



4TU.Centre for Engineering Education

The impact of COVID-19 on
university teaching and
learning:

Evidence for the central
importance of student and
staff well-being

4TU White paper

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University of
Technology

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UNIVERSITY OF
TECHNOLOGY

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**4TU. CENTRE FOR
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Executive summary

The Covid-19 pandemic prompted a rapid shift to online education. The 4TU.Centre for Engineering Education (4TU.CEE), initiated the writing of a white paper. This white paper was motivated by a desire to understand:

“How have students and staff been affected as a result of the shift to online education?”

“How should universities be preparing for the future?”

The authors present a research synthesis conducted across the four Universities of Technology in the Netherlands (hereafter the 4TUs). They also reflect on what the Covid-19 pandemic has brought to our education system. Based on the synthesis results, they provide policymakers with implications relevant to the (immediate) response to continued pandemic-related restrictions. At the same time, they signal that digital education offers new opportunities for both scaling-up and quality improvement to actively shape a preferred future for teaching.

Methodology

4TU.CEE initiated this white paper to communicate the results of independent groups conducting similar research across the 4TUs. We have used currently available research at the four Universities of Technology and input from CEASAR, IDEA League and CDIO initiatives as a benchmark for engineering education initiatives. The different research studies concern data collections using mixed-method research and design-based research, including surveys, interviews, and participatory workshops to explore well-being interventions. An overview of the target groups and response rates is provided in the appendix. As the sources are different and the research questions do not always cover all the universities' target groups, some universities may be more emphasised at times than others. The references to university research are used to refer to the original studies realised at

each university. For a thorough reading and understanding we advise to read the entire studies included in the references.

Summary of results: challenges and transitions

Our results reflect a primary emergent theme regarding the importance of student and staff well-being within the overall educational system. In the future, education is possibly remaining or evolving into more blended (hybride) education. If carefully designed, it allows keeping the “good” things of online education and offline education. Online education allows for the inclusion of a more diversable audience. It stimulates students to take more responsibility for their learning and, if designed correctly, makes the learner more autonomous. Moreover, it may offer more personalised learning to large groups of students that Dutch universities face nowadays. At the same time, more information is needed on what makes “good” online education – e.g. shared regulation, enhancing online engagement, structure for self-regulation, feedback and questioning mechanisms, appropriate levels of support, and much more.

While positive results are generated by online education, concerns also exist. Students and staff's mental well-being and sense of community were negatively affected despite students' learning results remaining at a reasonable to a good level. The changes in mental well-being and sense of community for both staff and students were, amongst others, a result of their home situation. Being at home caused isolation, a lack of belonging (to a student group or the institution) and a feeling of being overwhelmed by the information overload (searching for information on different software systems). International staff and students are even more vulnerable due to their families' financial and health status. The fact that their families are far away caused additional anxiety and loss of control. The workload, time, and resources for quality development of education and support should be serious considerations in future education initiatives for staff.

Summary of recommendations

We argue that the future design of education at the 4TUs should consider the effects of educational formats on the well-being of students and staff. A careful mixture of on-campus and online teaching (hybrid and blended learning) is likely to be the best option. With a focus on community building, campus education could exploit practical lab work, teamwork, fieldwork, and other contact intensive learning formats. Blended or hybrid learning could include interactive meetings and leave room for students' autonomy to strengthen motivation. If possible, universities could offer students study environments that make them more independent from limitations in their home environment during phases of online learning. Training of digital skills and digital teaching needs to be intensified. Many new forms of blended and hybrid teaching could not yet be assessed. Accordingly, there should be more room for teachers to experiment systematically with and thoroughly evaluate new forms of learning and teaching concerning learning outcomes, teacher efficiency, student motivation, and well-being. Online education made teachers revise their teaching or even sparked their creativity and motivation to further develop and experiment. This means that digital education (i.e. blended, hybrid and online) can offer opportunities for the future, but only if some important criteria are met.

1. Introduction

In 2020 the first lockdown due to the Covid-19 pandemic forced a new reality upon education and forced a rapid adaptation to a new context. While quickly shifting to teaching and learning online, university management kept education open and accessible to most students, who were suddenly confined to home in the Netherlands. While having survived the first lockdown with makeshift education, the second wave required an improved and upgraded curriculum in terms of quality and approach. It also showed the initial effects of the first wave, forcing a reconsideration of pre-pandemic success measures and consolidation of initial successes. The steep learning curve has shown positive and negative challenges, which may benefit post-Covid-19 education. Finally, institutions look at returning to business as usual in the restoration phase if there is any such thing. In this white paper, we will loosely follow the structure of adaptation, improvement, consolidation and restoration. In the adaptation/improvement part we will initially address the challenges teachers and students faced concerning motivation, working from home, well-being, diversity, teaching methods and many more issues.

This part will present a generalised overview of the findings across the different studies concerning teachers, students, and the educational environment, both emerging from evaluative studies of the first and second lockdown. In the second part, addressing consolidation and restoration, we will suggest a way forward and discuss (external) findings regarding the option for proceeding into post-pandemic education and being prepared for subsequent possible lockdowns. We begin by showing the central research questions asked in the different case studies across the 4TUs that form the basis of this paper.

"How have students and staff been affected as a result of the shift to online education?"

"How should universities be preparing for the future?"

Please note that the different case studies were set up with different goals in mind, and were only later brought together in this white paper. This means that the studies differ in methods, data collection, types of analyses conducted and so on.

WUR

Understanding the impact of the transition on online education. How does the transition influence course design, teaching and the learning (outcomes) of students? What differences exist among students, and among teachers, in this respect?

TU Twente

Support and experience of online education during Covid-19 times: How have students and teachers experienced online education during the fourth quartile of the academic year 2019-2020 and how was support provided during this period?

TU Delft

Designing a campus-wide well-being feedback loop: How might we develop an actionable well-being assessment programme that can be delivered to all students and staff? Beyond measurement, how might we design a programme that can help the university measurably improve well-being outcomes? How can we design well-organised and empathic online design studios and other types of inspiring learning environments for students and teachers to support well-being?

TU Eindhoven

The influence of Covid-19 conditions on learning experience and well-being: How do learning experiences and well-being relate to conditions that teachers and students can influence during the Covid-19 education period?

In the different studies, several methods have been used to investigate the research questions. On the one hand, these concerned deductive/ inductive mixed-method research. On the other hand, it concerned design-based well-being interventionist research, mainly employed in Delft. Recommendations for solutions in this paper are guided by the outcomes of these different studies, design plans, and the many (policy) papers, webinars and panel discussions going into post-Covid-19 education. They informed our policy recommendations for the future of (digital) engineering education.



Observed challenges for teachers



2. Observed challenges for teachers

This part will present a generalised overview of the findings across the different studies concerning teachers, emerging from evaluative studies of the first and second lockdown.

For teachers, the stress and feelings of being overwhelmed predominantly emerged from a lack of appropriate equipment, increased workload, disturbance of work-life balance, feelings of isolation and pressure on research and tenure tasks. Additionally, the international staff in particular, had to cope with being disconnected from their families and feelings of a lack of belonging at the institution. The lack of a social network exacerbated feelings of loneliness. The extent to which teachers dealt with these issues partly depended on their attitude towards online learning, suggesting that some may have suffered more than others.

The challenges teachers encountered during the transition period at the different institutions are described in the following paragraphs:



Workload and digital skills

At WUR, many teachers experienced increased levels of stress (66%), difficulties working from home and an increased workload (80%). On average, they spent 43.8% more time on education than arranged by contract (teaching hours for a course). However, although teachers experienced high work pressure, “being forced” to teach fully online and preferred on-campus education, they were generally motivated to teach online. They felt they possessed the (IT and didactical) skills needed to teach online and felt that they successfully and satisfactorily taught their course online.

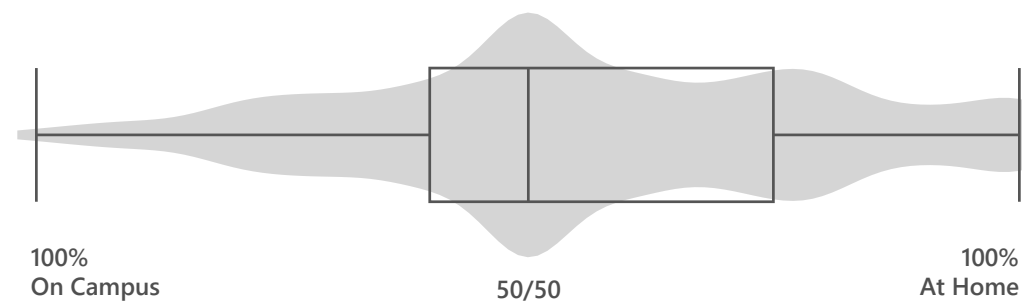
Teacher needs

At TUD, a list of teacher needs in lockdown situations was generated, based on qualitative data collection. As the focus is on problem and needs it may emphasise the issues that need attention. The lockdown showed people were minimally prepared to work from home, lacking furniture, space, access to data and software, and technical issues with, e.g. good working wifi. They felt socially isolated and lost their sense of community, felt guilty about taking leisure time and missed their informal coffee machine meet-ups. The uncertainty (government/university communications) and impact on ongoing research (access to experimental work, PhD deadlines, kids at home, delays, visa and income issues for international staff), together with continued high expectations, called for an immediate need to improve support services. Support included services (tooling & structures) for informal online meet-ups, flexible furniture, space and hardware rental, data access services, financial compensations or temporary loans for international staff and administrative support. Possibly, mental support and clear communication concerning realistic task expectations relieved mental stress. Some of these challenges were adequately dealt with in the second lockdown.

Wellness measurements results among 1627 people in June 2021 show that life satisfaction and physical well-being have improved again. Looking to the future most staff wishes to work 50% on campus – 50% from home (online). Preferred activities on campus are teaching/labwork, spontaneous meetings with colleagues, practice and creative sessions and concentrated work. Flexible work schedules were for

keeps, facilitating online lectures, doing gradings, making exams and dedicated research work. Also one on one meetings would ideally be done at home. Societal impact is driving motivation in Delft as well as contact with colleagues, working with students and freedom and autonomy.

Ideal Working Week at TU Delft



Tooling, support – learning and creativity

During the first weeks of lockdown at UT, some teachers faced difficulties due to a lack of suitable equipment to teach online from home (38.3% of the teachers disagreed that they got everything they needed). The most commonly listed items missing were drawing pads/tablets with a stylus for writing out equations and good headsets. Some teachers said that they purchased the required equipment on their own. However, this situation has quickly been remedied.

At the UT, teachers indicated that most of them learned about online teaching from their (more experienced) colleagues. They also mentioned receiving help from programme staff: Canvas support, TELT (Technology Enhanced in Learning and Teaching) and LISA (Library, ICT Services & Archive). Some teachers reported feelings of frustration and felt overloaded with information, especially during the first few weeks of online teaching. But, overall, they seemed to be satisfied with the support provided: 72,3% of the teachers reported that they received adequate information to teach.



At the month of education in Science & Technology an event at the UT, colleagues mentioned that Covid-19 sparked creativity among lecturers. As a result, there is real momentum for change and lecturers want to explore more. Lecturers need to get more time to experiment, develop and change their teaching with 'new' formats of education (e.g. hybrid or blended learning).

Teacher types- coping mechanisms

At WUR, teachers differed significantly in their attitude towards online education, beliefs about students' learning, stress, self-efficacy, and professional development during the Covid-19 crisis from March till July 2020.



Profile 1: Critical but eager to learn (39%)

Negative about online education, support and themselves, but use many services, and positive about their learning



Profile 2: Positive but stressed teachers (33%)

Positive about online education, support and themselves, but experience the highest level of stress.



Profile 3: Reluctant teachers (20%)

Very negative about online education and support, not much stress, low use of services, and do not learn from the experience.

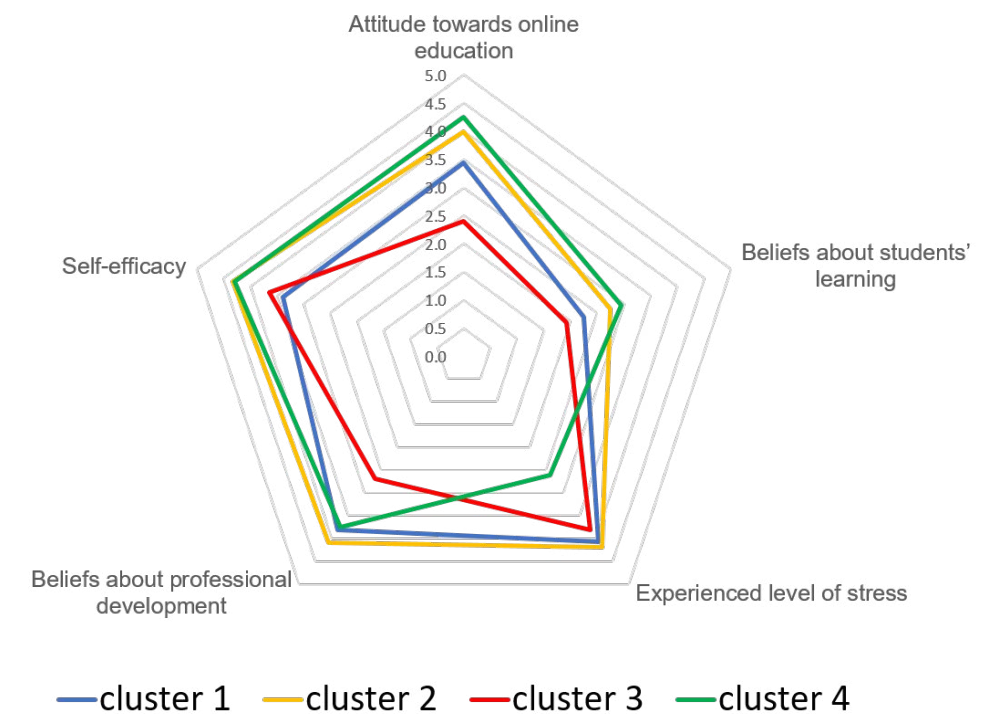


Profile 4: Optimistic and easy-going teachers (8%)

Very positive about online education, support and themselves low level of stress and low use of services (support, tools, trainings).

Based on a hierarchical cluster analysis on these five variables, four teacher profiles were identified: profile one was critical but eager towards online learning; profile two was positive but stressed; profile three was critical and reluctant; profile four was optimistic and easy-going. Hence, two profiles were relatively positive about online education (profiles 2 and 4) and two profiles were relatively critical about online education (profiles 1 and 3). The positive group could be differentiated into a profile that experienced high-stress levels (profile 2, positive but stressed) and a profile that experienced

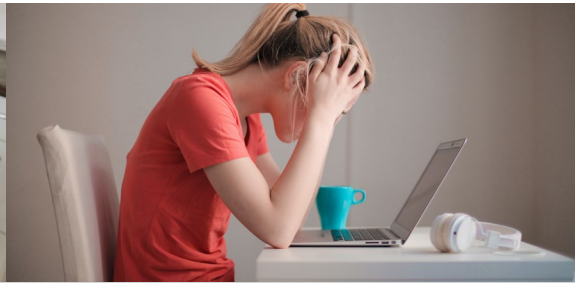
low-stress levels (profile 4, optimistic and easy-going). The critical group consisted of two profiles. A profile that experienced stress had a relatively low self-efficacy but believed they learnt a lot from experience (profile 1, critical but eager). Furthermore, a profile that experienced somewhat less stress had a relatively high self-efficacy and believed they did not learn that much (profile 3, critical and reluctant). Moreover, subsequent statistical analysis showed that the teacher profiles significantly differed in their evaluation of education support, their participation in teacher training and their use of new online teaching tools. The teacher profiles can help to develop more targeted forms of communication, support and policy.





Problematic working environment

Furniture and Hardware
Network stability
Teaching Gear
Children
Increased financial burden



Mental – physical well-being

Worries for at home families
Workload: overwhelmed/increased working hours/zoom fatigue
Life/work imbalance
Tenure pressure
Isolation

Table: Summary of teacher challenges (across all universities)



Observed challenges for students

3. Observed challenges for students

Student situations have been evaluated extensively. Studies show problems with the home situation, finances, well-being, motivation and diverse impact. In general, female and international students suffered more than Dutch and male students. Similar to the teaching staff, students' beliefs on how to deal with the situation influenced the impact on learning and well-being.

Home situation

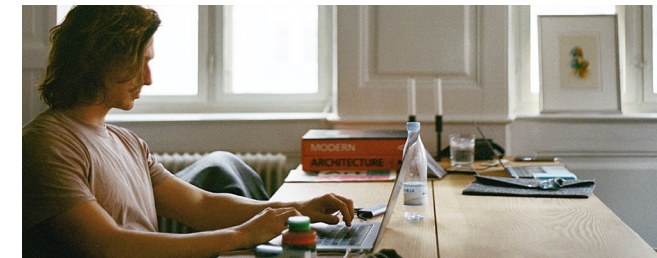
At TU/e two-thirds (68%) of the sampled students in Q3 (n=302) at the Faculty of Industrial Engineering & Innovation Sciences at TU/e encountered difficulties due to the transition towards online education. Most of these difficulties were related to a complex working environment, including noise issues, no dedicated study space, sluggish or unreliable internet, and too many people in one room during students' learning. Only a couple of students indicated difficulties due to caring for children/housemates or because of health issues. The transition also seems to have had financial impacts, but only for a minority of students. A few students encountered financial issues in the last term (7%). Very few students took out a Covid-19 related loan (2%), but several students did have to increase their existing loan (17%).

At WUR, many students (56%) experienced difficulties combining online education with a personal life at home. Students' experiences about their working environment at home, the work set-up at home (chair, computer, and alike) and the network stability at home differed significantly. Students were also asked about their use of and satisfaction with campus facilities (November 2020). Most students (70%) came to campus only if there was a scheduled class, and 69% wanted to join on-campus course activities as much as possible. However, 24% of the students did not join on-campus activities because they felt that being present on campus would not add much.

At UT, both the student and teacher groups would prefer to have face-to-face sessions for group discussions, Q&A sessions, practicals and other similar activities (68.1% of teachers strongly agree; 49.8% of

students strongly agree). Almost a year into the pandemic, students appreciated the more flexible education. The increase of pre-recorded lectures made it possible for students to learn at their own time, pace and place.

At TUD similar issues as at the other three universities played a role. At home students did have difficulty creating study space in their small rooms, suffering from ergonomic issues, technical issues and screen exhaust. Other issues related to finding it difficult to separate life from work, to concentrate due to noise and other distractions.



Problematic working environment

- Furniture and Hardware
- Network stability
- Noise – disturbances
- Increase financial burden

Table: Summary of the home situation (across all universities)

Well-being

Rapid changes in teaching and learning have introduced a new focus on understanding the well-being of staff and students.

At TU/e the most prevalent limitation in student well-being is manifested in a pretty large proportion of students who felt lonely after the transition until the summer break (Q3 and Q4). After the summer break, problems of loneliness decreased much but did not completely disappear. Other well-being issues related to stress, such as worrying or symptoms of burnout, persisted to a severe degree for a not too small minority of students after the summer break. The level of student well-being was related to several factors, like the

home situation and self-confidence, which were not under the control of the faculties. Well-being and self-confidence are related to teacher behaviour (instructional communication and timely offer of support) and the course design: students who perceived their course to offer more autonomy for their learning suffered less from many well-being issues.

At TUD a substantial decrease in well-being was observed from June 2020 to March 2021. Student data show they experienced adverse effects on their feelings of belonging to a community, their physical well-being and their confidence and optimism about their study. Even though their learning results on average did not deteriorate much, their well-being was seriously and adversely affected. International students who resided in their home country were likely to feel worse as they have to follow classes in time zones that made it hard to stay awake.

		Percentage saying yes (%)			
		Jun	Nov	Mar	Diff in % points
		Jun-Mar			
Belonginess	I feel part of a community at TU Delft	44	28	20	-24
	I often feel lonely	31	40	42	11
	I feel like I belong at TU Delft	57	41	41	-16
	It often feels like no one at TU Delft cares about me	21	21	25	4
Overall well-being	overall, I felt good about my exercise levels	45	44	34	-11
	overall, I felt good about my sleep quality	52	51	48	-3
	overall, I felt good about my diet	61	62	54	-7
	overall, I often felt down	46	46	59	13
	I often worry too much	58	65	58	0
	overall, I felt good about the amount of time I spent outside			26	
Studies	I feel confident about graduating on time	50	45	42	-8
	I am generally optimistic about the future	61	56	51	-10
	I am happy with how I am performing in my studies	63	50	48	-15
	I am satisfied with my study/life balance	39	31	19	-20
	I feel capable at what I do			35	
	I feel motivated to finish my current study program			57	

Table: Research results amongst TU Delft students on well-being

At WUR, 54% of the students felt left out, 68% experienced loneliness, 54% experienced physical problems due to spending more time at home, and 63% experienced more stress with following courses online.



Well-Being Issues

- Loneliness – Isolation
- Lack of social network
- Physical setbacks -limited exercise
- Mental setbacks-
- Loss of confidence
- Feelings of Burn out

Table: Summary of students' well-being (across all universities)

Motivation

At WUR, the motivation for online education reported by students can be interpreted as problematic. About half of the students (52%) indicated they were not motivated to follow online education, and 56% became less motivated from March to July 2020. Students' motivation for online education was much lower than that of teachers. In comparison, only 16% of the teachers indicated they were not motivated, and 38% indicated to have become less motivated. Students emphasised that they missed the personal interaction and sense of connection.

At UT, some students indicated that they struggled with online learning and felt "demotivated and disoriented, getting stressed". Teachers had similar concerns; it was difficult to reach out to students to motivate and keep them on track.

At TUD students indicated they lacked motivational workspace, devoid of intrinsic motivation driven by the contact with other students. Self-initiation due to the loss of regularly scheduled course-times, made it hard for some to start working by themselves. Finally, students felt overwhelmed by the amount assignments given to them by the teachers.

Diversity

TUD found that internationals tend to struggle more across the board. Of staff, PhDs struggled the most. In regression models involving multiple factors, university departments did not have a significant effect on well-being. Instead, for both students and staff, the strongest predictors of well-being included: physical health, home environment, workload, optimism, loneliness and finances.



At TU/e in Q3 and Q4, women suffered from burnout symptoms more than men (Female = 4.5 versus Male = 4.0), of which 11% of the total sample is problematic. No statistically significant differences were found according to ethnicity or nationality, although burnout scores were somewhat higher for non-Dutch students. Because female students and non-Dutch students reported lower well-being than male and Dutch students, we compared the results for the influencing factors for these groups of students. It turned out that female students reported more home issues (specifically lack of dedicated study space:

3.04 vs 2.57, and health issues: 2.41 vs 1.89) and lower perceived autonomy in courses (4.76 vs 4.96) than male students. Non-Dutch students reported more home issues (specifically health issues: 2.71 vs 2.08, and caring for family members: 2.65 vs 1.79) than Dutch students. They also showed less persistence in learning (4.64 vs 5.06) and sought fewer online resources (5.19 vs 5.59). In general, the percentage of students with very high scores dropped from 23% in Q1 to 3% in Q3/4. There does not seem to be a single explanation, as influencing factors such as the home situation and seeking social resources do not seem to have changed. The broader context has changed, though, from completely online education and examination when the Q3/Q4 questionnaire was filled in (between June 24 and July 7) to more hybrid education and on-campus group work opportunities when the Q1 questionnaire was filled in.

At WUR, the differences between students were explored through a statistical method in which data are clustered in hierarchies based on several psychological latent variables from the student survey (N=676) collected during period 1 (sept-nov 2020). Six (latent) variables were included; motivation, ability, performance, stress, attitude toward interactive learning, and attitude toward individual learning. The cluster analysis resulted in 3 student profiles; 1) a relaxed/positive profile, 2) a stressed/negative profile, and 3) a somewhat stressed/neutral profile.

- Profile 1 (22.1 %): Student motivated to study online and feels able to study online, is neutral on effects of online education and experiences some stress (lowest of all groups), likes active learning and is neutral about on-campus interaction (motivated-relaxed student).
- Profile 2 (29.3%): Student is not very motivated to study online, feels not so able to study online, and believes that online education weakens outcomes, experiences much stress (most of all groups), is neutral about active learning and positive about on-campus interaction (unmotivated-stressed student)
- Profile 3 (48.8%): Is neutral about motivation, feels somewhat able, is a little pessimistic about effects of online learning, experiences quite some stress, is optimistic about active learning and on-campus education (able-stressed-somewhat critical student).

Subsequent statistical analysis showed that the student profiles significantly differed on various other variables, such as presence on campus, experienced support from university and exam stress. Profile 1 was (very) positive about support from university/staff, was not much on campus and experienced little exam stress. Profile 2 was neutral about support from university/staff, was relatively often on campus and experienced exam stress (most of all profiles). Profile 3 was somewhat optimistic about support from university/staff, was relatively often on campus (same as profile 2) and experienced some exam stress (in-between other profiles). There was no relation of profiles to student background variables, such as age, gender and cultural background.

	
<p>Motivation</p> <ul style="list-style-type: none"> Less Motivation Disorientation Autonomy can Help Beliefs in "Can DO" experienced more support 	<p>Diversity Impact bigger for:</p> <p><i>International students:</i></p> <ul style="list-style-type: none"> Loneliness Financial Worry about family Work-stress Optimism Work environment <p><i>Females:</i></p> <ul style="list-style-type: none"> Lower health Less study-space Lower autonomy

Table: Summary of Student Challenges (across all universities)



Learning environment

4. Learning environment

The last part of this paper reporting from the conducted studies focuses on challenges in the learning environment. In general, after the rapid adaptation phase, improvements and optimisation of online education were carried out. New teaching methods have been tried at all the institutions, yet WUR/UT have also documented these methods. The general belief was that online learning would lead to poorer learning results. Contrary to this belief, results have remained stable or in some cases have even gone up, as some students thrived in studying from home, while others struggled and did worse. An important intervention is the support of teachers experienced by students while shifting online and finding learning platforms that allow for extensive interaction such as Discord. With respect to remote assessment, students tend to value open book exams as it takes of part of the pressure to perform the exam online.

Teaching methods

At WUR, the results showed a trend from a crisis of 'online only' education to a transition period of blended education. Almost all teachers (>90%) used new methods for live online interaction and recordings. On average, 60% of the teachers who used a new method for live interaction, feedback or assignments would like to use that new teaching method again next year. Hence, despite a preference for on-campus education, many teachers intend to maintain some changes in teaching method.

Moreover, teaching methods were more often revised rather than just maintained or entirely replaced: lectures were more often revised instead of just maintained. Group work, practicals and excursions were more often revised instead of entirely replaced.

When asked about keeping or discarding changes in the course setup for the next year, teachers' responses were diverse. Overall, many teachers would like to keep some changes in online videos and assignments (and combine this with small in-class sessions that focus on interaction). In contrast, changes to excursions and practicals were largely discarded.

At UT, teachers have been creative and utilised diverse tools to offer educational activities continuously. Recorded videos and live online lectures were received as the most helpful ways for online education. Online tutorials were rated relatively high by teachers but got the lowest score from students. Overall, students gave lower rates than their teachers for all online activities. This rate also confirms that students had more difficulties adapting to online learning.

Skipped or heavily adapted educational activities were seen in the 4th Quartile of 2020 at the UT. Some programmes sent out lab equipment (e.g. electronics kit) to students to do some lab work at home, but overall, the quality of lab work was not rated satisfyingly. Both the student and teacher groups would prefer to have face-to-face sessions for group discussions, Q&A sessions, practicals and similar interactive formats (68.1% of teachers strongly agree; 49.8% of students strongly agree).

Student learning results

At WUR, both students and teachers indicated that they thought students' learning performance in online education would be worse than on-campus education. The feedback of teachers to students, the collaborative learning among students, the motivation of students, and the engagement of students were all considered to be lower in online education.

Although both teachers and students thought that students' learning is worse in online education, the average grades and pass rates of the period April to July showed no difference compared to previous years. The student course evaluations also remained stable: overall, students were equally satisfied with the courses. The level of learning (acquiring new knowledge/skills), the level of engagement, the workload, and the assessment were all evaluated positively.

Regardless of the difficulties, the bulk of the students in the sample of 504 in Q3 and Q4 at TU/e did not seem to require more effort to complete their coursework (Average mean = 3.68 on a 7-point scale, Standard Deviation = 1.79). Still, 35% of the students in Q3 and Q4 (total n=504) indicated their coursework took more effort than traditional style education. In addition, they argued that the quality

of their course work slightly decreased ($M = 4.14$, $SD = 1.68$), with (almost) half of the students indicating that their quality decreased. Also, not surprisingly, students felt somewhat overwhelmed by the transition ($M = 4.23$, $SD = 1.81$).

Teacher communication and support

Teachers' communication during the transition period in Q3 helped TU/e students ($n = 302$) feel more confident about their abilities. The more frequently teachers communicated with their students after the transition, the more confident students felt about their abilities ($r = .24$, $p = .02$). The frequency of the teachers' communication was not related to students' feeling of being overwhelmed ($r = .04$, $p = .70$). Similarly, the more teachers provided learning support, the more confident students felt about their abilities ($r = .33$, $p < .01$), but the amount of support was unrelated to the perception of being overwhelmed by the situation ($r = .09$, $p = .10$). The type of learning support seemed less relevant, just as long as teachers offered some help.


The support level given by the instructor (Q3) was rated moderately sufficient, though not good, with an average of 5.80 ($SD = 2.23$) on a scale from 0 to 10. One-third of the students (34%) rated the support from the instructors as insufficient. Most support from instructors came via written instructions (68%), followed by interactive sessions (31%) and live-stream sessions (31%). A few students indicated they did not receive any support from their instructor (10%).



At UT, students, who most often got their information from their peers (project group, classmates and roommates) and the teachers, were less satisfied with the (amount of) information and support they received to study online. Only 42,9% of the students reported that they got adequate information —the explanation they gave varied and seemed to depend heavily on the programme or course. Course variation, for example, consisted of too much information vs not enough information, clear vs unclear, structured vs chaotic. Students who experienced problems studying at home (e.g. self-motivation, time management, stress) often reported that they did not receive any support.

What stood out is that many teachers and students reported using Discord as a channel or platform to communicate (although Discord is not officially being supported at UT due to known privacy issues). Existing platforms like Canvas, Skype, and email do not always fulfil this need and lack functionalities to support this communication.

The remote testing situation remained complicated for both teachers and students. Both teachers and students were looking for more explicit guidance. Teachers seemed to choose for open book exams more often than usual. Although it took much time to formulate and grade open book essay questions, most students seemed to like that the focus was more on insights and applying methods instead of knowledge and remembering facts from the textbook.



Methods	Student Result	Teacher Support
Quality of teaching goes down	Results are stable Experienced as becoming less positive:	Crucial Criteria for Online:
New methods for interaction/ feedback and labwork	<ul style="list-style-type: none"> • Feedback • Interaction • Collaborative learning • Motivation • Engagement 	<ul style="list-style-type: none"> • Structure • Expectations management • Clear Guidance • Communications
Discussions, Q&A, practicals preferably face to face		Help: Raising Self Confidence

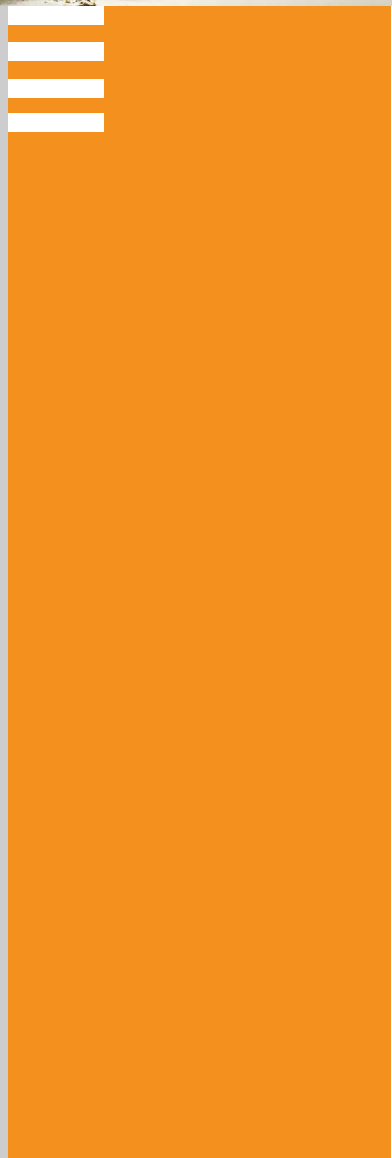
Table: Summary of learning environments challenges (across all universities)

Recommended solutions: A way forward

The teaching experience forced on both students and teachers during the Covid-19 lockdown has demanded increased awareness and reflection on teaching practices and the critical re-assessment of the (until then) almost natural and gradual evolution towards blended learning. The experience has shown that a complete virtual learning environment came with numerous challenges and caveats that limited the learning experience. Initially, therefore, the pre-Covid-19 success on blended learning may be evaluated in light of the pandemic experience. The positive and negative experiences should be taken on board to determine the way forward in the future. This re-valuation is relevant since it is expected that the pandemic will still be with us for several years to come and may enforce new lockdown measures, despite vaccinations. Leading questions have been formulated on the essence of learning, albeit these questions were partly addressed during the past months. They will be addressed in the next section. Finally, in the main drivers section we will share emerging foci that need attention in the future.



Leading questions



5. Leading questions

The leading questions are central questions that have been causing dilemmas and maybe answered or are already addressed in the past months with different actions at 4TU.

Leading questions for the way forward are:

1. How to embed student well-being structurally in education?
2. How to create a sense of connection?
3. Growing differences within and between teachers and student groups: how to reach the 'hard to get' people?
4. What support is needed by the university, centrally and locally?
5. How to create a good blend? What can be done online? What should be done on-campus?
6. Where to go in the future, how do we need to further develop blended education for the future?

In the paragraphs to follow, many already initiated and possible options will be shared.

Well-being

The period of pure online learning during the Covid-19 pandemic revealed that students' learning motivation was reduced and well-being issues showed up. We therefore advise universities to monitor students' and staff well-being, learning motivation, workload, social contacts, and other educational issues closely during the shift towards post covid-19 times. In this section questions 1 to 3 will be dealt with.

Effectiveness of well-being feedback loops and well-being actions being taken

At **TUD**, we saw that establishing a [well-being feedback loop](#) systematically assessing student well-being needs was very effective. It allows students have their voice be heard and highlights the different factors that are affecting students in the present time. Providing details to inform policymaking resulted in an informed administrative and constructive response. Amongst actions taken in response to

the well-being assessment was the 'Laptop project', which allowed students to acquire cheap accessories and laptops to make the home working environment more ergonomic. Another one is that more on-campus study places were made available. A special well-being page was created to inform students about available resources and options. Another initiative was '[Study Buddy](#)' that helps students find each other, stimulates projects together and helps students motivate each other.

Well-being and community building – A sense of Connection

At all four institutes, students emphasised that they missed personal interaction and a sense of connection. Personal contact was perceived essential for their well-being, for learning (to be able to discuss course content, freely exchange thoughts, learn from others), and create a sense of community (connecting). They came up with several suggestions for improvement, such as facilitating informal gatherings (breaks) and supporting and connecting students that struggle with the loss of motivation and focus (peer support). Universities, additionally, need to offer suitable study work/spaces. This way students and staff do not have to rely on their learning environment at home, which for many is not adequately equipped for teaching and learning. Although following online education was sometimes tricky, students did not seem to experience a significant increase in workload. In general, more attention for affective outcomes, well-being and resilience skills to maintain well-being would be good. In the light of environmental and ethical concerns and other pressures to be expected in the future, well-being will become a key issue.

Growing differences between teachers and between students, how to reach the 'hard to get' people?

At UT, the study shows that teachers enjoy sharing knowledge and getting input from their colleagues. However, the WUR study has shown that differentiation is needed. In addition to the university's centralised support system, there is a clear preference for peer support with traditional training and a standard website. Also, workload (research pressure/teaching) should be adapted to situational needs, without immediately placing careers in jeopardy, trusting the integrity and high levels of motivation from staff.

Working with networks of ambassadors/ expert teachers and professional learning communities are different formats that could be used. We should take this into account by giving teachers opportunities to share their expertise and form informal learning groups where they can share best practices and release pressure. In the post-Covid-19 support system, a university-wide teaching community is in high demand and maybe the way forward. However, we should also consider other preferences that meet the less socially inclined teacher, e.g. coaching and mentoring or chatbot PsyQ support structures.

Support

The universities need to reconsider the structure of support, to cater for more tailor-made local help and room for experimentation, while maintaining professionalisation for all accessible and relevant. This section deals with question 4.

What support is needed by the university staff, both centrally and locally?

In general, next to central support, more hands-on support per department is needed. Also, types of courses and student sizes differ per programme and suggest the need for tailor-made and local support. At TUD, for example, local studio rooms with tooling are set up to facilitate teachers to provide inspirational lectures, and TA's are hired to help moderate the high number of questions asked in the online chat during lectures. Support to explain simply how some tooling works helps to alleviate stress. A close-by person to go to enormously helps to manage increased online demand.

At UT, there is a growing tension between centrally offered support and the demands from the individual faculties. While centrally offered support structures aim at standardised and privacy-approved solutions, local initiatives at facilities seek more opportunities to meet their specific requirements. Follow-up research focused on experimenting with alternative professional development support for teachers to develop blended education is planned. Pre-Covid-19 professional teaching development focused on the front-running teachers at an individual level. UT believes it is essential to meet all teachers' needs and focus professional development activities on the entire teaching

staff. The centralised support structure and organisations should be adjusted to meet these criteria, using informal teaching communities and working more closely with individual faculties and educational programmes.



Creating a good blend

In this section we will address question 5 and 6. It is clear that under the influence of Covid-19 new tools have emerged, blended learning is enriched, hybrid learning has come into existence and campus education needs to be revamped in line with current insights about learning. There are a lot of sub-recommendations, which indicate the possible issues that need to be addressed. However, the coherence is still low. Therefore we will end this section with some recommendations.

How do we need to further develop blended education for the future?

At UT and TUD, questions arise related to the new hybrid education, where remote students are mixed with in-classroom students. One could question whether a university should continue with hybrid education or focus only on excellent blended education after the pandemic? Does hybrid education offer additional didactic value compared to blended education? Shouldn't we aim to design classroom activities that have more added value for students to come to campus and socially connect students? Ultimately, we should not forget the essential role of our campus university. Why do students need to be gathered at the campus? Activities like lab work, summative

assessment, tutorials cannot easily be moved online. We should consider the role of laboratories, practicals in engineering education. Lecturers point out that the buildings and rooms need to serve the new concept (blend). Could we significantly decrease large scale lecture halls? Face to face meetings need to make sense on campus, and it needs to have an added value. There is also an opportunity to explore more living lab and similar facilities. More importantly, the classroom and campus are the places where people can meet up and connect. Social cohesion and community building are likely to be important drivers for each institution.

New online teaching methods

At WUR, although following online education was sometimes tricky, students did not seem to experience a significant increase in workload. Several teachers transformed their courses or used intensive hybridised formats. Students differed in their evaluation of new online teaching methods. This evaluation shows that there is no single 'best method' for online teaching. Therefore, it is vital to combine and experiment with different online teaching methods that cater to different students. Students mentioned keeping and increasing the number of pre-recorded videos.



“At **TU/e**, teachers tried out various online teaching formats, including live-streamed online lectures, pre-recorded videos, flipped classroom approaches, interactive online meetings, the use of online quizzes, and many more. Only a few of them could be evaluated thoroughly concerning their effects on students' motivation and well-being. While students felt hardly motivated by any of them before the summer break 2020, learning motivation was higher thereafter (in Q1) and interactive meetings were regarded as more motivating than live-

streamed lectures. Students who experienced a higher degree of autonomy in an online or blended course reported being more motivated and higher well-being for quite a lot of indicators. On the negative side, students who were confronted with online proctoring of exams experienced somewhat higher test anxiety. Furthermore, the housing situation played a large role in student well-being and motivation during online teaching, as more issues in the home situation (e.g., no dedicated study space, connectivity problems) reduced students' motivation and well-being. The TU/e authors conclude that several new online and blended teaching methods are promising and worthwhile to be examined in more detail in future educational setups.”

Recommendations

Going forward with post-Covid teaching and learning: How to create a good blend? What can be done online? What should be done on-campus?

More in detail, the various studies suggest:

1. A substantial number of large-scale lecturing and traditional teaching methods can be done well online with clear structures and guidance for students on how to prepare themselves.
2. Several online assignments with (new) pedagogic approaches might be usable after Covid-19 – such as group work and online design sessions.
3. New tools to support online learning can be continued. People who dare to experiment with these tools should be supported with time and expertise.
4. The online teaching experiences during the pandemic clearly show that the social connection among teachers and students is an essential element for blended and online higher education. Teachers sometimes experience online teaching as talking to a black box. They need more guidance and support to reach out to their students and keep them motivated in learning. Interaction can partly be done online, but on-campus activities are dearly needed.
5. Teachers can help students in their time management by providing a clear structure and schedule, considering students' autonomy.

6. Many lab/engineering teaching methods do not have good online alternatives and (definitely) need to be done on-campus. Especially since despite the rapid development of online tooling, few alternatives are available for excursions, internships, challenges and other intensive types of education.
7. Online assessment could be used even more but may need a different approach; for example, open-book exams and similar types of assessment should be considered; although much assessment also needs to be done on-campus. More in general, a discussion on summative assessment and its current emphasis might be worthwhile. A shift to more programmatic assessment, with less focus on accountability and more focus on continuous feedback loops in learning, may benefit the learning process.
8. Make Edu-badges/micro-credentials a regular part of the curriculum.
9. Create Learning dash-boards for guided learning
10. Move from emergency remote learning to long term strategies with focus on quality of education. Evaluate and experiment with (blended) learning formats.



Evolving education

6. Evolving education

In this final section, we propose a research-focused agenda emerging from all the previous findings. This research agenda highlights the necessity to develop new insights, change and improve three areas of Higher Education (HE) learning. The three areas consist of (1) teaching and learning online and on-campus, (2) honouring diversity and exploring diverse pathways for working and learning and (3) well-being, social cohesion and community building for teachers and students.

Teaching and learning on-offline and mixed

New formats of online learning and on-campus learning, which create a more balanced Learning Ecosystem with online, hybrid learning, blended learning, and on/off-campus face to face learning, should be explored. The learning objectives will largely determine the need for the learning to be on/offline.

Diversity of the population

Other parameters in this mix of adequate learning design are the diversity of the population in terms of **learning profile** (e.g. disabled, international, gender), presence or long-distance learning for overseas students. In addition, flexibilisation and personalisation of education using Edu badge-Micro-credentials offer new opportunities for new learning methods or participation in Edu Hubs (ERIC's) for at home and far of students.

Well-being

An important lesson that we can draw from the impact on well-being on teachers and students during the pandemic emphasises the importance of informal contacts in learning (social network), trust, emotional stability, motivation, agency, and resilience are essential ingredients for well-being and learning.

Support structures

Tooling support, learning spaces and personal assistance (mental/financial/social) should be an essential part of the package deal one gets when attending university education. The trend is that social, financial and other structures should be available such that teachers can deal with their primary task of teaching and coaching and are not preoccupied with life's diversions. Equally, the administrative and logistic burden of online education should be investigated. More advanced tooling and support staff and TA's assistance are needed as well.



Suggested research questions

Education:

- How do we exploit customisation opportunities (students, professors, content)?
- How do we design and measure the value of in-presence, on-campus class, laboratories, projects?
- How do we design and measure the value of digital/remote activities?
- How do we measure the impact of online presence?
- How do we seamlessly integrate the virtual and physical mobility of students?
- How will exams and student assessment change?
- What are the main characteristics of education in the new normal?

Campus and online regeneration for social cohesion and well-being:

- What new campus services should we offer in order to promote wellness and well-being among students and staff?
- What kind of classrooms will we need in the future? What sizes? Which layouts?
- How should we design new offices and shared spaces for both faculty and staff?
- How could we deploy IT strategies to enable smart/flexible working?
- What is the role of the campus in creating a new university culture that fits the new normal?

Concluding remarks

We hope this document has given insights into the state of the art of the impact of the Covid-19 pandemic on education, teaching, and learning. We also hope it will inspire and generate clearly needed to follow up research into the future of Higher Education. Here we would like to acknowledge all those who contributed to this document with research data, feedback or other types of support.

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Appendix

Separate cases

Case Studies from the 4TUs

Overview table of methodology and response numbers:

Institution	Instruments	Faculty	Administered to	Time	Response Rate	Samle size
TUD	My Wellness check	Entire TU	Teachers, Support Staff, Researchers & Students	Nov/Dec 2nd round 2020	Staff: June 2020 - n=2328 Dec 2020 - n=1622 March 2021- n=1956 Students: June 2020 - n=2604 Nov 2020 - n=2841 March 2021- n=2221	All staff and students (approximately 6500 and 28000 respectively)
TUD	Participatory workshop	Entire TU	All relevant staff	Okt/nov 2020		50 +
TU/e	Survey	IE&IS	Students	Q3 2020/21 until Q2 2021/22	Q3: 32% Q4: 26% Q1: 37%	Q3:n=302 Q4: n=202 Q1:n=679
UT	Survey Survey	Internal Business Administration, Chemical Science and Engineering, Electrical Engineering and Advanced Technology)	Students		41%	319 out of 779
UT	Survey	idem	Teachers		69%	47 out 68
WUR	Survey	Entire WUR	Teachers		20%	521
	Survey	Entire wur	Students			1251
	PaCE student course evaluation	Entire Wur	Students		82%	11.526 (in 531 courses)
	Interviews		Teachers			