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REVIEW



Students' well-being and factors impacting it during COVID-19 pandemic – early findings from Delft University of Technology

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ABSTRACT

Even before the COVID-19 pandemic, student well-being was highlighted as an important public health issue. The study aims to gain insights into the exact factors that bachelor and master students from engineering fields at Delft University of Technology are impacted by. Multiple interviews were performed to identify the key areas of impact and then incorporated into a comprehensive survey. The questionnaire was divided into five blocks: course work factors, thesis, communication, study environment, the COVID-19 pandemic and disseminated between June and September of 2021. A convenience sample of 165 responses was collected and the Warwick-Edinburgh Mental Well-being Scale (WEMWBS) test was employed to quantify the well-being of the students. The survey analysis found different well-being scores between the students from the bachelor and master programs and concluded that having a consistent work environment played an important role in students' welfare. The COVID-19-related findings revealed that the recordings of lectures and remote studying were the most appreciated. The thesis-related section showed that the clarity and objectives of the thesis writing are particularly impactful. Although some of the findings are university specific, the recommendations could be considered by other universities as they refer to general indicators and relationships.

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Student well-being; higher education in COVID-19; education during the pandemic; mental health at universities

1. Introduction

Over the past years a growing body of empirical research has shown that university students are a high-risk population for psychological distress and mental disorders (Chen and Lucock 2022). While student well-being already showed worrying numbers before, the COVID-19 pandemic worsened the situation for many students. Recent assessments of the mental health of students in several countries found that a significant amount of the student population showed signs of poor mental well-being and depression (Inspectie van het Onderwijs 2021; Struijs 2020; Wang et al. 2020).

Over the years, there have been many studies that explored student well-being in the context of different countries and institutions (Cha 2003; Crocker et al. 1994). More recently, there have been several studies that specifically examine the impacts of the COVID-19 pandemic on student well-being (Schmits et al. 2021; Struijs 2020; Wang et al. 2020). These studies suggest that as a result of the COVID-19 pandemic and corresponding measures, such as lockdowns and the closing of universities, students experienced higher rates of negative feelings, anxiety, stress, and tiredness.

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Former research in this domain clearly highlights the need to improve student well-being. The Netherlands has not been exempted and a recent study by the Dutch RIVM, GGD GHOR Nederland and the Trimbos-institute (2021) found that more than half of Dutch students questioned, experienced at least some form of psychological discomfort while 12% of the sample found the discomfort to be severe.

While the findings from multiple studies show concerns about poor well-being and mental health in the student populations, these studies largely focused on assessing and describing the observed well-being of student populations (Baik, Larcombe, and Brooker 2019). There has been less research on the measures that universities could take to reduce environmental stressors and promote protective factors in the university environment. Literature that proposes specific actions to increase student well-being is limited (Chadha et al. 2020; Dyrbye et al. 2007). Past research found that a students' active participation in well-being promotion programs is essential to the effectiveness of such programs (Griebler et al. 2017). It is also vital to the policy success to engage the students and involve them in naming the factors that cause their poor well-being.

Former literature also suggested that students from engineering and adjacent fields experience unique challenges and learning issues such as managing varied audiences, feedback, aligning content, communication tasks, or addressing interpersonal team issues (Dannels et al. 2003). Because of those specific challenges, engineering students must operate in unique environments. Gustems-Carnicer, Calderón, and Calderón-Garrido (2019) argue that exploring the individual needs of student groups and studying targeted solutions are needed to benefit this population.

To explore the factors affecting student well-being and gain further insights into the specific causes of poor mental well-being as well as the impact of the COVID-19 pandemic on students, a survey was developed. The exploratory data analysis and visualisation of the responses were performed to identify specific factors impacting university students' well-being. The study findings offer the opportunity for other universities to evaluate their own practices and implement some of the findings.

Because the study population includes university students, the goal of the research was to identify university-dependent factors potentially impacting well-being. Past research and interviews with student organisations and faculty members found education quality, research, communication, and environment as the important elements in students' well-being (Çetin et al. 2021; Son et al. 2020). To explore a comprehensive list of factors that were both, university-specific and scientifically based, the current study investigated the following categories – course experience, thesis writing, communication, study environment, and COVID-19 and their relationship to well-being.

2. Literature review

2.1. Defining well-being

There is a broad range of literature examining alternate perspectives of mental well-being, and most importantly the distinction between (mental) well-being and mental health. There has been no clear consensus on their definitions and the distinction between them.

The term 'well-being' alone is a broad term that generally represents how people feel and how they function. It is applied to both a personal and social level, as well as to evaluate life satisfaction (Michaelson, Mahony, and Schifferes 2012). Despite there being generally no accepted distinction between the concepts of mental well-being and mental health, The World Health Organization defines mental health as a state of well-being, in which an individual realises their own abilities, can cope with the normal stresses of life, can work productively, and is able to contribute to their community (WHO 2018). Mental well-being as regarded by Ryan and Deci (2001) covers both hedonic (happiness, subjective well-being (SWB)) and eudaimonic (positive functioning) well-being. In 2004, the Royal Society in the UK defined mental well-being as a positive and sustainable mental state that allows individuals, groups, and nations to thrive and flourish (Clarke et al. 2011).

Mental well-being can therefore be regarded as more than the absence of mental illness. In practice, the term 'well-being' is often used to refer to the mental health component of well-being alone (Warwick Medical School n.d.).

Kim-Prieto et al. (2005) explored this area further by analysing the diverse perspectives of SWB. They summarised the field by defining three main approaches, under which the existing well-being definitions can be characterised. First, SWB was defined as a global assessment of life wherein respondents self-report on their satisfaction with work, relationships, and other important domains. Second, a SWB definition was based on a recollection of emotional experiences over a specific timeframe as well as defined by an aggregation of multiple emotional reactions over time. The authors ultimately presented their own framework for an all-encompassing metric of well-being, which combined the elements of each of the three approaches. Dodge et al. (2012) examined a similar objective, and they too explored the main theoretical perspectives of well-being and proposed a novel definition of well-being as the balance point between an individual's resource pool and the challenges they face.

A noted difference in literature is that the concept of mental health includes both – the daily state of well-being and (signs and symptoms causing) mental health conditions and illnesses. Mental well-being, on the other hand, is often described as a broader concept, focussing on the positive aspects of how one feels and responds to life's ups and downs. Nonetheless, the concepts are often used interchangeably.

Clarke et al. (2011) acknowledged that while the definitions of mental illness have been the subject of much investigation, the definitions of mental well-being are less researched. Barkham et al. (2019) argued that the field of student mental health is currently limited due to using imprecise definitions, and that this is detrimental to the literature base. They raised the issue of piecemeal surveys that often provide conflicting definitions of well-being and mental health diagnosis. Given that the accurate diagnosis of a mental health condition should rely upon clinical diagnosis, the self-selecting surveys employed in the majority of studies appear to inadequately capture the true mental health landscape in the student population.

Nevertheless, the former research did acknowledge a large range of different interpretations of well-being, which underlines the diversity of the well-being field. These papers further agree that a clear definition of well-being should be presented when performing research to prevent misunderstanding. There, however, still exist many divergent proposals on a single all-encompassing definition. This lack of consensus suggests that the specific choice on the definition of well-being should instead rely upon the specific research application.

An important next step is to clearly outline the definition of well-being in the context of current research. This study focusses solely on mental well-being and aims to better understand the university-related factors that can influence students' mental well-being in a very broad sense, from mild discomfort to severe stress and anxiety. A broad definition of mental well-being is therefore applicable in this case. The mental well-being definition is utilised and is most closely associated with that presented by Tennant et al. (2007). In this definition, mental well-being is described as the positive aspect of mental health, which is more than the absence of mental disease. Mental well-being is represented as both feeling good and functioning well. It should be noted that this research is limited to factors influencing well-being and does not explore the impact on any specific mental health conditions. When mentioning 'well-being' in the proceedings of this report, it should be noted that this refers to 'mental well-being'.

2.2. Quantifying well-being

Having established the appropriate definition or perspective of well-being that is relevant to the current research application, the issue of how to quantify it, remains to be established. To apply statistical modelling methods on collected data, a metric is required to compare and evaluate the well-being of different respondents. Specific psychological measures of well-being for clinical

applications are numerous (Maruish 2017). There is also a number of established metrics that cover both well-being and mental health (Joseph et al. 2004; Ryff and Keyes 1995; Watson, Clark, and Tellegen 1988). For this study, however, mental well-being will only be addressed.

With these criteria, two promising metrics were identified; each based on a broad underlying perspective of well-being: the GP-CORE method and the WEMWBS method. Other methods employed in the literature are the Ryff Psychological Well-Being (PWB) Scales (Baik, Larcombe, and Brooker 2019), Student Resilience Survey (Lereya et al. 2016), the Perceived Stress Scale (Cohen, Kamarck, and Mermelstein 1983), the TEIQUÉ-ASF (Siegling et al. 2015) and the WHO-5 Well-being index (Topp et al. 2015). Evans et al. (2005) developed a 14-item general population well-being measure defined as GP-CORE. GP-CORE has been derived from a more comprehensive clinical measure (CORE-OM) that encompasses domains of well-being, problems/symptoms, functioning, and risk (Evans et al. 2009). GP-CORE focused on psychological well-being and associated factors and has been shown to have high reliability and validity (Kim-Prieto et al. 2005). The other considered metric was developed by Tennant et al. (2007) and defined as the Warwick-Edinburgh Mental Well-being Scale (WEMWBS). This is also a 14-item well-being measure designed for a broad general population with a focus on student groups. The metric was developed with the following key concepts of mental well-being: positive affect and psychological functioning (autonomy, competence, self-acceptance, personal growth) and interpersonal relationships. The authors chose to use exclusively positively keyed questions to avoid recognised impacts of negatively focused statements in mental health applications (Tennant et al. 2007). As with the GP-CORE scale, the 14 items are answered with a 5-point Likert scale but in this case, the respondents are asked to answer with consideration of their experience over the last two weeks. Analysis of the WEMWBS has shown this method to have a high content validity and high correlations with other well-being scales (Tennant et al. 2007). Besides, the international research validates that this method is trustworthy and valid in many different research applications and countries. It has also been validated in different research papers as a suitable method to investigate students' well-being specifically (Clarke et al. 2011; Fung 2019; López et al. 2013; Tennant et al. 2007).

Ultimately, for the current study, the WEMWBS method was employed. This tool has proven a valid and reliable tool for measuring mental well-being in diverse populations and applications, also specifically in investigating well-being in student groups (Stewart-Brown et al. 2011). This method also enables measuring the impact of policies and the comparison of the different types of interventions, as the method is suitable to apply in repeated questionnaires. Furthermore, it complies with the aim of this research to not only investigate the status of mental well-being in the student population at Delft University of Technology, but specifically to identify indicators of poor well-being and formulate next steps needed to improve student well-being. The WEMWBS has been also found easy to complete, clear, and has proven itself popular with practitioners and policy-makers (Tennant et al. 2006). The WEMWBS scale covers both eudemonic and hedonic well-being, psychological functioning, and SWB. Such approach also properly aligns with the chosen abovementioned mental well-being definition.

2.3. Existing studies in the field of student well-being

There is a breadth of research into the state of student well-being. Interest in student well-being is not novel and past work addressed it in varying domains and to varying dimensions (Witter et al. 1984). More recent studies explored well-being at schools in specific fields such as engineering related and made recommendations that fell within teaching, giving feedback, and course structure (Nair, Patil, and Mertova 2011; Rodríguez-Jiménez et al. 2022). Most studies, however, have largely focused on describing the observed well-being from one of the perspectives of well-being definitions described earlier (Chadha et al. 2020; Evans et al. 2018; Hernández-Torrano et al. 2020). Nevertheless, there has been consensus among researchers on worrying levels of poor well-being and mental health in student populations. A number of papers examined the specific impacts

that the COVID-19 pandemic has had on student well-being (Burns, Dagnall, and Holt 2020; Kaparounaki et al. 2020; Rajkumar 2020; Van de Velde et al. 2021) and has shown a decline in well-being as a result of the pandemic, especially in vulnerable groups.

Overall, existing research can be categorised into four distinctive groups: (1) studies describing the observed well-being of student populations (including those investigating the impact of COVID-19), (2) studies identifying specific positive or negative indicators for mental well-being, (3) studies that investigate what metrics can be used to enhance student well-being, and (4) studies investigating the impact of specific coping techniques on well-being.

The first group of studies such as those by Schmits et al. (2021) and Wang et al. (2020), aims to describe the observed well-being of student populations and highlights the needs to improve it. The findings on well-being outcomes in universities can be useful to spur action from administrators. However, the scope of these papers does not often extend to studying the specific causes of poor well-being. They often do not offer insights into how well-being can be improved or make recommendations. Besides, such research applications were often high-level and of national scope. Research by the GGD GHOR, Trimbos Institute and RIVM (2021) and the Inspectie van het Onderwijs (2021) in the Netherlands investigated students' well-being on a national level to derive high-level policy measures and not practical, actionable improvement steps for universities.

The second group of studies, that identify specific positive or negative indicators for mental well-being, and the third group, that investigate what metrics can be used to enhance student well-being and allow a more targeted approach to improving well-being are scarce. Baik, Larcombe, and Brooker (2019) defined categories marked by the students as important factors in improving their well-being. These categories, amongst others, include academic teachers and teaching practices, student services and support, study environment, and course design. The study emphasised improving teachers' approachability, empathy, communication, and interaction with the students having potential to positively improve students' well-being.

Finally, there also exist studies exploring how specific coping techniques (Gustems-Carnicer and Calderón 2013) or changes to the syllabus (Gurung and Galardi 2021) may influence well-being. These studies, therefore, provide the greatest information on how likely certain actions would influence the well-being of students. Although they are comprehensive, they are also much more resource intensive, require a control group, and longitudinal surveying.

Studies that investigate specifically how student well-being can be improved at universities allow the most actionable approach to well-being. However, as noted, these studies should not be used to provide educators or administrators with a ready-to-implement prioritised list of strategies. Rather, they aim to describe a replicable method for involving the students to inform the design and evaluation of well-being strategies. The process of investigating, analysing, and acting on students' suggestions helps to foster the inclusion and empowerment of students, making it evident that the goal of improving students' mental well-being can only be achieved through an effective partnership between students and institutional actors. Addressing the factors that the students identify as causing poor well-being is essential in creating a tailored, effective strategy to improve well-being on an institutional level.

Because former studies aiming to explore the well-being of students at universities found well-being a critical aspect to academic performance (Gurung and Galardi 2021; Gustems-Carnicer and Calderón 2013), the current study identifies crucial well-being factors. Furthermore, recent research also found a relationship between COVID-19 pandemic and well-being (Schmits et al., 2021; Struijs 2020; Wang et al. 2020), therefore the analysis in this paper contributes to the body of literature in education and examines how it was impacted by the pandemic. Lastly, while past work has also investigated the factors impacting well-being of the university students and identified that education quality, research, communication, and environment to be important areas worthy of investigation in a university context (Çetin et al. 2021; Son et al. 2020), present research narrows down these categories and pays special focus to factors where the university could have a substantial impact.

3. Research design and methodology

3.1. Survey design and data collection

The objective of the study was designed to gain insights into well-being of the students during COVID-19 pandemic as well as to identify the key areas that the students find the most important to their well-being. Past work by Son et al. (2020) found that the students were concerned with the sudden changes in the syllabus, the quality of the classes, technical issues with online applications, the difficulty of learning online, and their own living environment and the role it plays in their education. Social isolation and communication with peers and faculty members were classified as particularly worrisome. Former research categorised the factors playing a role in well-being of the students into four main domains – education quality, research, communication, and environment as important elements playing a role in students' well-being (Çetin et al. 2021; Son et al. 2020). Because of the exploratory nature of this study, the main goal was to determine the average well-being score for both – bachelor and master students, determine if well-being scores vary between the groups and identify the areas impacting well-being the most.

To achieve this objective, an online survey was designed and conducted at Delft University of Technology at the Faculty¹ of Technology, Policy and Management. The target population included approximately 1400 students of the bachelor and master level, out of which 165 responded to the survey. The survey questionnaire received approval from the Human Research Ethics Committee. The survey was distributed to all students via the internal university communication system. The survey questionnaire was sent to each student twice and the convenience sample was collected. Participation in the study was optional and non-identifiable information was collected. The students could terminate their participation at any moment.

Before beginning the survey, each participant was presented with a consent page where the purpose of the survey, length, type of questions, and contact person were indicated. If a participant did not provide consent, the survey questionnaire automatically expired, and the survey response was not collected. Although the focus of the study was placed on the students, the survey was designed to also gain information from the PhD Candidates, and faculty from Delft University of Technology (it should be also noted that PhD Candidates, in this case, are considered full-time employees).

The survey design took place from February until June 2021. The study had two main objectives – first, to assess the current level of well-being and second, to identify the causes of poor well-being among the surveyed population. To achieve the first goal, the WEMWBS instrument was used. The remaining questions were then designed based on the output of multiple interviews with the students and the faculty members as well as study association members. The interview approach was used to guide the project, identify the survey topics, and to ensure broad, quality, and inclusive survey questions. The questionnaire contained mostly of multiple-choice questions and a few free-text fields were available for elaboration. The survey consisted of the following sections:

Demographics

This section included questions related to the participants' age, gender, college classification or profession, program and year of study, living situation, and background.

General well-being

This section included the 14 WEMWBS statements (Tennant et al. 2007). The statements were positively phrased and related to well-being. Respondents were asked about the frequency of their experiences during the last two weeks. The 14 items were answered on the 5-point Likert scale: none of the time, rarely, some of the time, often, and lastly all of the time.

Faculty member question

This section was directed at faculty members of the Faculty of Technology, Policy and Management. Four questions were included to map the experience of the faculty members with well-being measures for staff at the faculty.

Student well-being questions

The following section was aimed at the students and covered the ‘degree of negative impact’ that different aspects of studying at the university had on the student in the recent past. The degree of negative impact was defined in a broad sense, from severe stress and anxiety to mild discomfort or annoyance. Based on the literature review and the interviews with the members of the academic community and to provide a logical flow of questions, the section was divided into five sub-sections (Çetin et al. 2021; Son et al. 2020):

- *Course-related well-being indicators.* The first set of questions described the students’ course experience and aimed to understand how aspects of the course structure, organisation, and presentation can negatively impact well-being.
- *Master thesis and well-being.* The second set of questions related to working on a master’s thesis and how aspects of this process, such as finding thesis supervisors and process clarity, can negatively impact well-being.
- *Communication and well-being.* The third set of questions related to communication between the students and the faculty and aimed to understand how aspects such as teaching staff availability and feedback can impact student well-being.
- *Environment and well-being.* The fourth set of questions addressed living and working environment, and how aspects such as inadequate study places or technical issues can impact well-being.
- *COVID-19 impact on well-being.* The latter set of questions related to the impact of COVID-19 on student experience within the department.

The survey was published in July 2021 using the online survey platform Qualtrics. Data collection remained open until September 2021. Delft University of Technology closed campuses during the COVID-19 pandemic in 2020. During the data collection process, campuses were partially reopened but some education remained virtual in response to the national COVID-19 measures.

3.2. Survey instruments and methodology

The main objective was to determine the average well-being score for both – bachelor and master students as well as establish if the well-being scores vary between these groups. Additionally, the aim was to identify the areas impacting well-being the most. To assess the overall well-being, the WEMWBS method was employed. To determine the statistical differences between subpopulations in the study, a one-way ANOVA test was used, and lastly self-assessed well-being statements were visualised using graphs.

WEMWBS was selected because it has been shown to have a high content validity and high correlations with other well-being scales (Tennant et al. 2007). Furthermore, it was validated by international research and found trustworthy in many different research domains. It has also been validated in different research papers as a suitable method to investigate student well-being (Clarke et al. 2011; Fung 2019; López et al. 2013; Tennant et al. 2007).

ANOVA (Analysis of Variance) is one of the most widely used statistical methods for hypothesis testing (Stahle and Wold 1989). Homogeneity of variance to assure the applicability of the ANOVA was confirmed and therefore multiple hypotheses were tested.

The hypothesis about population means μ_j where j implies a characteristic (e.g. gender, study environment) was formulated. In this particular example, it is tested whether there is a statistically significant difference between the means of different study environment groups. Therefore, the hypothesis can be written as:

$$H_0: \mu_1 = \mu_2 = \mu_3$$

H_1 : Not all μ_j are equal ($j = 1:3$) where j means one of the three options – having a reliable study environment, not having a reliable study environment or not consistently having study

environment. The test is based on the observed sample means $\bar{x}_j$. The result of the F-test is a positive number which, if it exceeds 1.0, indicates that there are differences between the means (Stahle and Wold 1989). If the p -value is less than or equal to the significance level (0.05), the null hypothesis can be rejected, and it can be concluded that there is a statistically significant difference between the means of different study environment groups. Similar test was performed for other variables noted in Section 5.1.1 and included – study programme, gender, origin of the home country.

3.3. Sample demographics

During the initial data collection period from July until September 2021, the survey received 179 responses (which is approximately 12% of the total student population at the department). Due to the limited number of observations, the survey and research at this stage is exploratory. As results from the research demand to be addressed in a timely manner, the initial results are nonetheless investigated.

The sample distribution includes students, PhD candidates, and faculty members at Delft University of Technology from the Department of Engineering Systems and Services. In total, 179 students and faculty members responded to the survey. Of these participants, 99% gave their consent to participate in the survey and completed the questionnaire from start to finish. Age of the participants ranged from 18 to 60 years, with most aged between 18 and 29 years old. 44% of participants in the sample were man and 54% women. The respondents were mostly Dutch (69%) compared to the international group (31%). Because the research was aimed at the students from the faculty of Technology, Policy and Management, which is a part of the Department of Engineering Systems and Services, 94% of the respondents were directly associated with the faculty, while the remaining 6% indirectly, likely due to cross-faculty study programmes. The general student profile in the faculty includes often engineering background as the students could choose to specialise in transportation, logistic, information and communication technology, energy modelling and other topics relating to engineering, science, or qualitative methods. It is a multidisciplinary environment where the students are encouraged to reflect on their work and its societal implications. A considerably large amount of the collected sample group consisted of students 97% (bachelor and master), compared to only 3% PhD Candidates and staff members. Of the students, 65% were master-level students and 35% were bachelor-level students.

As it is the case with all survey questionnaires, discussing bias is essential. Although the survey was sent to all the students at all levels in the faculty, it is possible that the students with particular interest in well-being responded, which could lead to self-selection issues in the sample. Furthermore, on-going pandemic could also have an impact on the objectivity of the respondents as the entire paradigm of education and studying from home was transformed.

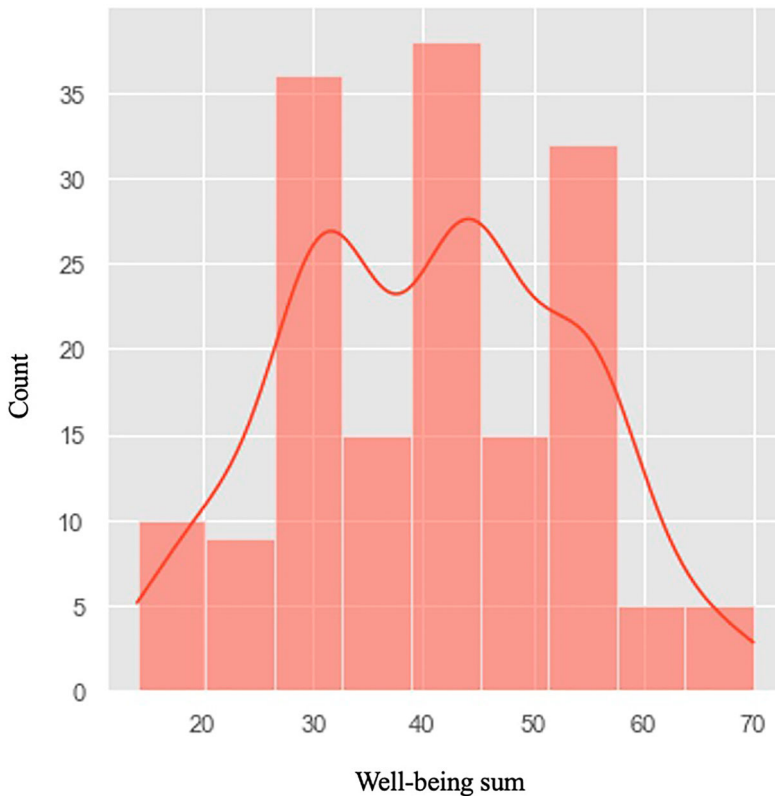
3.4. Data cleaning and formatting

From all the responses, one participant did not consent to their response being used and this instance was deleted. To assure data quality all responses under two minutes as well as those with missing entries were removed. Based on the initial analysis of the sample group, it was decided that for the remaining of the study, the focus will be solely on the students. This is due to the insufficient share of the latter group in the sample group. After performing all data cleaning steps, 165 instances remained.

For the remaining instances, a well-being score was calculated. The well-being score was a sum of the 14 well-being questions, where the categorial answers have been transposed into numeric answers to enable calculating an overall well-being score. Participants' scores are presented in Table 1 (Figure 1).

Table 1. Number of participants per well-being category ($n = 165$).

Well-being score range	Percentage of respondents in group
0–17.5	3.0%
17.5–35	38.8%
35–52.5	33.9%
52.5–70	24.2%

**Figure 1.** Distribution of participants' well-being scores.

4. Limitations

Several limitations may impact the generalisability of the findings reported in this paper. Turning to the results, it must be noted that the questionnaire received a relatively low number of responses. The findings may therefore not be representative of all students and have unaddressed unobserved heterogeneity in the data. Due to the low number of observations, the analysis has for now been limited to exploratory data analysis, visualisations, and statistical tests. However, because of the timely nature of this work, there is a value in sharing the preliminary results. The early findings from the study could also serve future research and be used by other universities to structure their surveys.

As this survey is first ever exploited during the COVID-19 pandemic, it lacks comparison to a typical semester unaffected by the pandemic. To properly understand the mental well-being of students and assess the impact of COVID-19, it is valuable to keep monitoring the change to understand the long-term effect of the pandemic.

Although ANOVA analysis has been well accepted in the scientific community for its reliability (Stahle and Wold 1989), some researchers argue that ANOVA will fail to detect even large

amounts of bias (Camilli and Shapard 1987), while others emphasise that hypothesis testing in ANOVA by the F-test is based on the assumption that the data are drawn from a population with a normal distribution and any data not normally distributed cannot be analysed by ANOVA (Stahle and Wold 1989).

Lastly, the answers are based on self-reporting, which are subject to bias and inconsistencies. Respondents were not asked whether they experienced any existing mental health issues before starting the university or prior to the pandemic. Another remark is that most students come from the faculty of Technology, Policy and Management (94%) so the analysis could be much different if performed on observations collected in another faculty or from students from non-technical backgrounds.

5. Results

Because of the relatively low number of observations, advanced statistical and econometric analysis was not justified and to keep the paper timely and relevant, preliminary analysis was performed. Current results still provide meaningful insights and allow to provide recommendations into what the key areas of poor well-being in engineering students population. To confirm the internal consistency of the well-being questions, a Cronbach's alpha score was calculated, and it was found to be equal to 0.97, which suggests excellent internal consistency.

5.1. Students' mental well-being

Table 1 presents the number of participants per well-being category. Among the 165 complete responses, the average well-being score is 40.6 (out of the maximum score of 70). When dividing the maximum score of 70 by four equal parts, 41.8% of the respondents are found to have a total score of 35 or lower. Turning to the well-being statements, it appears that 46.1% of the respondents rarely or never feel relaxed. Besides, 41.8% of the respondents indicate they never or rarely have the energy to spare. On a positive note, more than half of the respondents (56.4%) indicate they do often feel optimistic about the future.

5.1.1. Comparing groups

To investigate possible significant differences in well-being scores among the participants, the scores of the participants have been compared according to their socio-demographic characteristics.

The mean well-being score between bachelor ($n = 57$) and master students ($n = 108$) was found to be significantly different ($t(162) = 2.0$, $p = 0.04$). In the sample, master students have, on average, a lower well-being score (39.1) than the bachelor students (43.3) (see Figure 2).

A one-way Anova revealed that the mean well-being score significantly differed between the students with no suitable working environments, inconsistent suitable working environments or proper suitable working environments ($F(2,0) = 3.6$, $p = 0.03$). Students who answered 'no' on whether they had a suitable working environment, were found to have an average well-being score of 35.8, compared to the students who answered 'not consistently' with an average of 37.0 and students who answered 'yes' with an average of 42.5. The distribution between these groups is shown in Figure 3. To confirm the findings, a new analysis without the outliers was performed and p -value of 0.01 indicating a statistical difference between the two means was found (same analysis was performed for the data after removing the outliers and the results remained significant).

Although former research studying student well-being suggested the importance of gender or housing situation (Çetin et al. 2021), surprisingly, no significant difference in average well-being scores was found between the participants when considering these two groups. Furthermore, a remarkable difference was found by GGD, RIVM and Trimbos Institute (2021) indicating a higher rate of psychological complaints indicated by the students with international (non-Dutch) backgrounds, whereas the current study did not find a significant difference in well-being between local/Dutch and the international students.

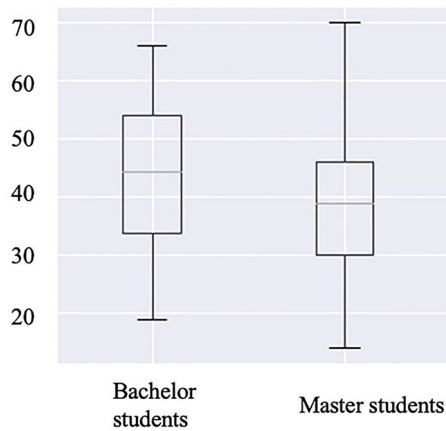


Figure 2. Well-being score distribution per student's degree.

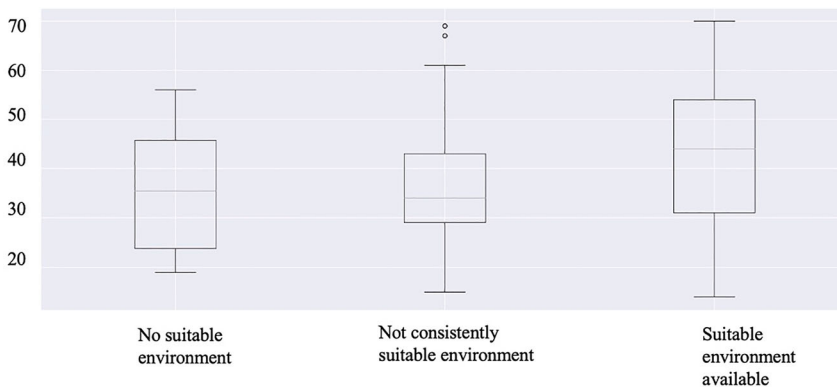


Figure 3. Well-being score distribution per availability of suitable working environment.

5.2. Factors affected students' mental well-being

5.2.1. Course experience

When looking at how aspects of course experience impact well-being, the most important topics appeared to be (unclear or contradictory) instructions relating to assessment and (insufficient) learning resources. 81% of respondents indicate that when the instructions relating to assessments are unclear or contradictory to grading rubrics, it has a moderate or significant negative impact. 72.7% of respondents indicate that they experienced a moderate or significant impact from insufficient learning resources to adequately meet the learning objectives. Furthermore, 43% of the respondents state that they encountered unclear organisation on Brightspace (learning platform) and 42% of respondents encountered that the instructions relating to the assessments were unclear or contradictory to the grading rubrics (Figures 4 and 5).

5.2.2. Thesis

108 respondents in the sample were master students, of which 76 reported on the thesis-themed section of the survey. The most important thesis-related factors impacting well-being are thesis supervision and thesis timelines: 66.7% of the respondents ($n = 51$) reported they have felt a moderate or significant impact of their thesis supervisors not being available and/or not providing

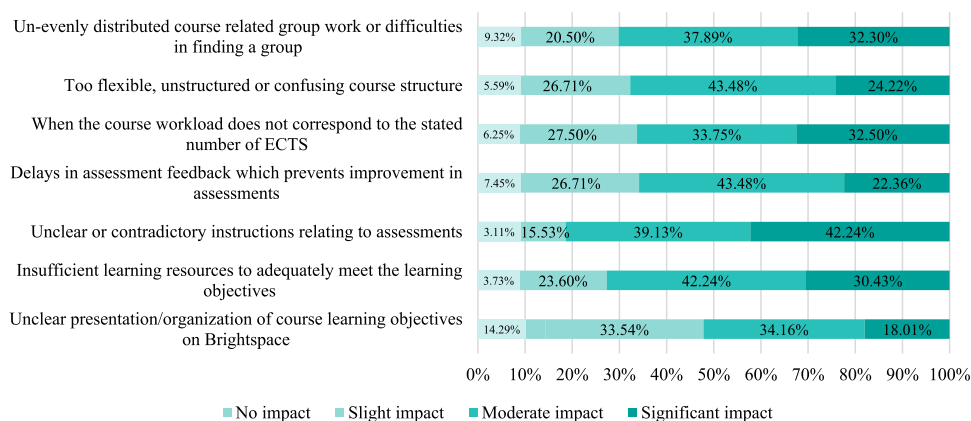


Figure 4. Course-experience related factors and their impact on well-being. Percentage distributions.

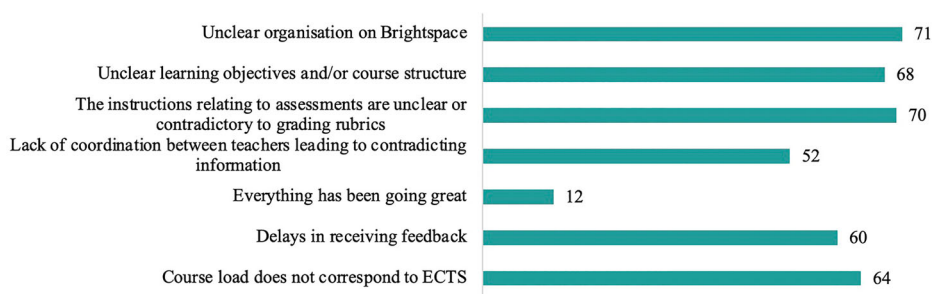


Figure 5. Course-experience related factors and their impact on well-being. Count of students indicating this topic has affected their well-being ($n = 165$).

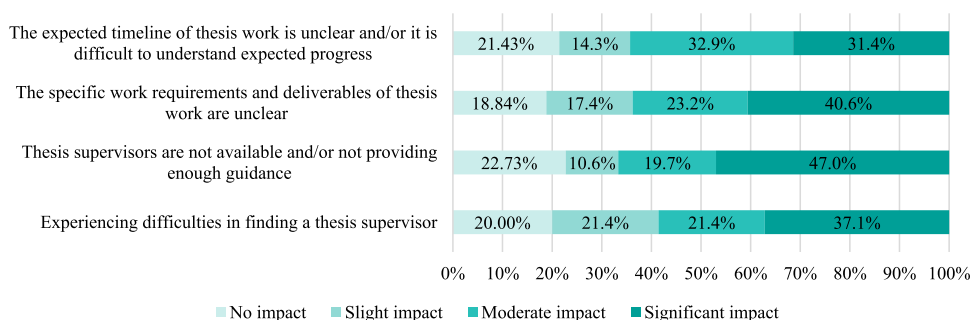


Figure 6. Thesis-related factors and their impact on well-being. Percentage distributions.

enough guidance, and 64.3% ($n = 49$) indicated that the expected timeline of the thesis work is unclear or that it is difficult to understand the expected progress (Figure 6).

Among the master students, 47.4% ($n = 36$) state they encountered difficulties due to unclear research requirements and deliverables, 35.5% ($n = 27$) reported to have had difficulties in finding a thesis supervisor, 35.5% ($n = 27$) reported that the unclear timeline of thesis work and/or difficulty in understanding expected progress have impacted them (Figure 7).

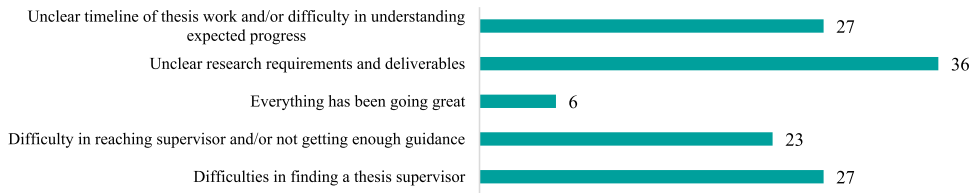


Figure 7. Thesis-related factors and their impact on well-being. Count of students indicating this topic has affected their well-being ($n = 76$).

5.2.3. Communication

Communication, feedback on assessments, transparency in grading, and the availability of the teaching staff are found to be the most important topics impacting well-being. 74.9% of the respondents indicate that receiving inadequate or vague feedback on assessments and/or lack of transparency in grading have had a moderate or significant negative impact, and 64.2% of the respondents indicate that teaching staff being not available and/or difficult to contact has had a moderate or significant negative impact (Figures 8 and 9).

5.2.4. Environment

In terms of the environment, the most remarkable themes are the home studying environment, the availability of study places on campus, and the separation between living and studying spaces. 75% of the respondents indicate that an inadequate home studying environment has had a moderate or significant negative impact on them. 43.1% of the respondents indicate that the lack of separation between living and studying spaces has had a significant negative impact on them. 56.3% of the

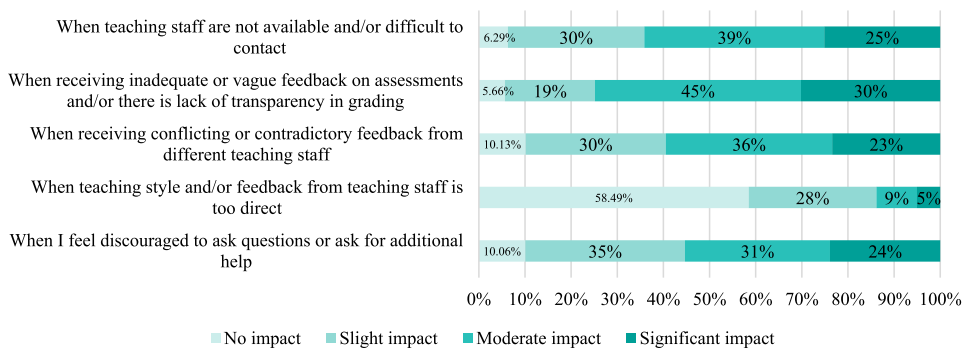


Figure 8. Communication-related factors and their impact on well-being. Percentage distributions.

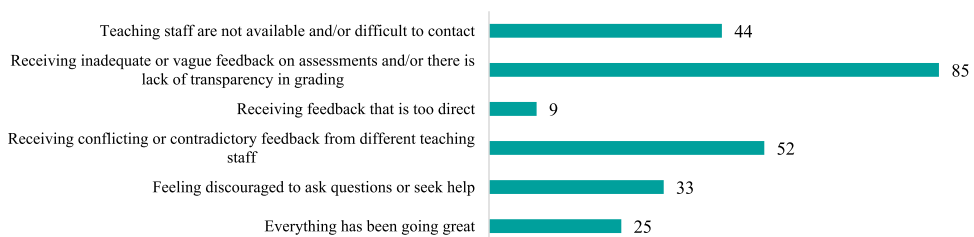


Figure 9. Communication-related factors and their impact on well-being. Count of students indicating this topic has affected their well-being ($n = 165$).

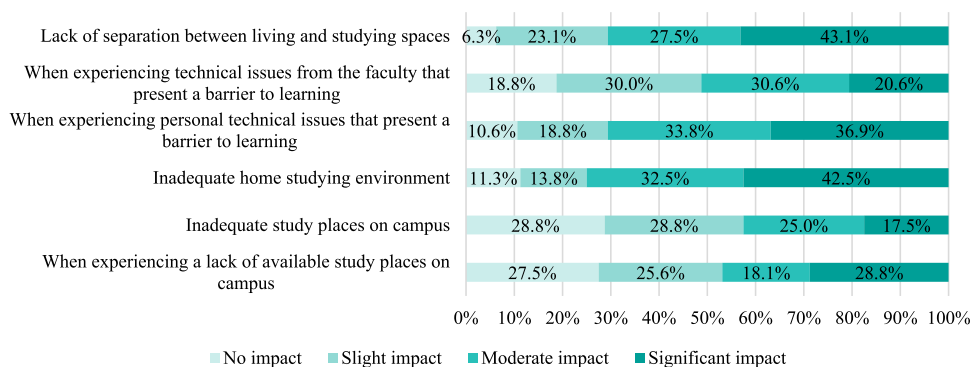


Figure 10. Environment-related factors and their impact on well-being. Percentage distributions.

respondents indicate that the lack of available study places on campus has had a moderate (27.5%) or significant (28.8%) negative impact (Figure 10).

5.2.5. COVID-19

When looking at the COVID-19-related impact, 44.0% of the respondents reported that in their opinion the overall education quality has been reduced due to COVID-19 restrictions either, most of the time or always. Most respondents indicate that the faculty is mostly or always adhering to the COVID-19 measures (73%) (Figure 11). Because there was no follow-up question on education quality, it is uncertain which aspects of education impacted the most.

Turning to the future improvements related to COVID-19 measures, a very large share of the respondents ($n = 143$, 86.7%) indicate that they would like to see the recordings of lectures/discussions/labs remain. While 110 respondents (66.7%) state that they would like to have the freedom to study remotely, a very limited number of the respondents would like to continue online discussion sessions (11.5%) or labs/working sessions (7.3%) remain (Figure 12).

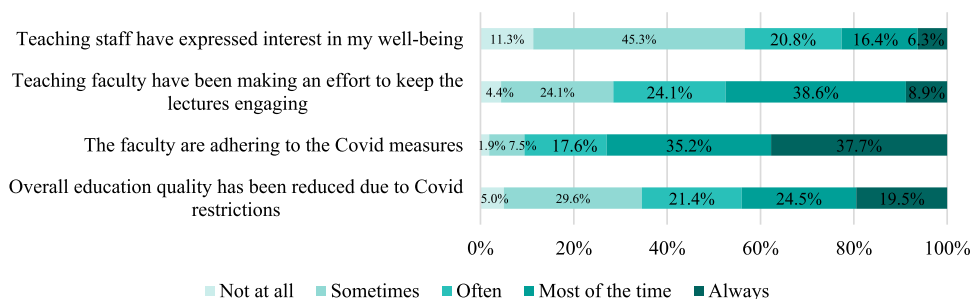


Figure 11. COVID-19-related factors and their impact on well-being. Percentage distributions.

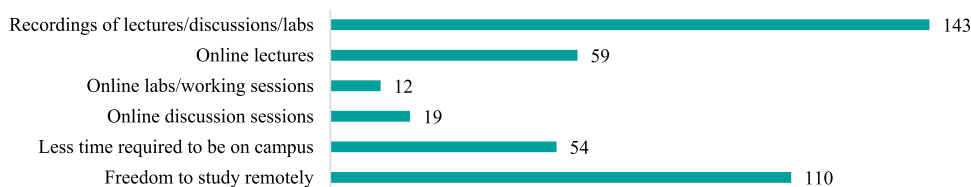


Figure 12. COVID-19-related well-being statements on students' preferences post COVID-19 ($n = 165$).

5.3. Main findings

The main contribution of this work is present in capturing the engineering students' well-being during the COVID-19 pandemic. Their average well-being score was found to be 40.6 (out of 70). The mean well-being score between bachelor ($n = 57$) and master students ($n = 108$) appeared significantly different ($t(162) = 2.0$, $p = 0.04$). In the sample, master students, on average, had a lower well-being score (39.1) than the bachelor students (43.3). By contrasting these numbers with former studies, it can be concluded that the average well-being score is lower than the scores estimated by other researchers. A study from England and Scotland, where a total of 1,650 young people (not only university students) completed the questionnaire, found the mean of WEMWBS score equal to 48.8 (Clarke et al. 2011). Looking at other student populations, Fung (2019) concluded that the mean scores of the WEMWBS for students in China were 47.41. Çetin et al. (2021) found the average well-being score for the student population in Turkey range between 47 and 48, while Mair et al. (2021) explored well-being scores of the UK students and concluded their average to be 47.17.

The second main contribution is connecting different aspects of studying at a technical university to well-being scores. The most critical areas that impacted the well-being of the respondents were related to the course-experience and receiving feedback. Course organisation, clearly stated learning objectives, grading rubrics as well as clear and consistent feedback were some of the most frequently indicated areas that impacted students' well-being.

6. Conclusions and recommendations

The results of this study are in line with the prevalent outcomes of other studies in the student mental well-being field: worrying numbers of students have a low mental well-being and are affected by the consequences of the COVID-19 pandemic.

Although different measurement methods were used, a recent study from the Netherlands also reported an average well-being score just above the sufficient mental health score: 3.6 out of 6 (while current study reports the average mental well-being number to be 40.6 out of 70). Both studies have also shown high rates of stress among the participants (41.6% of the sample in this study, compared to 62% in the Dutch study). A remarkable difference is that the study by the GGD, RIVM and Trimbos Institute (2021) revealed a significantly higher rate of psychological complaints in students with international backgrounds, while the current study did not confirm this finding. It could be due to many factors such as the impact of COVID-19 making the university experience more unfirm for all students.

6.1. Findings on general student population

Current research offers some initial perspectives on student mental well-being at Delft University of Technology. It explores the outcomes of a questionnaire that covers several well-being-related educational themes such as the course experience, communication, and environment. Among the participants, not only the average well-being score was found to be 40.6 (out of 70) but 41.8% of the respondents' well-being was below 35 (out of 70). Besides, it was found that 46.1% of the respondents rarely or never feel relaxed. Because the study did not ask about the pre-pandemic well-being or did not collect medical and often sensitive information on respondents' mental health, it is difficult to assess the findings in a longitudinal context. Furthermore, all data points are self-reported and likely vary per individual. By their personal nature, the statements about levels of feeling relaxed or stressed will have large individual differences, therefore one should be cautious generalising the findings. Nevertheless, the findings provide opportunities and signal universities to further study this topic and devote time and resources to identify whether there is any action that could be taken to improve well-being of the students.

The well-being score between bachelor and master students from the engineering fields was found to be significantly different. In the sample, master students had a lower well-being score

than bachelor students (as confirmed by one-way ANOVA test). This finding suggests an unequal experience between students at different levels at the same university. Because the master students were found to have significantly lower well-being scores, exploring opportunities within that community that relate to the supervision dynamics and master's thesis writing would be of value. Besides, the well-being score also significantly differed between the students with no/inconsistent/consistent suitable working environments. Students with no or inconsistent suitable working environments experience slightly lower well-being. Having identified the two groups of students suggests that a different approach should be recommended for improving well-being of master students, and particularly those with inconsistent study environment. Expanding study spaces and creating more campus-based facilities have potential in improving the environment driven well-being.

For several educational themes, the impact on well-being was investigated, to explore the factors of the highest importance and corresponding improvement opportunities. Looking at the course experience, unclear or contradictory instructions relating to assessments and insufficient learning resources have had the most impact on students from the engineering fields. It is suspected that this finding could be relevant for other universities, particularly because it was not related to the environment that is specific to Delft University of Technology but rather focused on the key course-related challenges that the students were experiencing. The abovementioned findings also suggest the importance of the overall course setup and indicate that the education and how the students perceive it should not be only evaluated in the context of content but also consider other elements such as course layout, logic, and feedback.

Furthermore, the students indicated to have been impacted by inadequate or vague feedback on assessments and/or a lack of transparency in grading. The next most important aspect was the availability of teaching staff. Increasing contact and ensuring communication transparency between the university staff and the students could provide many benefits. Additionally, during the initial interviews with the students and student organisations, the interviewees kept emphasising more practical aspects of university education as opposed to features like staff's empathy or understanding. Because of the abovementioned inputs, the survey did not focus on personality-based traits and targeted only actionable measures like communication, it is likely that there is a considerable unclarity about the factors that the students from engineering fields find important. Therefore, sharing the results with university administration, and supervisors could be valuable to foster positive relationships at the university.

Regarding the environment, the most remarkable theme was the home studying environment: a vast majority of the students (75%) indicated that their inadequate home studying environment has had a moderate or significant negative impact on them. This finding was followed by the availability of study places on campus and the separation between living and studying spaces, which was also discussed above.

44% of the respondents indicated that the overall education quality has been reduced due to the COVID-19 restrictions most of the time or always. Because the survey did not include any follow-up questions, it is uncertain what aspects of education were most impacted. It is also plausible that the perceived decrease in the quality of education could not be controlled by the university, as higher education had to comply with the governmental rules and ultimately became an undesired but unavoidable consequence of the pandemic. Nevertheless, increasing the engagement of teaching staff in the well-being of students could possibly aid in monitoring and improving student well-being.

Although close to 90% of the students indicated an interest in recording of the lectures, the universities should remain cautious to cater to these suggestions because there is an undeniable and intangible gain from social and educational events that require in-person attendance. Potentially finding a balance between an on-demand lectures and physical presence would be recommended but more research on the exact design of the hybrid model would have to be performed. Particularly, the overall model of work-from-home and how the education and employment will form post pandemic is yet to be seen (Barbour, Menon, and Mannering 2021).

6.2. Master thesis

Regarding the master's thesis, it is recommended that the most attention is paid to the availability of the thesis supervisors and the guidance they offer. A large share of the master students (46.4%) reported to experience difficulties in understanding the requirements and deliverables of their thesis project. Here, again a general direction of students' challenges was identified. This challenge could be also present at other institutions, as these questions were not specific to the Faculty of Technology, Policy and Management and the thesis process that is implemented at Delft University of Technology is generally comparable to other top-tier universities. The findings indicate that, many times, the students feel unclear about the process of writing a thesis, and it is plausible that they also feel uncomfortable asking their supervising team about its details. Creating supportive, safe, and robust learning environment for the master students could be especially an important factor in their well-being.

6.3. Future research

Having investigated some of the important topics impacting student mental-well-being, specific actions can be derived to improve student well-being in the future. However, prior to generalising these results and drawing conclusions, more extensive research should be performed on a larger number of observations. Such research could deepen the understanding of the dynamics of communication between the students and their supervisors as well as examine in detail the thesis writing process. Nevertheless, current findings can serve as early findings and guide future research that particularly relates to the master students.

Note

1. The word *faculty* is often an equivalent of the *department* in many other institutions.

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No potential conflict of interest was reported by the author(s).

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