studying, mobility and dwelling. Comparisons between student types reveal stark differences regarding professional and social goals that students associate with their studies, influencing university-related mobility and residential choices. This

leads to varying assessments of online education, with some students expecting benefits and others anticipating severe drawbacks.

Practical implications – The typology developed in this paper can assist Higher Education Institutions (HEIs) in comparable contexts in understanding the distinct needs and motivations of students, thereby proactively identifying sustainability dilemmas associated with online education. By leveraging these findings, HEIs can effectively balance diverse interests and contribute meaningfully to sustainability.

Originality/value – To the best of the authors' knowledge, this study is among the first to systematically investigate conflicts and rebound effects of online education in the context of sustainable mobility within HEIs.

Keywords University, Student mobility, Online education, Commuting, Residential location

Paper type Research paper

1. Introduction
In modern societies, physical mobility is a fundamental prerequisite for social participation. However, it can also be associated with significant negative environmental impacts and high individual costs regarding time and money (Banister, 2008; Schwanen *et al.*, 2011; Holden *et al.*, 2019). Sustainable mobility concepts aim to balance various dimensions of sustainability and the demands of an increasingly heterogeneous society. As societal actors, Higher Education Institutions (HEI) seek effective policies for sustainable mobility to reap environmental, social and health benefits (Delmelle and Delmelle, 2012; Rérat, 2021; Mustafa *et al.*, 2022). Previous studies have suggested strategies for promoting sustainable mobility at HEIs, such as shifting the mode of transport of students who live near the campus toward more sustainable alternatives (Vásquez *et al.*, 2015), improving relevant physical and financial infrastructures (Pérez-Neira *et al.*, 2020) or encouraging transport providers to offer more sustainable mobility options (Hancock and Nuttman, 2014).

In recent years, however, the discussion has taken a new turn: Online education has emerged as an alternative to traditional face-to-face learning, providing students with a convenient and flexible way to acquire knowledge. During the COVID-19 pandemic, large parts of HEI operations were shifted into virtual space. Thus, the physical co-presence of students and staff was no longer a requirement for studying, calling into question the need to commute (Rérat, 2021; Lamb *et al.*, 2022). For HEIs, this offered opportunities to contribute to sustainability in two respects: from a social perspective, the compatibility of personal life and education could be improved, potentially reducing access barriers to higher education (Allen and Farber, 2018; Versteijlen *et al.*, 2021). In addition, CO_2 emissions from university-related travel could potentially be lowered, which is particularly relevant for HEIs whose students do not reside close to campus.

However, experiences during the COVID-19 pandemic have shown that reduced social contact can pose significant challenges to students and lecturers alike, lowering overall levels of well-being (Farnell *et al.*, 2021; Kanning and Ohlms, 2021). One plausible explanation is that, for certain students, attending university not only serves educational and professional goals but also social processes, such as close interactions with peers and, by extension, personal development and identity formation. Online education can hamper these processes, as virtual interaction lacks the richness of face-to-face communication (Schwanen *et al.*, 2006; Brändle, 2014). Suggestions to replace face-to-face courses with online education completely thus appear to be problematic, raising questions about the potential role of online education in future efforts to promote sustainable mobility at HEIs. This study addresses these questions. Building on data from mobility diaries and semistructured interviews from students attending university in a mid-sized German city, the study develops a typology of students that considers both the ecological and social

dimensions of mobility, with a particular focus on the diverse needs of students. It focuses on three key aspects:

(1) What mobility practices exist among students?

(2) What educational and social needs and requirements lead to these practices?

(3) Can online education contribute to shifting students' mobility practices toward sustainability?

It is shown that the heterogeneity of students presents diverse sustainability challenges, especially concerning potential conflicts between ecological and social aspects of mobility. Sustainability dilemmas that can arise in both online and offline teaching scenarios are outlined. This study thus contributes to the ongoing discussion about sustainable mobility within digitized higher education contexts in highly developed countries in the Global North. The results are particularly relevant for HEIs in comparable contexts (see Section 3.2).

The article is structured as follows: Section 2 provides an overview of the literature on students' everyday mobility as well as the potentials and drawbacks of online education for sustainable mobility. Section 3 outlines the methodological approach. In Section 4, key results are presented using a typology of students. Section 5 details possible sustainability dilemmas and rebound effects and provides recommendations for HEIs. The paper concludes with a summary of the key findings (Section 6).

2. Literature review

2.1 University-related student mobility

Student and staff mobility significantly contributes to HEIs' overall CO_2 emissions, with studies reporting shares ranging from 15 to 91% (Versteijlen *et al.*, 2017; Jarillo *et al.*, 2019). A comparative study by Helmers *et al.* (2021) found that, on average, the mobility sector accounts for 45.3% of universities' CO_2 emissions, with commuting trips alone contributing 27.7%.

Compared to the general population, students tend to use public transport and active travel modes more often (Khattak *et al.*, 2011; Whalen *et al.*, 2013; Versteijlen *et al.*, 2021). They do so for pragmatic reasons, including cost, travel time and distances, transport infrastructure or weather conditions (Shannon *et al.*, 2006; Delmelle and Delmelle, 2012; Wilson *et al.*, 2018; Ribeiro and Fonseca, 2022). Student mobility is also influenced by local conditions such as city size, aspects of the transport system, campus location (e.g. urban or suburban) and mobility-related conditions on campus. High accessibility, good walkability, well-functioning public transport systems, dedicated cycling lanes to campus, high-quality cycling facilities and parking restrictions on/near campus can facilitate more sustainable mobility patterns (Khattak *et al.*, 2011; Vale *et al.*, 2018; Ribeiro *et al.*, 2020).

Residential location thus influences students' mobility in fundamental ways. Those who live on or close to campus take more trips but use sustainable modes of transportation more often than students living off campus (Khattak *et al.*, 2011). Students who reside with their parents have longer commutes and emit significantly more CO_2 than those who leave home to attend higher education (Davison *et al.*, 2015; Versteijlen *et al.*, 2017). In Germany, residential location decisions of young adults reflect social and economic factors such as affordability, access to public transport, neighborhood characteristics and proximity to friends, peers and relevant sites of everyday life such as the university campus for students (Scheiner and Holz-Rau, 2013; Nash and Mitra, 2019; Seyfarth *et al.*, 2021). Care responsibilities and other social obligations can play a key role in this context. Students living on campus tend to be younger, unmarried and in full-time education, compared to

those living off campus (Khattak *et al.*, 2011), whereas students with children are less likely to live close to campus and use active modes of travel (Delmelle and Delmelle, 2012). Personal preferences and lifestyle choices also influence aspects such as modal choice or the number of trips per day (Nash and Mitra, 2019).

2.2 Online education, student mobility and physical co-presence

Given the significant environmental impact of university-related travel, online education is increasingly being considered as a possibility to change student mobility and reduce travel-related CO_2 emissions while also providing high-quality education (Caird *et al.*, 2015; Gamba *et al.*, 2021; Versteijlen *et al.*, 2021). In this study, online education refers to academic learning activities offered by HEIs and attended by students through the internet, specifically aiming at substituting face-to-face contacts. Studies suggest that online education could lower the carbon footprint of HEIs by up to 85% when compared with campus-based study models due to reduced commuting, international travel and energy demand for building infrastructure (Roy *et al.*, 2008; Caird *et al.*, 2015; Gamba *et al.*, 2021).

Furthermore, as students face lesser restrictions of time and place, online education can promote individualized learning processes, increase autonomy for both students and lecturers (Versteijlen *et al.*, 2017) and facilitate participation (Allen and Farber, 2018). Students can better coordinate their studies with other responsibilities, such as care obligations or part-time work (Giesenbauer, 2021). In addition, online education potentially improves access to higher education (Bygstad *et al.*, 2022), thus contributing to several UN Sustainable Development Goals by reducing the social gap and promoting equality, inclusion, equitable education and lifelong learning opportunities (Jarillo *et al.*, 2019).

However, online education has also been subject to sustained criticism. Concerning ecological arguments, it has been suggested that online activities, such as telework and online education, may simply shift energy demand and costs from businesses and HEIs to private households, placing a financial burden on vulnerable groups such as students and initiating rebound effects in the private sphere (e.g. O'Brien and Aliabadi, 2020). Recent studies offer evidence that CO_2 reductions might not be as significant as expected due to the domestic energy demand associated with online education (e.g. for heating or use of electronic devices) (Filimonau *et al.*, 2021; Shi *et al.*, 2023; Wattenbach *et al.*, 2022).

In online education settings, students usually face a higher degree of self-responsibility for their learning progress. This is especially disadvantageous for students who tend to procrastinate, who are easily distracted and who do not have a strong intrinsic motivation for their studies. These groups typically benefit from the strong learning structures that face-to-face teaching provides (Kanning and Ohlms, 2021). Furthermore, limited resources, such as having only one room for both sleeping and studying, can negatively affect academic performance (Lischer *et al.*, 2022). Kanning and Ohlms (2021) summarize that satisfaction with online education settings is on average lower than with face-to-face teaching. Critics of online education point out that certain aspects of traditional on-campus learning cannot be transferred to the virtual space, such as direct interaction with professors and peers (Ellis and Goodyear, 2016). However, for some students, this exchange and meeting new people are important features of their studies (Zimmermann and Neyer, 2019). Hence, the physical mobility required for enabling co-presence is not an end in itself but serves the fulfillment of needs, a fact that has been well documented in the mobility biographies literature (Sattlegger and Rau, 2016; Scheiner and Rau, 2020; Greene *et al.*, 2022). Reducing mobility to "trips from A to B" without recognizing its social and economic root causes can thus lead to conflicts, especially during life stages characterized by extensive social interaction (e.g. student life). Therefore, sustainable mobility concepts need to extend

beyond ecological factors to include the varied needs and experiences of an increasingly diverse student body (Arnold *et al.*, 2021; Filimonau *et al.*, 2021).

In this context, several key questions emerge:

Q1. What diverse mobility practices and motivations exist among students?

Q2. How might they evolve with online education?

Q3. What sustainability-related benefits and drawbacks may arise for different types of students?

Understanding the varied impacts of online education on students is crucial for enhancing HEI sustainability while ensuring high-quality education.

3. Material and methods

3.1 Research approach and data collection

University-related mobility is intertwined with various aspects of students' daily life. To illustrate the complex relationships among students' mobility behavior and the potential effects of online education, the authors have chosen to create a typology of students based on an exploratory qualitative research design (Creswell and Poth, 2018), combining insights from the initial literature analysis with data from 24 mobility diaries and 26 semistructured qualitative interviews. This three-stage approach facilitated a comprehensive and multifaceted investigation, enabling subsequent triangulation of results and thereby enhancing the quality and rigor of the study.

Following the initial literature analysis, an activity space research approach (based on Hägerstrand, 1970) was used to gather data on students' everyday mobility patterns and the places relevant to their studies. Participants were asked to maintain a digital diary for one week during the semester, documenting their study-related behavior. This included detailed information on all activities and travel related to the university, such as attending lectures, commuting, virtual meetings or studying alone. In addition, participants also provided background information such as their motivations, involvement of other students or relevant equipment (Büscher and Urry, 2009).

Third, semi-structured in-depth interviews were conducted with all participants (Creswell and Poth, 2018). The interview guideline was developed based on the insights gained from the literature analysis as well as the mobility diaries and included questions about the place of residence, daily commuting patterns and the practical realization of online and offline studies. The resulting in-depth interviews lasted 60 min on average and yielded detailed information about students' educational and social needs, university-related mobility and potential connections to online education. Overall, the interview format provided an appropriate balance between flexibility and consistency (Patton, 2015).

The interviews were audio-recorded and transcribed *verbatim* for further analysis. Data collection took place in May/June 2022 and November 2022. All study participants were students at the Osnabrück University of Applied Sciences at the time of the interview. To ensure the sample was as heterogeneous as possible various sampling methods such as public invitations, snowballing and personal contact were used until theoretical saturation was reached. Table 1 provides an overview of the participants. To protect the identities of the participants, pseudonyms were used.

3.2 Study area

The Osnabrück University of Applied Sciences is located in Osnabrück, a city in Northwest Germany with about 165.000 inhabitants and 24.700 students in total (Destatis, 2022, 2023).

#	Pseudonym	Age	Gender	Semester	Residential location
1	Marie	25	Female	6	University town
2	Sophie	21	Female	6	University town
3	Lea	24	Female	4	Nonlocal
4	Alexander	23	Male	5	University town
5	Maximilian	20	Male	1	University town
6	Anna	21	Female	2	University town
7	Laura	31	Female	4	University town
8	Lukas	22	Male	6	Nonlocal
9	Leon	27	Male	12	University town
10	Maria	52	Female	4	Nonlocal
11	Julia	26	Female	6 (master's program)	University town
12	Paul	26	Male	4	University town
13	Katharina	20	Female	2	University town
14	Tim	25	Male	6	Nonlocal
15	Niklas	20	Male	2	University town
16	Jonas	23	Male	3	University town
17	Sarah	22	Female	2	University town
18	Daniel	26	Male	9	Nonlocal
19	Jan	20	Male	3	Nonlocal
20	Finn	23	Male	5	University town
21	Hannah	28	Female	3	University town
22	Florian	22	Male	6	University town
23	Philipp	21	Male	6	University town
24	Lisa	20	Female	2	University town
25	Leonie	22	Female	5	Nonlocal
26	Annika	23	Female	3	Nonlocal

Table 1.
Overview of study
participants

Source: Table created by authors

3.3 Data analysis

Moving beyond conventional approaches to qualitative data analysis, this study used a combination of thematic analysis (Braun and Clarke, 2006, 2013) and a typification approach (Kelle and Kluge, 2010). The authors chose to develop a new typology, as existing ones do not sufficiently cover the effects of online education on the mobility practices of students.

First, building on initial literature analysis and insights from mobility diaries, interview data were systematically coded, thematically sorted and analyzed using the MAXQDA software (Braun and Clarke, 2006, 2013). The aim was to describe and explain the backgrounds of existing university-related mobility practices. To enhance code and category validity, three researchers crosschecked, discussed and refined the data. Thus, seven focal categories were identified. The first three categories are based on the activity space research rationale, describing students' mobility patterns throughout the day and answering the question: who does what when and where? The remaining four categories shed light on the main needs and drivers related to student mobility, providing explanations for their behavior (see Table 2).

In the next step, following Kelle and Kluge's (2010) procedure, the research team assessed categories for typification, aiming for internal homogeneity and external heterogeneity in group classification. Notably, the categories "Residential location" and "Motivation to study" were identified as particularly suitable. When combined, they facilitated a clear type assignment with high explanatory power for mobility practices.

Type of category	Category	Description	Exemplary excerpts from interviews
Behavior/ activity space	1) Residential location	Respondents' statements about their main place of residence during the semester. Students' commuting patterns are shaped by their residential location, which dictates the distance to campus and available mobility options	"[B]ecause I don't live in Osnabrück, it's a challenge for me to get to campus in time. (. . .) I plan to be on the road for 45 minutes, but sometimes it takes two and a half hours". – Maria, 52
	2) Relevant learning spaces	Respondents' statements about learning spaces (e.g. campus, private dwellings), including frequency and purpose of use. Depending on which learning spaces students use, travel demand is generated	"We often have Fridays off now, but sometimes I still go to the campus to study. So, I'm there quite often". – Katharina, 20
	3) Commuting behavior	Respondents' statements about commuting between campus, home and/ or other relevant learning spaces.	"One or two times a week I might ride my bike, depending on the weather as well. But for the most part, I usually take the bus". – Sophie, 21
Motivations and drivers	4) Motivation to study	Respondents' statements about why they study and which goals they pursue. Study motivations and pursued goals significantly affect university-related mobility patterns, including residence choices and commuting frequency	"[T]he main reason why I left [my home region], [is] because there are only commuter universities nearby. (. . .) And there's absolutely no student life there. That's why I think Osnabrück is really nice". – Maximilian, 20
	5) Center of life	Respondents' statements regarding their center of life, i.e. the place where close social contacts, properties, jobs and volunteer/club work are located. It affects residence choices and where they spend leisure time and self-study periods	"Actually my entire social environment is here [in my hometown]. [. . .] [I]f I'd lived in Osnabrück, I would still drive to [my hometown], where I currently live, every day, and that would only increase the costs". – Annika, 23
	6) Learning preferences and abilities	Respondents' statements about individual learning preferences and abilities; attitudes towards different teaching formats, e.g. preference to learn alone or with other students. These preferences affect learning spaces choices, determining whether students will commute to campus or not	"I am often on campus because it's quiet there and there's enough space. [. . .] At home, I can't study at all. There are far too many things to distract you". – Leon, 27
	7) Mobility preferences and access	Respondents' statements about their individual mobility preferences and access to different mobility options and how they shape individual mobility patterns.	"I always go to campus by bike. [A]t the beginning, I used to take the bus, but it was always packed and also always late. That was really annoying, so (. . .) I got a bike". – Finn, 23

Source: Table created by authors

The category "Residential location" is differentiated into "University town (local)" and "Non-local". Those classified as "University town (local)" lived in the city of Osnabrück with a commuting distance below 6 km. Non-local participants resided outside of Osnabrück and had commuting distances ranging from 11 to 80 km. It is important to highlight that one type (Type 4) is derived from a single participant. Nonetheless, the data analysis indicates that it represents a distinct type (e.g. Henderson-King and Smith, 2006), reflecting a broader student group that is challenging to reach through traditional research methods. To avoid overlooking this subgroup, the authors chose to include this type in the analysis.

After assigning the types, they were described using the category system, emphasizing the potential impacts of online education and assumptions regarding potential shifts in mobility patterns.

4. Results

Through the procedure outlined in Section 3, it was possible to identify six types of students with regard to their daily practices of mobility, education and dwelling (see Table 3). The types are presented below. Interviewees' quotes are used for illustration purposes.

4.1 Type 1: study enthusiasts

Study enthusiasts view their student years as a period of personal growth and professional development. Intrinsically interested in their studies, they also aim for the expansion of their social network. Because they often move for their studies, they are usually unable to maintain their previous social environment. Their study program serves as the primary frame to make new social contacts. They emphasize the importance of forming roots in the university town:

> For me, studying is not just about getting the content into my head somehow, but it's also about personally making connections there. – Maximilian, 20.

For these students, the campus is the center of their academic life, serving not only as a place to acquire knowledge but also for socializing and participating in leisure activities. Hence, they often reside close to the campus:

> I just find it much nicer if you somehow feel connected to the place where you study and can spend time with people here on campus. – Paul, 26.

Despite recognizing the potential of online education, they reject it as a substitute for face-to-face interaction, believing it should rather complement in-person courses.

In terms of university-related mobility, *study enthusiasts* travel to campus daily and may even make multiple trips a day, including occasions when no classes are scheduled. Because they live in the city and in close proximity to the campus, they mainly use low-carbon travel options such as biking, walking or buses.

4.2 Type 2: socializers

Socializers pursue higher education primarily for the freedom it offers, aiming to develop their personality, emancipate from their parents and expand their social networks:

> You really should participate in student life. I enjoy being a part of it. I live in a shared apartment. So, I take advantage of everything that's possible. – Hannah, 28.

These students frequently struggle with motivation for their coursework, lacking intrinsic interest. Consequently, they rely on their peers to stay engaged. They view the campus as their primary learning space, occasionally visiting it simply to be in the company of fellow students. They usually do not study at home, resulting in less well-equipped domestic study spaces:

> I find it difficult sometimes to motivate myself. And especially when I'm at home, it's not possible. I always try to somehow get to the university and be productive there. – Lisa, 20.

Because online education requires a high level of self-discipline, it can be challenging for *socializers* who typically rely on strong learning structures to succeed in their studies. Therefore, they resist the idea of replacing face-to-face learning with online classes.

Type Category	Type I: Study enthusiasts	Type II: Socializers	Type III: Independent achievers	Type IV: Accidental students	Type V: Distant enthusiasts	Type VI: Homebirds
Residential location	University town (local)	University town (local)	University town (local)	University town (local)	Non-local	Non-local
Relevant learning spaces	Mostly campus	Mostly campus	Campus and dwelling in equal parts	Campus and dwelling in equal parts	Campus and dwelling in equal parts	Dwelling, if not required otherwise
Commuting behavior	Walking, cycling or local public transport	Walking, cycling or local public transport	Walking, cycling or local public transport	Walking, cycling or local public transport	Car, regional public transport or intermodal	Car, regional public transport or intermodal
Motivation to study	• Professional qualification • Intrinsic interest • Personality development • Social networking	• Personality development • Social networking	• Professional qualification • Intrinsic interest	• No specific purpose • Enrollment in the study program due to lack of better alternatives.	• Professional qualification • Intrinsic interest • Personality development • Social networking	• Professional qualification • Intrinsic interest
Center of life	University town	University town	University town or not in commuting distance to campus	University town	At residential location outside of university town	At residential location outside of university town
Learning preferences	Face-to-face teaching	Face-to-face teaching	Face-to-face teaching; occasional online teaching is endorsed	Face-to-face teaching; occasional online teaching is endorsed due to convenience	Face-to-face teaching; occasional online teaching is endorsed if number of days on campus can be reduced	Face-to-face teaching; online teaching is endorsed if number of days on campus can be reduced
Mobility preferences	Individual preferences	Individual preferences	Individual preferences	Individual preferences	Pragmatic	As time efficient as possible
Assigned participants	1, 4, 5, 6, 11, 12, 13, 22	9, 21, 23, 24	7, 15, 16, 17, 20	2	14, 19, 25	3, 8, 10, 18, 26

Source: Table created by authors

Table 3.
Characteristics of different types of students

Compared to *study enthusiasts*, *socializers* spend less time on studies and commute to campus less frequently. However, their commuting patterns are not solely based on schedules, but rather on their individual needs. They may commute for extracurricular events or study sessions with peers. Residing in inner-city locations close to campus, they predominantly use low-emission transportation modes.

4.3 Type 3: independent achievers

Independent achievers pursue professional qualifications while maintaining existing social networks in their hometowns. They reside in the university town because either it is their hometown, and they prefer not to leave for studies or because they had to relocate, as daily commutes from their hometown to campus would have been impractical. The latter often lead multilocal lives, spending their weekdays in the university town and weekends in their hometowns:

> My center of life [is] definitely in my hometown, because many of my friends still live there. So I'm here [in Osnabrück] for like six or five days a week. But in my hometown, there are more people I know, and I also do more activities outside of studying there. – Finn, 23.

Independent achievers prefer residential locations near the campus to minimize their commuting time. For them, the campus is primarily a place of learning, not socializing. While they value interaction with their peers for learning purposes, they do not feel compelled to socialize with them outside of their study program. *Independent achievers* tend to study at home when no presence on campus is required. They are self-regulated and autonomous learners with well-equipped domestic learning spaces (e.g. second screen, height-adjustable desk). They are generally open to online education, given their resources and skills to cope with it, as long as it meets high-quality standards and is adjusted to their schedule. Yet, they often prefer face-to-face teaching because it tends to produce better learning outcomes.

In terms of university-related mobility, they commute primarily for mandatory classes, with short distances enabling the use of public transportation and active means of transport.

For *independent achievers* who lead multi-local lives their secondary residence can become a relevant learning space. These students are especially open to online education as it facilitates their lifestyle:

> I would be up for working online on Mondays, then I could stay at [my hometown] on Sundays as well. – Finn, 23.

Furthermore, members of this group may have a more complex commuting behavior, for example, when they commute from their secondary residence to the campus.

4.4 Type 4: accidental students

Accidental students enroll in university without a clear professional or social goal, often due to a lack of better alternatives:

> I actually decided to study because other things didn't work out and I had to do something. [. . .] Everything was always just coincidence. – Sophie, 21.

This lack of motivation often leads to lethargy and a below-average amount of time spent on studying. They rely on the structured environment provided by the university to stay on track. While they appreciate the social aspect of being around other students, it is not a driving force for them to visit campus. They primarily commute when obliged and may skip classes if not in the right mood. Preferring convenient learning settings, *accidental students*

welcome online education, even though they know it could potentially harm their academic success as they struggle with motivation and self-discipline:

> I like being at home. [. . .] At home, I'm more easily distracted though, [. . .] but usually, I'm still studying at home if I have the opportunity. – Sophie, 21.

Like other types that live in the university town, *accidental students* primarily use public transportation, walk or bike for commuting.

4.5 Type 5: distant enthusiasts

For *distant enthusiasts,* professional qualification, successful studies and maintaining their familiar social environment are of utmost importance. At the same time, they view their studies as an opportunity to meet new people and engage in diverse student activities, seeking to experience as much of "student life" as possible without having to relocate. Attendance on campus often goes beyond the mandatory requirements, e.g. to participate in extracurricular activities. Despite the importance of campus attendance, distant enthusiasts only visit when required for courses due to long travel distances. They use well-equipped domestic learning spaces, preferring to do tasks like group work online to avoid commuting on noncourse days:

> I prefer doing what I can online, as it saves me the commute. Traveling for an hour to get to the university is time-consuming and expensive. – Leonie, 22.

Distant enthusiasts are open to expanding online education to reduce travel time if personal interaction is not significantly impaired. Nonetheless, their preference leans toward in-person courses, and the acceptance of online education depends on the didactic quality. Being motivated and well-equipped for self-study activities, they are not overwhelmed by the demands of increased online learning:

> I have a bedroom and a study room. A big one. So I have all the possibilities there. That's why it was rather secondary to move to Osnabrück. – Jan, 20.

Distant enthusiasts use free time on campus, e.g. to socialize with peers. Thus, as they have a certain tolerance toward travel delays, they are inclined to adapt to public transportation schedules and avoid using a car when feasible.

4.6 Type 6: homebirds

Homebirds prioritize acquiring professional or technical qualifications while preserving their local social connections, which is why they seek to avoid relocation for their studies. The expansion of their social network during studies is of lesser importance to them:

> I don't really have any social contacts at university; I'm just with a few people with whom I sit during the courses [. . .]. But in my free time [. . .] I'm with my friends in my hometown. – Lukas, 22.

To these students, physical presence on campus is a means to academic success and is limited to mandatory courses. While they value personal interactions during classes, their focus is on improving their learning outcomes. Their home serves as their primary learning space, often well-equipped. Whenever feasible, study tasks such as group work are conducted virtually to avoid commuting to campus:

> [A]fter the lectures [. . .] it just makes more sense to go home and continue learning there. Because there you have other resources available. – Lea, 24.

They welcome the expansion of online education to reduce commuting, provided it is high quality. However, in general, they prefer face-to-face teaching due to better learning results. *Homebirds* try to minimize time spent on campus, arriving and leaving as time efficiently as possible, so transportation choice is focused on time efficiency. If public transportation is available, time- and cost-effective, it is typically preferred. Otherwise, they use a private car. Overall, *homebirds* resemble multilocal *independent achievers*, but unlike them, their center of life is at a distance that allows for daily commuting.

5. Discussion

The typification approach outlined in this paper revealed a range of benefits and challenges related to the rise in online teaching and brings to light potential sustainability conflicts, trade-offs and dilemmas that require negotiation between students and HEIs.

5.1 Dealing with dilemmas: social implications of online education

The results reveal conflicting needs among students. Undoubtedly, online education can lower access barriers to higher education in some cases, making it easier for students such as *independent achievers, distant enthusiasts* and *homebirds* to balance their studies with other commitments such as family or work. However, it also requires a high degree of self-studying skills, posing challenges for socializers and accidental students reliant on structured learning and face-to-face interaction. Study enthusiasts face a fundamental dilemma: while they are dedicated enough to cope with the demands of online education, they reject substituting face-to-face courses, believing it hinders their broader study goals, including participation in campus life, expanding their social network and, ultimately, personal growth (Zimmermann and Neyer, 2019).

Online education can also present significant additional financial costs for students (e.g. for technical equipment, electric and heating energy), which is especially challenging for students with limited financial resources (Farnell *et al.*, 2021). Previous studies suggest that these costs may be offset by potential cost savings and enhanced well-being from reduced commuting (Lyons and Chatterjee, 2008; Sha *et al.*, 2019). Particularly, *remote enthusiasts* and *homebirds,* with high commuting costs but generally adequate home workspaces, could significantly cut their commuting expenses by increasing online education, without the need for additional investments in their domestic workspaces. On the contrary, socializers, accidental students and study enthusiasts present a contrasting situation: while their commuting costs are low, they often lack adequate home workspaces. Consequently, they would likely incur increased financial expenses due to the necessity of investing in suitable study environments for online education.

It should be noted that none of the types currently expresses a desire for an increase in online education. Even *remote enthusiasts* and *homebirds* are willing to accept trade-offs and bear commuting costs for an enhanced learning experience through in-person interaction, citing benefits such as enhanced attention and focus, better peer interaction, room atmosphere and nonverbal communication.

5.2 Ecological impacts

Potential ecological benefits of online education, like social impacts, require nuanced consideration beyond prior studies (see Sections 2.1 and 2.2). Despite the assumption that online learning decreases commuting and thus CO_2 emissions, the typology reveals a more intricate situation. Students residing near campus, such as *study enthusiasts* and *socializers*, often use eco-friendly transport, resulting in minimal emissions. Conversely, students with long car commutes, like *homebirds*, are more relevant. The findings suggest a potential increase in such

groups with the expansion of online education, especially if multilocal students relocate farther from campus. Some participants indicated that the decision to relocate their place of residence to Osnabrück or to stay in their hometown was determined by the time and money spent on commuting, the number of mandatory in-person days and the costs of either renting a flat or owning a car. This indicates a threshold beyond which no relocation occurs, and instead long commutes are accepted. Expanding online education might affect this threshold, leading some students to relocate. These findings align with studies indicating potential increases in average commuting distance and less sustainable transportation modes through online education (Caird *et al.*, 2015; Rérat, 2021). Furthermore, evidence exists that working from home does not reduce overall mobility, potentially leading to increased leisure mobility when commuting needs are reduced (e.g. Axenbeck *et al.*, 2023; Shi *et al.*, 2023). In addition, rebound effects such as rising energy consumption for domestic heating and growing information and communication technology use need to be taken into account (Arnold *et al.*, 2021; Shi *et al.*, 2023). These environmental impacts of online education remain under-researched due to limited scope in previous studies. Therefore, blended study models, combining "online days" and face-to-face meetings, may have smaller carbon reduction effects than expected (Caird *et al.*, 2015). Shi *et al.* (2023), for example, conclude that especially low-frequency teleworkers (one to two days of remote work) have high CO_2 emissions due to increased heating energy demand, longer commutes and additional noncommuting travel.

This study challenges the prevailing notion that online education universally contributes to sustainable mobility, emphasizing the need for HEIs to consider a range of social and ecological factors in developing sustainable online education scenarios. To depict the effects of online education more realistically, future inquiries must adopt a cross-cutting approach that includes aspects such as domestic and institutional water and energy use, or individual time use patterns.

5.3 Recommendations for Higher Education Institutions
Based on the results, several recommendations can be made to help HEIs in comparable contexts reap the benefits of online education and adopt more sustainable mobility strategies. In Germany, there are over 20 cities with populations of less than 250,000 that are hosting more than 15,000 students (Destatis, 2022, 2023), thereby sharing similar conditions.

The sufficiency principle, emphasizing deliberate resource reduction by altering consumer lifestyles and behaviors (Rammler, 2016), could inform different approaches. Applied to the topic of this study, this could translate into a certain number of days on campus sufficient to foster social networks and support learning processes, aiming to balance students' needs for face-to-face interaction with those benefiting from flexible schedules. Monitoring potential rebound effects is essential to mitigate unintended consequences.

HEIs could also implement more targeted measures to address the diverse needs of students identified in this paper. Encouraging students to reside near campus by providing housing options and on-campus activities could reduce long commutes and CO_2 emissions (Allen and Farber, 2018). Furthermore, HEIs can provide support for students facing technical or spatial limitations to participate in online education effectively (Farnell *et al.*, 2021). For students who prefer not to relocate for their studies, HEIs could expand their online programs with minimal face-to-face requirements to decrease daily commutes significantly (Filimonau *et al.*, 2021).

5.4 Limitations of the study
The study is subject to various limitations. First, study participants' views and practices may be shaped by negative experiences of emergency remote teaching that dominated

during the COVID-19 pandemic. Furthermore, the typology draws on qualitative data, making it challenging to estimate the consequences of reducing on-campus days, as the distribution of types is unknown. Causality can be difficult to determine. It is assumed that individual motivations to study significantly shape where students live and how they travel. However, there might be cases where this link is reversed, with students developing aspirations toward their studies due to their residential location. External conditions such as attendance requirements, infrastructure or the housing market were not investigated. Therefore, the study results mainly pertain to the study region of Osnabrück, as conditions may vary significantly at other HEI locations, especially in countries of the Global South. The impacts of online education on the complex social relationships of students can only be presented in a simplified manner. Finally, the ecological effects of online education remain ambiguous as no CO_2 assessment was conducted within the study.

6. Conclusion
This study explored the question of whether online education can contribute to sustainable mobility in the context of HEIs through the development of a student typology. It is one of the first studies deriving individual needs from student mobility and housing patterns, thus making them accessible for analysis. It addresses key factors (social needs, ecological impacts and education concerns) for all identified types of students, assessing the positive or negative impacts of online education on each. Overall, the results reveal the complexity of promoting sustainable mobility in digitized higher education due to observable tensions between diverse environmental and social factors. While online education undoubtedly has great transformative potential, the ecological benefits must be assessed realistically, which includes potential rebound effects such as increasing commuting distances and higher domestic energy use. In socio-economic terms, students have different resources for adapting to online education requirements. Neglecting the social and economic costs can introduce fault lines, such as limited space preventing students from working efficiently from home. Furthermore, students who consider face-to-face interaction as an inherent part of their studies or even rely on it to successfully complete their studies have different needs than those prioritizing quick and convenient study completion. Due to diverging interests regarding online education, there will be winners and losers in every scenario. This study highlighted the conflicts and dilemmas surrounding sustainable mobility in the context of digitized higher education, urging HEIs to address them. The presented typology can serve as a valuable tool in this regard, facilitating the balancing of diverse interests.

References

Allen, J. and Farber, S. (2018), "How time-use and transportation barriers limit on-campus participation of university students", *Travel Behaviour and Society*, Vol. 13, pp. 174-182, doi: 10.1016/j.tbs.2018.08.003.

Arnold, M.G., Vogel, A. and Ulber, M. (2021), "Digitalizing higher education in light of sustainability and rebound effects – surveys in times of the COVID-19 pandemic", *Sustainability*, Vol. 13 No. 22, p. 12912, doi: 10.3390/su132212912.

Axenbeck, J., Bertschek, I., Breithaupt, P. and Erdsiek, D. (2023), "Firm digitalisation and mobility – do COVID-19-related changes persist?", ZEW Discussion Papers 23-011, ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung, Mannheim, available at: https://ftp.zew.de/pub/zew-docs/dp/dp23011.pdf (accessed 21 December 2023).

Banister, D. (2008), "The sustainable mobility paradigm", *Transport Policy*, Vol. 15 No. 2, pp. 73-80, doi: 10.1016/j.tranpol.2007.10.005.

Brändle, T. (2014), "Studienmotive und lebensziele: ein vergleich der intentionen nicht-traditioneller und traditioneller studierender", *Beiträge Zur Hochschulforschung*, Vol. 36 No. 4, pp. 92-119.

Braun, V. and Clarke, V. (2006), "Using thematic analysis in psychology", *Qualitative Research in Psychology*, Vol. 3 No. 2, pp. 77-101, doi: 10.1191/1478088706qp063oa.

Braun, V. and Clarke, V. (2013), *Successful Qualitative Research: A Practical Guide for Beginners*, SAGE, Los Angeles, London, New Delhi.

Büscher, M. and Urry, J. (2009), "Mobile methods and the empirical", *European Journal of Social Theory*, Vol. 12 No. 1, pp. 99-116, doi: 10.1177/1368431008099642.

Bygstad, B., Øvrelid, E., Ludvigsen, S. and Dæhlen, M. (2022), "From dual digitalization to digital learning space: exploring the digital transformation of higher education", *Computers and Education*, Vol. 182, p. 104463, doi: 10.1016/j.compedu.2022.104463.

Caird, S., Lane, A., Swithenby, E., Roy, R. and Potter, S. (2015), "Design of higher education teaching models and carbon impacts", *International Journal of Sustainability in Higher Education*, Vol. 16 No. 1, pp. 96-111, doi: 10.1108/IJSHE-06-2013-0065.

Creswell, J.W. and Poth, C.N. (2018), *Qualitative Inquiry and Research Design: choosing Among Five Approaches*, 4th ed. SAGE, Los Angeles, London, New Delhi, Singapore, Washington, DC.

Davison, L., Ahern, A. and Hine, J. (2015), "Travel, transport and energy implications of university-related student travel: a case study approach", *Transportation Research Part D: Transport and Environment*, Vol. 38, pp. 27-40, doi: 10.1016/j.trd.2015.04.028.

Delmelle, E.M. and Delmelle, E.C. (2012), "Exploring spatio-temporal commuting patterns in a university environment", *Transport Policy*, Vol. 21, pp. 1-9, doi: 10.1016/j.tranpol.2011.12.007.

Destatis (2022), "Bevölkerung und erwerbstätigkeit. Bevölkerungsfortschreibung auf grundlage des zensus 2011", available at: www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsstand/Publikationen/Downloads-Bevoelkerungsstand/bevoelkerungsfortschreibung-2010130217005.xlsx?__blob=publicationFile (accessed 22 December 2023).

Destatis (2023), "Bildung und kultur. Studierende an hochschulen", Vorbericht, available at: www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bildung-Forschung-Kultur/Hochschulen/Publikationen/Downloads-Hochschulen/studierende-hochschulen-vorb-2110410238004.pdf?__blob=publicationFile (accessed 22 December 2023).

Ellis, R.A. and Goodyear, P. (2016), "Models of learning space: integrating research on space, place and learning in higher education", *Review of Education*, Vol. 4 No. 2, pp. 149-191, doi: 10.1002/rev3.3056.

Farnell, T., Skledar Matijević, A. and Šćukanec Schmidt, N. (2021), "The impact of COVID-19 on higher education: a review of emerging evidence", NESET report, Publications Office of the European Union, Luxembourg, doi: 10.2766/069216.

Filimonau, V., Archer, D., Bellamy, L., Smith, N. and Wintrip, R. (2021), "The carbon footprint of a UK university during the COVID-19 lockdown", *Science of The Total Environment*, Vol. 756, p. 143964, doi: 10.1016/j.scitotenv.2020.143964.

Gamba, A., Maldonado, D., Rowen, M. and Torio, H. (2021), "The effect of the COVID-19 pandemic on mobility-related GHG emissions of the university of Oldenburg and proposals for reductions", *Sustainability*, Vol. 13 No. 14, p. 8103, doi: 10.3390/su13148103.

Giesenbauer, B. (2021), "Veränderung durch veränderung: Nachhaltige entwicklung von hochschulen im huckepack der digitalisierung", in Leal Filho, W. (Ed.), *Digitalisierung Und Nachhaltigkeit*, Springer, Berlin Heidelberg, Berlin, Heidelberg, pp. 45-63.

Greene, M., Ellsworth-Krebs, K., Volden, J., Fox, E. and Anantharaman, M. (2022), "Practicing culture: exploring the implications of pre-existing mobility cultures on (post-) pandemic practices in Norway, Ireland, and the United States", *Sustainability: Science, Practice and Policy*, Vol. 18 No. 1, pp. 483-499, doi: 10.1080/15487733.2022.2091328.

Hägerstrand, T. (1970), "What about people in regional science?", *Papers Reg. Sci. Association*, Vol. 24, pp. 7-21.

Hancock, L. and Nuttman, S. (2014), "Engaging higher education institutions in the challenge of sustainability: sustainable transport as a catalyst for action", *Journal of Cleaner Production*, Vol. 62, pp. 62-71, doi: 10.1016/j.jclepro.2013.07.062.

Helmers, E., Chang, C.C. and Dauwels, J. (2021), "Carbon footprinting of universities worldwide: Part I —objective comparison by standardized metrics", *Environmental Sciences Europe*, Vol. 33 No. 1, doi: 10.1186/s12302-021-00454-6.

Henderson-King, D. and Smith, M.N. (2006), "Meanings of education for university students: academic motivation and personal values as predictors", *Social Psychology of Education*, Vol. 9 No. 2, pp. 195-221, doi: 10.1007/s11218-006-0006-4.

Holden, E., Gilpin, G. and Banister, D. (2019), "Sustainable mobility at thirty", *Sustainability*, Vol. 11 No. 7, p. 1965, doi: 10.3390/su11071965.

Jarillo, P., Pedraza, L., Ger, P. and Bocos, E. (2019), "Challenges of online higher education in the face of the sustainability objectives of the United Nations: carbon footprint, accessibility and social inclusion", *Sustainability*, Vol. 11 No. 20, p. 5580, doi: 10.3390/su11205580.

Kanning, U.P. and Ohlms, M. (2021), "Hochschullehre in zeiten von corona", *Wirtschaftspsychologie*, Vol. 2021 No. 2, pp. 44-55.

Kelle, U. and Kluge, S. (2010), *Vom Einzelfall Zum Typus: Fallvergleich Und Fallkontrastierung in Der Qualitativen Sozialforschung*, 2nd ed. VS Verlag für Sozialwissenschaften, Wiesbaden.

Khattak, A., Wang, X., Son, S. and Agnello, P. (2011), "Travel by university students in Virginia", *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2255 No. 1, pp. 137-145, doi: 10.3141/2255-15.

Lamb, J., Carvalho, L., Gallagher, M. and Knox, J. (2022), "The postdigital learning spaces of higher education", *Postdigital Science and Education*, Vol. 4 No. 1, pp. 1-12, doi: 10.1007/s42438-021-00279-9.

Lischer, S., Safi, N. and Dickson, C. (2022), "Remote learning and students' mental health during the covid-19 pandemic: a mixed-method enquiry", *PROSPECTS*, Vol. 51 No. 4, pp. 589-599, doi: 10.1007/s11125-020-09530-w.

Lyons, G. and Chatterjee, K. (2008), "A human perspective on the daily commute: costs, benefits and trade-offs", *Transport Reviews*, Vol. 28 No. 2, pp. 181-198, doi: 10.1080/01441640701559484.

Mustafa, A., Psarikidou, K. and Pranjol, M.Z.I. (2022), "Beyond the COVID-19 pandemic: can online teaching reduce the carbon footprint of the internationalisation of UK higher education?", *International Medical Education*, Vol. 1 No. 2, pp. 85-96, doi: 10.3390/ime1020011.

Nash, S. and Mitra, R. (2019), "University students' transportation patterns, and the role of neighbourhood types and attitudes", *Journal of Transport Geography*, Vol. 76, pp. 200-211, doi: 10.1016/j.jtrangeo.2019.03.013.

O'Brien, W. and Aliabadi, F.Y. (2020), "Does telecommuting save energy? A critical review of quantitative studies and their research methods", *Energy and Buildings*, Vol. 225, p. 110298, doi: 10.1016/j.enbuild.2020.110298.

Patton, M.Q. (2015), *Qualitative Research and Evaluation Methods: Integrating Theory and Practice*, SAGE, Los Angeles, London, New Delhi, Singapore, Washington, DC.

Pérez-Neira, D., Rodríguez-Fernández, M.P. and Hidalgo-González, C. (2020), "The greenhouse gas mitigation potential of university commuting: a case study of the University of León (Spain)", *Journal of Transport Geography*, Vol. 82, p. 102550, doi: 10.1016/j.jtrangeo.2019.102550.

Rammler, S. (2016), "Nachhaltige mobilität: gestaltungsszenarien und zukunftsbilder", in Schwedes, O., Canzler, W. and Knie, A. (Eds), *Handbuch Verkehrspolitik*, 2nd ed Springer VS, Wiesbaden, pp. 899-917.

Rérat, P. (2021), "A campus on the move: modal choices of students and staff at the university of Lausanne, Switzerland", *Transportation Research Interdisciplinary Perspectives*, Vol. 12, p. 100490, doi: 10.1016/j.trip.2021.100490.

Ribeiro, P.J. and Fonseca, F. (2022), "Students' home-university commuting patterns: a shift towards more sustainable modes of transport", *Case Studies on Transport Policy*, Vol. 10 No. 2, pp. 954-964, doi: 10.1016/j.cstp.2022.03.009.

Ribeiro, P., Fonseca, F. and Meireles, T. (2020), "Sustainable mobility patterns to university campuses: evaluation and constraints", *Case Studies on Transport Policy*, Vol. 8 No. 2, pp. 639-647, doi: 10.1016/j.cstp.2020.02.005.

Roy, R., Potter, S. and Yarrow, K. (2008), "Designing low carbon higher education systems", *International Journal of Sustainability in Higher Education*, Vol. 9 No. 2, pp. 116-130, doi: 10.1108/14676370810856279.

Sattlegger, L. and Rau, H. (2016), "Carlessness in a car-centric world: a reconstructive approach to qualitative mobility biographies research", *Journal of Transport Geography*, Vol. 53, pp. 22-31, doi: 10.1016/j.jtrangeo.2016.04.003.

Scheiner, J. and Holz-Rau, C. (2013), "Changes in travel mode use after residential relocation: a contribution to mobility biographies", *Transportation*, Vol. 40 No. 2, pp. 431-458, doi: 10.1007/s11116-012-9417-6.

Scheiner, J. and Rau, H. (Eds) (2020), *Mobility and Travel Behaviour Across the Life Course: Qualitative and Quantitative Approaches*, Edward Elgar Publishing, Cheltenham, UK, MA.

Schwanen, T., Banister, D. and Anable, J. (2011), "Scientific research about climate change mitigation in transport: a critical review", *Transportation Research Part A: Policy and Practice*, Vol. 45 No. 10, pp. 993-1006, doi: 10.1016/j.tra.2011.09.005.

Schwanen, T., Dijst, M. and Kwan, M.-P. (2006), "Introduction—the internet, changing mobilities, and urban dynamics", *Urban Geography*, Vol. 27 No. 7, pp. 585-589, doi: 10.2747/0272-3638.27.7.585.

Seyfarth, E., Osterhage, F. and Scheiner, J. (2021), "Auch dauerhaft urban? Empirische untersuchung kurz- und langfristiger wohnumfeldwünsche junger erwachsener als beitrag zur reurbanisierungsdebatte", *Raumforschung Und Raumordnung*, Vol. 79 No. 5, pp. 453-469, doi: 10.14512/rur.88.

Sha, F., Li, B., Law, Y.W. and Yip, P.S.F. (2019), "Associations between commuting and well-being in the context of a compact city with a well-developed public transport system", *Journal of Transport and Health*, Vol. 13, pp. 103-114, doi: 10.1016/j.jth.2019.03.016.

Shannon, T., Giles-Corti, B., Pikora, T., Bulsara, M., Shilton, T. and Bull, F. (2006), "Active commuting in a university setting: assessing commuting habits and potential for modal change", *Transport Policy*, Vol. 13 No. 3, pp. 240-253, doi: 10.1016/j.tranpol.2005.11.002.

Shi, Y., Sorrell, S. and Foxon, T. (2023), "The impact of teleworking on domestic energy use and carbon emissions: an assessment for England", *Energy and Buildings*, Vol. 287, p. 112996, doi: 10.1016/j.enbuild.2023.112996.

Vale, D.S., Pereira, M. and Viana, C.M. (2018), "Different destination, different commuting pattern? Analyzing the influence of the campus location on commuting", *Journal of Transport and Land Use*, Vol. 11 No. 1, doi: 10.5198/jtlu.2018.1048.

Vásquez, L., Iriarte, A., Almeida, M. and Villalobos, P. (2015), "Evaluation of greenhouse gas emissions and proposals for their reduction at a university campus in Chile", *Journal of Cleaner Production*, Vol. 108, pp. 924-930, doi: 10.1016/j.jclepro.2015.06.073.

Versteijlen, M., van Wee, B. and Wals, A. (2021), "Exploring sustainable student travel behaviour in The Netherlands: balancing online and on-campus learning", *International Journal of Sustainability in Higher Education*, Vol. 22 No. 8, pp. 146-166, doi: 10.1108/IJSHE-10-2020-0400.

Versteijlen, M., Perez Salgado, F., Janssen Groesbeek, M. and Counotte, A. (2017), "Pros and cons of online education as a measure to reduce carbon emissions in higher education in The Netherlands", *Current Opinion in Environmental Sustainability*, Vol. 28, pp. 80-89, doi: 10.1016/j.cosust.2017.09.004.

Wattenbach, L., Aslan, B., Fiore, M.M., Ding, H., Verdecchia, R. and Malavolta, I. (2022), "Do you have the energy for this meeting? An empirical study on the energy consumption of the Google Meet

and Zoom Android apps", Proceedings of the 9th IEEE/ACM International Conference on Mobile Software Engineering and Systems, pp. 6-16.

Whalen, K.E., Páez, A. and Carrasco, J.A. (2013), "Mode choice of university students commuting to school and the role of active travel", *Journal of Transport Geography*, Vol. 31, pp. 132-142, doi: 10.1016/j.jtrangeo.2013.06.008.

Wilson, O., Vairo, N., Bopp, M., Sims, D., Dutt, K. and Pinkos, B. (2018), "Best practices for promoting cycling amongst university students and employees", *Journal of Transport and Health*, Vol. 9, pp. 234-243, doi: 10.1016/j.jth.2018.02.007.

Zimmermann, J. and Neyer, F.J. (2019), "Entwicklung und mobilität im jungen erwachsenenalter", in Kracke, B. and Noack, P. (Eds), *Handbuch Entwicklungs-Und Erziehungspsychologie*, Springer, Berlin Heidelberg, Berlin, Heidelberg, pp. 441-457.

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