University of Twente
Faculty of Behavioural, Management and Social Sciences (BMS)
Professional Development at the Workplace (HRD)

Bachelor thesis

An examination of how technology-related changes in work characteristics lead to a change in the technostress uncertainty, technostress overload, technostress literacy facilitation and technostress support of university lecturers

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Date: June 30th, 2021

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Abstract

Due to the corona pandemic, many students and thus also lecturers were forced to switch to online teaching. The unexpected changes can trigger technology-related stress, which has consequences such as coronary heart disease, anxiety or depression. This study examines how the shift from face-to-face classes to online teaching changes the technology-related stress experienced by lecturers. The changes in work characteristics are considered to be the main trigger for the technology-related stress and afterwards it was examined to what extent there were differences in the stress level in the different branches of science. Lastly, it was considered whether age plays a role in the perceived stress.

All respondents (*N*=221) came from Germany, with the age ranging from 24 to 70 years old and a gender distribution of 49.3 percent male (*N* = 103), 50.2 percent female (*N* = 105) and 0.5 percent divers (*N* = 1). All respondents were lecturers at universities or colleges and were asked to fill out an online questionnaire. Afterwards, a multivariate analysis was performed to analyse the effect of changes in work characteristics on technostress overload, technostress uncertainty, technostress literacy facilitation and technostress support. Moreover, a UNIANOVA analysis and a linear regression analysis were performed to investigate the moderating effect of the different branches of science and the age of the respondents. The result showed employees who experienced changes in work characteristics were more likely to experience technostress uncertainty. This effect was additionally increased by advancing age. However, the different branches of science did not moderate the relationship between the changes in work characteristics and technostress uncertainty or technostress overload.

Key words: Stress, Technostress overload, Technostress uncertainty, Changes in work characteristics, Branches of science

The Effects of Technology-related Changes in Work Characteristics among Lecturers

Since the beginning of 2020, the COVID-19 virus has started to spread around the world and more and more employers and employees have had to rethink in order to maintain systemically important jobs. The WHO ("world health organization") declared the COVID-19 virus officially as a pandemic on the 11th of March 2020 due to the internationally growing case rates (Velavan & Meyer, 2020) and a lockdown was imposed in many countries which included the closure of daycare centers, schools and universities (MDR, 2020). As a result of the closure of all educational institutions, there was a rethinking of other methods of continuing work. Many schools and universities had to start online lessons within a very short period of time and thus teachers and lecturers had to rethink their usual learning and teaching strategies.

The Changes in Work Characteristics

Since the end of March 2020, according to Amemado (2020), more than 1.7 billion students and pupils around the world need online education as a result of the closure of all educational institutions. In times of the pandemic, this requires a rethinking of teaching strategies and inevitably leads to a change in the work characteristics of lecturers as technology related changes. A clear picture emerges, if one looks at technology from two sides, once technology as "things" and once technology as "human activity". It is important to distinguish between the different types of technologies in order to differentiate more precisely between the changes that have been experienced. The first side, technology as "human activity"; technology is the application of scientific knowledge to practical tasks by humans (Naughton, 1994). Second, according to Beer and Mulder (2020), technology can be described as mechanical or digital devices, systems or tools. In this case, technology-related changes describe all changes that take place on the digital level of work, such as the switch from face-to-face classes to online education.

These technology-changes in work characteristics can be manifold. In the case of lecturers in times of the pandemic, however, the main focus of the changes lies in the workload, mental work and the autonomy they experience (Beer & Mulder, 2020). The fact that lecturers now have to switch from face-to-face classes to online teaching increases the amount of work they have to cope with. This also includes the mental work, which is increased by the new requirements of online teaching, which may still have to be acquired in the first place. However, workload focuses on all external work that arises, such as preparing the teaching materials and mental work focuses on the internal work of the lecturers, such as the learning of new technologies. Finally, the switch to online teaching also changes the autonomy of the lecturers, as the self-determination of the type or method of teaching is withheld from them (Beer & Mulder, 2020).

If these changes are examined more closely using the job-demand control model (JDC model) by Karasek (1975), the results of these technology-related changes become apparent. The two dimensions of the JDC model show on the one hand the psychological job demands such as job stressors like workload and on the other dimension job control which refers, for example, to the possibilities which lecturers have to decide on how to meet these job demands. This also includes, for example, the autonomy (Verhofstadt, Baillien, Verhaest & De Witte, 2015). The JCD model states that high job demands and low job control can lead to impaired well-being and high strain of those affected (Verhofstadt, Baillien, Verhaest & De Witte, 2015). In this case, those affected are the lecturers, who suffer from increased workload and mental work due to the technology-related changes and at the same time experience reduced autonomy with regard to their way of working.

Technology-related Stress and its Consequences

This new task of the systematic and organized application of technology has resulted in an increase in the level of forced dependence on technology among lecturers. Employees, in this case lecturers, have to constantly get used to new applications, workflows and functionalities (Ragu-Nathan, Tarafdar, Ragu-Nathan & Tu, 2008). This raises the question of what the consequences of the technology-related changes are. The phenomenon that can occur is called technostress, which by definition means: "technostress relates to the phenomenon of stress experienced by end users in organizations as a result of their use of information and communication technologies" (Ragu-Nathan, Tarafdar, Ragu-Nathan & Tu, 2008, p. 417-418). Generally, it can be said that perceived stress is "the general perception that environmental demands exceed perceived capacity regardless of the source of the environmental demand" (Richardson, Shaffer, Falzon, Krupka, Davidson & Edmondson, 2012). Possible consequences of the increased dependency and use of technologies are, for example, the variables technostress overload and technostress uncertainty dealt with in this thesis.

Technostress overload describes the state that lecturers experience because of the continuous accessibility through the technologies, but also the additional work that arises from the use. Technostress overload is therefore said to be a technostress creator (Ragu-Nathan, Tarafdar, Ragu-Nathan & Tu, 2008). This means that the changes in work characteristics, which are expressed in the increased and more permanent use of technologies, could trigger technostress overload. If one looks at the JDC model here, job demands are supposed to promote the motivational process of employees. However, if the demands are too high for the employee and his or her capacities, damage to health can occur (Verhofstadt, Baillien, Verhaest & De Witte, 2015). The changes in work characteristics, namely the rapid shift from face-to-face classes to online education, can therefore have triggered difficulties for many lecturers, which exceed their own capacities. They experience a significantly higher workload and have to do even more mental work (Beer & Mulder, 2008). Among other things, all of this can trigger insecurity, stress or burn-out (Ingusci et al., 2021).

The second variable, which is also technostress creator, is technostress uncertainty, which measures the changes in updates, hardware and software in an organization and with that the resulting fluctuating uncertainties of the employees. Another definition comes from (Li & Wang, 2021): "Technostress uncertainty describes situations where university teachers feel unsettled about the integration of ICT in their work, which creates ambiguous work requirements and expectations". The uncertainty of lecturers mostly comes from the pressure from outside to always have the latest technologies, with which they are often not familiar (Ingusci et al., 2021). The uncertainty that is triggered often means that lecturers are exposed to an increased mental workload and experience reduced autonomy (Beer & Mulder, 2008). This can result in a lower intention to use technologies and they also experience lower work performance from the lecturers (Li & Wang, 2021).

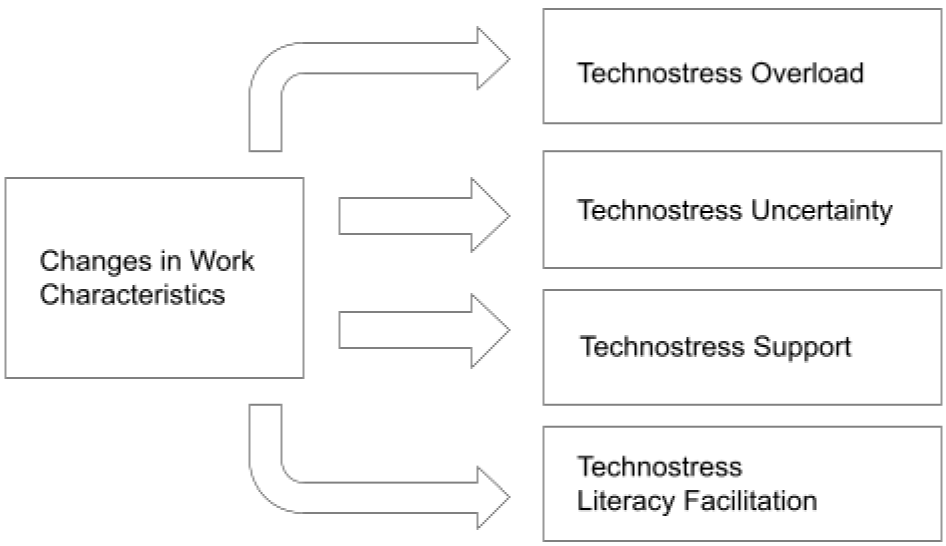
On the other hand, there are two other variables that are said to have a negative effect on the stress experienced through technology. The first variable is technostress support and the second technostress literacy facilitation. Technostress literacy facilitation is an inhibitor of the stress experienced that is triggered by technology and thus a moderator variable. Inhibitors describe organizational processes that reduce the decrease in job satisfaction of employees triggered by technostress creators (Tarafdar, Bolman Pullins & Ragu-Nathan, 2014). Generally, it can be said that literacy facilitation refers to mechanisms which increase the level of ICT literacy of an employee (Fuglseth & Sørebø, 2014). These mechanisms are the aforementioned changes in work characteristics and are for example applications that are introduced or the involvement of employees in technology implementation decisions (Tarafdar, Bolman Pullins & Ragu-Nathan, 2014). According to Califf and Brooks (2020), a collaborative workplace culture can also be a mechanism of technostress literacy facilitation that inhibits stress, because here employees encourage each other to share and facilitate knowledge, general advice or skills for technologies at the workplace. All of these mechanisms contribute to the fact that the end user, in this case employees or lecturers, is literate about using technology for their work, making it easier for them to cope with problems associated with the technologies on their own (Califf & Brooks, 2020). Through the increased use of literacy facilitation mechanisms, it is possible to reduce the effects of the changes in work characteristics like workload and mental work of lecturers and thereby reduce the stress experienced at the same time. The inhibitor effect of literacy facilitation often reduces the perception of complexity about the technologies, uncertainties or the overload experienced by employees (Califf & Brooks, 2020).

Technostress support is also an inhibitor and thus a moderator of experienced stress through technology. It evaluates the support that employees receive from their organization, especially IT support and with that the supporting change in work characteristic. As soon as employees are given the opportunity to receive special training in the area of the technologies used or receive technical support, the effects of technostress are reduced (Ahmad, Amin, & Ismail, 2014; Özgür, 2020). The other way around, however, it can also be said that insufficient technical support increases the effects of technostress. More precisely, insufficient technical support was the second largest cause of higher work stress (Ahmad, Amin, & Ismail, 2014). The IT support received from universities or colleges also reduces the stress experienced by lecturers. Further training in the area of the used technologies and the opportunity to get help with the IT service relieve lecturers of a lot of mental work with which they would have to deal with alone otherwise.

Taken together, it can be said that four variables are triggered by the changes in work characteristics. First, the two technostress creator variables are technostress overload and technostress uncertainty which should have a positive effect on the technology-related stress experienced by the lecturer in the end. Second, the two inhibitors technostress literacy facilitation and technostress support which should have a moderating effect on the two technostress creators and thereby reduce the technology-related stress experienced by the lecturers. The relationships are displayed in Figure 1.

Figure 1

The relations between the independent variable changes in work characteristics and the dependent variables technostress overload, technostress uncertainty, technostress support and technostress literacy facilitation.



Hence, the main research question is:

"*To what extent do technology-related changes in the work characteristics of university lecturers lead to a change in technostress uncertainty, technostress overload, technostress literacy facilitation and technostress support?*"

Different Branches of Science

Each subject area brings its own challenges that a lecturer has to master and every branch of science has different requirements for conveying the learning material (Fatonia, Nurkhayatic, Nurdiawatid, Fidziahe, Adhag, Irawanh & Azizik, 2020). Generally, it can be said that all branches of science can be divided into four categories: humanities, natural sciences, technical sciences and social sciences.

The humanities subjects include language subjects such as German and English, but also pedagogy, history and medical humanities. It is precisely in these subjects that it has often been noticed that students underestimate how much they actually have to read, whereby this is generally central to learning in the humanities sector (Maher & Mitchell, 2010). This breadth of requirements often causes uncertainty among students (Maher & Mitchell, 2010). Especially with medical humanities subjects, it is important that the students learn to understand and critically reflect on their professions in order to develop as much self-awareness as possible (Shapiro, Coulehan, Wear & Montello, 2009). The reason for this is that in these subjects there is also the fact that in the future they will work with people. Therefore, it can be said that it is important for the humanities sector that students can exchange ideas with one another in order to develop self-reflection, but also to support one another. Regular face-to-face classes, discussions and lectures can help to maintain contact and motivate the students again and again and bring them up to date.

The natural sciences include subjects such as astronomy, physics, chemistry and biology. Natural sciences can be defined as scientific subjects that deal with objects, phenomena and the laws of nature and the physical world (Bosman, 2006) with the aim of promoting scientific literacy. Bosman (2006) defines scientific literacy as follows: "Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity". By studying natural sciences, students should be able to collect, analyze and critically evaluate information and then effectively communicate the results through visual, symbolic or language skills (Bosman, 2006). Motshoane (2006) adds that another essential point is that the results have a certain validity and credibility. It is therefore particularly important in this department to focus on demonstrations and experiments (Motshoane, 2006). In summary, it can be said that for natural sciences it is important to broaden the horizons of the students through live demonstrations of experiments and to control their results in order to ensure validity and credibility.

Subjects of technical science include physics, technology, engineering or mathematics. There are several definitions of what technical sciences encompass. According to Sebestik (1983) technical sciences is "the science which teaches how to treat the natural products, or the knowledge of the handicrafts". Another definition comes from Voogt, Fisser, Pareja Roblin, Tondeur and van Braak (2013) who state that technical sciences teach procedural knowledge and thus also operational skills which are needed to work with technology, but also to solve problems independently. Both definitions explain the importance of the operational skills which are required in this subject area and the important component of technologies. It is just as important here that work is carried out in a systematic order, true principles are taken into account and everything is explainable (Sebestik, 1983). What has turned out to be helpful in this subject area is the active involvement in the lessons, as well as modeling and microteaching (Voogt, Fisser, Pareja Roblin, Tondeur & van Braak, 2013).

Last but not least: social sciences. Subjects that fall under this subject area are, for example, psychology, special education, political science or social work. In this department, too, it has been found that reading and practice are central to learning and that uncertainty about the quantity and quality of the things to be learned quickly arises (Maher & Mitchell, 2010). It is therefore particularly important in this domain that the students are offered opportunities to develop and practice skills in social scientific reasoning (Caulfield & Caroline, 2006). Lecturers are therefore advised to structure their lessons in such a way that the interests of the students are stimulated and active involvement takes place. One method that has proven to be particularly effective in this field is group-based learning. This enables students to actively participate and to practice their practice and social skills (Caulfield & Caroline, 2006).

Based on the descriptions of the individual branches of science, it becomes clear that each individual area pursues a different teaching objective and that this creates differences in the conveying of the teaching unit. Each department teaches on a different level, for example in the experimental area, in the craft area or in a social area. A change in the teaching method can therefore also have different effects on the departments. Due to the technology-related changes in the last few months, it was no longer possible for all branches of science to continue teaching as usual. It is therefore possible that natural sciences experience the greatest influence, because it is no longer possible here to perform experiments and live demonstrations or even to carry them out together with the students. Technical sciences cannot continue the lessons as usual either, because modeling is omitted here and active involvement proves to be difficult. Social sciences and humanities are probably not that difficult, because group-based learning and discussions can also be carried out in online lessons.

Figure 2 shows the moderating effect that the branches of sciences have between the changes in work characteristics and technostress overload and technostress uncertainty. In order to investigate these considerations further, the current study is designed to determine whether the branches of science act as a moderator with regard to the stress created by the technology-related changes. It is hypothesized that:

H1a: *The changes in work characteristics have the greatest influence on technostress uncertainty for lecturers in the domain of natural sciences*

H1b: *The changes in work characteristics have the greatest influence on technostress overload for lecturers in the domain of natural sciences*

H2a: *The changes in work characteristics have the second greatest influence on technostress uncertainty for lecturers in the domain of technical sciences*

H2b: *The changes in work characteristics have the second greatest influence on technostress overload for lecturers in the domain of technical sciences*

H3a: *The changes in work characteristics have the second least influence on technostress uncertainty for lecturers in the domain of social sciences*

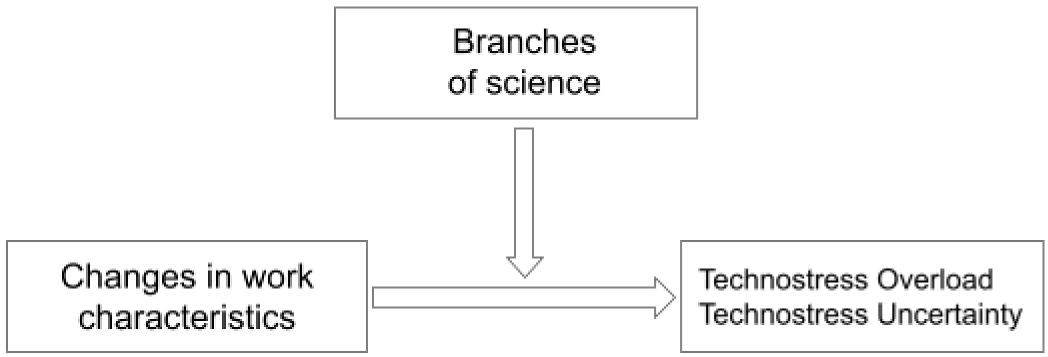
H3b: *The changes in work characteristics have the second least influence on technostress overload for lecturers in the domain of social sciences*

H4a: *The changes in work characteristics have the least influence on technostress uncertainty for lecturers in the domain of humanities*

H4b: *The changes in work characteristics have the least influence on technostress overload for lecturers in the domain of humanities*

Figure 2

The moderating effect of branch of science on the relationship between changes in work characteristics and technostress overload and technostress uncertainty



The Role of Age

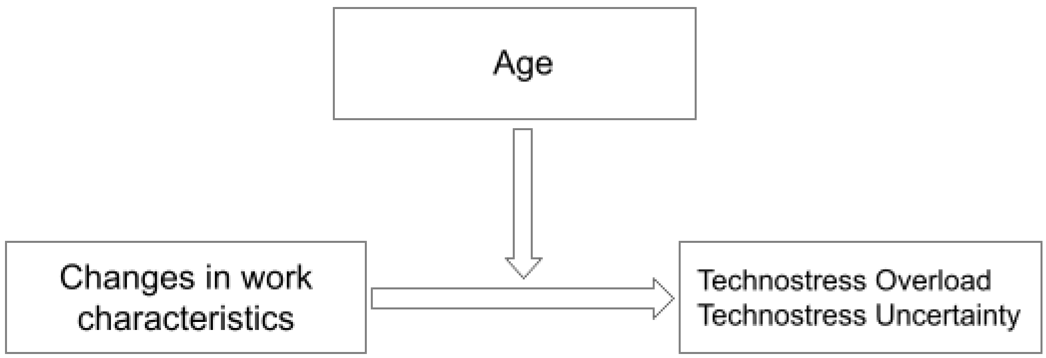
Another factor that could moderate the relationship between the technology-related changes in work characteristics and technostress uncertainty or technostress overload is age. According to Hauk, Göritz and Krumm (2019) the moderating influence of age on perceived stress tends to be rather positive, meaning that the older a person is, the higher the probability that they will experience an increased stress level due to technology. This positive influence could have two reasons. The first one is that the aging of a person is also related to the physical degeneration processes of the body. This physical degeneration also includes the slow loss of hearing and vision as well as the loss of fine motor skills. However, it is precisely these skills that are required to effectively use technologies (Hauk, Göritz & Krumm, 2019). Moreover, Tams (2011) adds the second reason that supports the positive influence of age on the perceived stress. The cognitive workload that people experience when they learn something new triggers more psychological stress in older people than in younger people. This means that it is mentally more difficult for older people to learn new technologies than for younger people. A reason for that could be that older people are more likely to rely on familiar methods and embroider more strongly to a conventional work environment. This often triggers a higher level of resistance in older people and many feel challenged or overwhelmed more quickly by new technologies (Tams, 2011). Therefore, the expectation arises that

H5: *The changes in work characteristics trigger less technostress overload for younger lecturers than for older lecturers*

H6: *The changes in work characteristics trigger less technostress uncertainty for younger lecturers than for older lecturers*

Figure 3

The moderating effect of age on the relationship between changes in work characteristics and technostress overload and technostress uncertainty



Methods

Respondents

This quantitative study focused on university lecturers and how they perceived the technology-related turnaround since January 2020. During the data collection, a total of 221 responses were collected, whereas 12 were deleted because of e.g. missing answers. The age of the respondents ranged from 24 to 70 years old (*M* = 41.21, *SD* = 11.37) with a gender distribution of 49.3 percent male (*N* = 103), 50.2 percent female (*N* = 105) and 0.5 percent divers (*N* = 1). All respondents came from Germany and 197 universities and colleges were contacted from all 16 federal states. These included 11 respondents from the humanities sector (5.3%), 122 respondents from the social sciences sector (58.4%), 43 respondents from the technical sciences sector (20.6%), 32 respondents from the natural sciences sector (15.3%) and 1 respondent from another sector (0.5%). Table 1 shows the teaching experience of the respondents in years. Seen here is that the years of experience ranged between 1 and 40 years (*M* = 10.50, *SD* = 8.50).

Moreover, Table 2 summarizes the functions of the respondents. All respondents were reached through convenience sampling.

Table 1

The age and teaching experience of the respondents

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Age	209	24	70	41.21	11.37	129.27
Teaching experience in years	207	1	40	10.50	8.50	72.32
Values	203					

Table 2

Functions of the respondents in percentage

	0	Scientific assistant	Academic adviser	External lecturer	Other
N	1	145	11	31	21
%	0.5%	69.4%	5.3%	14.8%	10.0%

Materials

An online questionnaire was used for this study, which was opened on the online platform questback. The aim of the questionnaire for this study was to find out in which branch of science the lecturers or assistants work, as well as to what extent they have experienced the perceived stress caused by the technology-related changes in their work characteristics. In general, the questionnaire consisted of several parts and began with a brief introduction to the study and contact details which the respondents could use to contact someone if they had any questions. This was followed by active informed consent, in which the respondents gave their consent by ticking one box. Followed by questions about the activities in the summer semester 2020, the changes in work in the summer semester 2020, up to questions about the emotions that the respondents perceived as a result of the changes. Finally, demographic questions were asked, including questions about the type of organization, branch of science, function at the organization, qualifications, teaching experience over the years, gender, age and which federal state the respective respondent comes from. In total, the online questionnaire consisted of 96 questions, which measured the following different variables.

The principal axis factor analysis with oblique rotation with 10 fixed effects (N=188) achieved a Kaiser-Meyer-Olkin measure of .79, $p < .001$ The factors accounted for 66.92 per cent of the total explained variance. Moreover, the visual examination of the factor loadings showed that the items were clustered in the intended manner. No factor loadings are reported in this thesis because of confidentiality purposes.

Professional Development. The first variable that was measured was the dependent variable professional development with three different sub-constructs. This variable was developed based on Simons & Ruijters (2004). The respondents were asked to indicate on a Likert scale from -3 'much less often' to +3 'much more often' how often they performed the listed activities within the digital semester compared to the previous semesters. The first sub-construct is ‘individual learning activity’ with a total of 6 items and a Cronbach's alpha of .79. An example item is "*implemented and checked ideas that I have newly developed, in mener teaching*". The second sub-construct is ‘social learning activity’ with a total of 5 items and a Cronbach's alpha of .77. As an example item there is "*talked to colleagues about my behavior as a teacher*". For the first two constructs, Cronbach's alpha can be perceived as acceptable internal consistency. The third construct of the variable is ‘externalization’. This construct measures a total of 5 items and has a good internal consistency with a Cronbach's alpha of 0.81. An example of this construct is "*Organizing the exchange of information among colleagues*".

Work-related reflection. The second tested variable is the dependent variable work-related reflection, which was published by Mulder and Messmann (2015). This variable was measured by using a Likert scale with -3 equal to 'much less often' and +3 'much more often' and was intended to measure what the respondents do in the course of their work in order to question or control work tasks, goals, processes and results. The respondents were asked to compare the listed activities within the digital semester with the previous semesters. This variable was again measured by three sub-constructs. The first sub- construct is 'task-related reflection' consisting of a total of 5 items and an acceptable Cronbach's alpha of .76. An example item is "*Think about to what the results and further steps which I do in my work lead to*." Furthermore, 'context-related reflection' with a total of 4 items and a questionable internal consistency of the Cronbach’s alpha of .66. "*Thinking about whom I could get support or inspiration from for a work task*" is an example item for this sub-construct. Finally, 'competence-related reflection', which was measured with a total of 5 items showing good internal consistency with a Cronbach's alpha of .83. An example of this construct is "*Thinking about the extent to which I have the skills required for various work tasks*."

Change in work characteristics. Next, the independent variable changes in work characteristic was measured. This section dealt with the changes that have taken place in the respondent's work during the digital semester. The respondents were asked to indicate on the Likert scale from -3 'greatly decreased' to +3 'greatly increased' to what extent the use of technologies had changed the following aspects compared to their everyday work in the previous semesters. There were a total of 20 items that had to be answered, with a Cronbach's alpha of .83 and thus a good internal consistency. Examples of the items are for example "T*he lack of clarity about what my work tasks are has ...*" or "*The level of physical activity that is necessary to get to my work place and back home has ...*"

Organisational learning culture. The next variable that was measured is the moderator variable organizational learning culture. This variable was created based on the dimensions of the learning organization by Marsick and Watkins (2003) and Kortsch and Kauffeld (2019). With a Cronbach's alpha of .92 it has an excellent internal consistency. In this section, the respondents were asked to answer a total of 21 items, on the Likert scale from 1 'does not apply at all' to 6 'fully applies', to what extent the following items apply to their university according to their personal perception. These included items such as "*In my university you also ask what other people think when you present your point of view*" or "*My university gives people control over the resources they need to successfully complete their work.*"

Self-efficacy. After the independent, dependent and moderator variables have been measured, the control variables are now measured in the following section. The first variable is self-efficacy by Rigotti et al. (2008) which is measured by a total of 6 items and a good internal consistency with Cronbach's alpha of .88. The respondents were asked to indicate on the Likert scale from 1 'does not apply at all' to 6 'fully applies' to what extent items such as "*I am relaxed about professional difficulties because I can always rely on my abilities*" hold to be true.

Technical support. Another control variable measured in this section is technical support. This variable was based on Raghu-Nathan et al. (2008) and was again measured using the Likert scale. The respondents were asked to indicate from 1 'does not apply at all' to 6 'fully applies' to what extent the four items applied to them and their work environment in the last six months. With a Cronbach's alpha of .92 this variable shows an excellent internal consistency. An example item for this variable is "*Our IT support does a good job answering questions about technology*."

Attitude towards change. The last control variable that was measured is attitude towards change which was based on Oreg (2006). This variable has a Cronbach's alpha of .87 and thus a good internal consistency. The respondents were asked to think about the changes in their work in the past semester and then to answer a total of 15 items. Again, they were asked to define their answers on a Likert scale from 1 'does not apply at all' to 'fully applies'. Example items for this variable are "*I was afraid of changes*" or "*I was stressed by the changes*".

Technostress Overload. As part of this bachelor thesis, four new variables were created from the variables and items already described, which are now presented. The first variable created is technostress overload, which investigates how overwhelmed the respondents are by the required use of the technologies and is measured on a Likert scale from -3 'greatly decreased' to +3 'greatly increased'. This variable is measured with four items and has a Cronbach's alpha of .84 and thus shows a good internal consistency. An example item is "*I felt the technology forced me to do more work than I could actually handle.*"

Technostress Uncertainty. The second variable is technostress uncertainty which measures the changes in updates, hardware and software in the organization and is measured on a Likert scale from -3 'greatly decreased' to +3 'greatly increased'. With a total of four items, this variable has a Cronbach's alpha of .92 and thus shows an excellent internal consistency. The following is an example item: "*The technologies that we use in our university have been updated continuously*". Both of the variables technostress overload and technostress uncertainty should have a positive influence on the stress experienced by the respondents.

Technostress Support. Next, the variable technostress support which examines the support that the respondents receive from the IT support of their facility. A total of four items were used here and again it was measured on a Likert scale from -3 'greatly decreased' to +3 'greatly increased'. The variable has a Cronbach's alpha of .83, which indicates a good internal consistency. An example item is: "*Our IT support did a good job answering questions about technology.*" This variable is said to have the potential to lower the effects of technostress and thus to be a technostress inhibitor.

Technostress Literacy Facilitation. Last but not least, technostress literacy facilitation, which measures the university's overall support for coping with technology problems. It is measured on a Likert scale from -3 'greatly decreased' to +3 'greatly increased' and has five items with a Cronbach's alpha of .77, and thus an acceptable internal consistency. A possible example item here is: "*Our university provided end users with clear documentation on the use of new technologies*." "*Technostress literacy facilitation*" should have the effect of lowering the experienced technostress of the respondents.

Procedure

To reach the respondents for this study, convenience sampling was used. For this purpose, various universities from all federal states were selected, where the scientific staff can be contacted by email. A prepared email was sent to several academic staff members at a university at the same time. This email contained a link, which the academic staff members can follow, which leads to the online platform questback and thus to the questionnaire. The entire questionnaire takes an estimated 20 minutes and all data is analyzed with SPSS after the data gathering is finished. All data was gathered between february 2021 and may 2021.

Data analysis

At the beginning of the data evaluation, some items of the variable changes in work characteristic and the sub variables technostress overload, technostress uncertainty, technostress literacy facilitation and technostress support were recoded. A factor analysis was carried out with the recoded items in order to identify possible underlying factors. Then, the mean of each variable was calculated with the SPSS mean option and the same items. Afterwards, the correlations among the variables were established. The reliability was calculated for the new variables technostress uncertainty, technostress overload, technostress support and technostress literacy facilitation.

To answer the research question: "*To what extent do technology-related changes in the work characteristics of university lecturers lead to a change in technostress uncertainty, technostress overload, technostress literacy facilitation and technostress support?*" a multivariate analysis with the independent variable changes in work characteristics and the dependent variables technostress overload, technostress uncertainty, technostress literacy facilitation and technostress support was performed. This tested whether the changes in work characteristics actually changed the stress level of the respondents.

To test the effect of branches of science on the dependent variable technostress overload, technostress uncertainty, a contrast analysis was performed. Afterwards, in order to test the moderating effect of branches of science for the hypotheses H1a - H4b, an UNIANOVA analysis with an interaction effect was carried out with the dependent variables technostress overload, technostress uncertainty and the independent variable changes in work characteristic.

Lastly, in order to test the moderating effect of age for the hypotheses H5 and H6, a multivariate analysis with an interaction effect was performed with the dependent variables technostress overload, technostress uncertainty and the independent variable changes in work characteristics.

Results

This section first presents the descriptives of the study variables. Then, the results of the multivariate analysis are presented, which aimed at answering the research question: "*To what extent do technology-related changes in the work characteristics of university lecturers lead to a change in technostress uncertainty, technostress overload, technostress literacy facilitation and technostress support?* ". Then, the moderating variables branches of science are discussed and the results of the contrast analysis and the UNIANOVA analysis are presented. Finally, the results of the linear regression analysis are depicted to determine the moderating effect of age.

Descriptives of study variables

Descriptive statistics of the study variables are presented in Table 3. The first variable is changes in work characteristics which describes the technology-related changes in work characteristics of the respondents. Technostress overload is the variable that describes the stress that is triggered by the overstrain of the respondents by the technologies. This variable is therefore a technostress creator. Technostress uncertainty describes the changes in technology within an organization and the associated insecurity of the respondents. The penultimate variable is technostress support which measures the IT support that the respondents receive in regard to the technologies. This variable is a technostress inhibitor. The last variable is technostress literacy facilitation and measures the university's overall support from the respondents organisations for coping with technology problems. Finally, the variable age which records the age of the respondents and determines the influence on the stress experienced.

The descriptive analysis of the variables determines mean values from -1.35 to .36 for the changes in work characteristics and the four dependent variables technostress overload, technostress support, technostress literacy facilitation and technostress uncertainty. The mean values illustrate that on average, lecturers do not experience technology-related changes in work characteristics (*M*=-.01, *SD* =.37). Negative mean values indicate a decrease in the dependent variable, positive mean values an increase in the dependent variable.

The correlation matrix displayed a significant positive correlation between technostress uncertainty and changes in work characteristics. This shows that lecturers who experience changes in their work environment on average also experience technostress uncertainty. Furthermore, the correlation matrix displayed a significant positive effect between technostress uncertainty and the variables technostress support and technostress literacy facilitation. This means that lecturers who experience uncertainty, on average also experience IT support and organizational support for the technostress. The correlation matrix also displayed a significant positive correlation between technostress literacy facilitation and technostress support, meaning that lecturers who receive IT support on average also receive organizational support. Finally, the correlation matrix shows that age has a significant positive correlation with changes in work characteristics.

Table 3

Correlation Matrix and descriptive statistics

	1.	2.	3.	4.	Age	Mean	Std. deviation
Changes in work characteristic	.047	.106	.155*	.015	.169*	-.01	.37
1. Technostress overload					-.025	-.85	1.32
2. Technostress support	-.015				.091	.36	1.37
3. Technostress uncertainty	.040	.294*			-.075	-1.35	1.04
4. Technostress literacy facilitation	-.127	.506*	.453*		.087	-.64	1.20
Age						41.62	11.445

*. Correlation is significant at the 0.05 level (2-tailed).

The predictive role of technology-related changes in understanding perceived technology-related stress

To determine to what extent technology-related changes in the work characteristics of university lecturers lead to a change in technostress uncertainty, technostress overload, technostress literacy facilitation and technostress support, a multivariate analysis was conducted. Here, the independent variable is changes in work characteristics and the dependent variables are technostress overload, technostress uncertainty, technostress literacy facilitation and technostress support. The results illustrated that the overall model was not significant with Wilk's $\Lambda = 0.956$, partial $\eta2 = .044$, and *p*. = .056. Inspection of the individual parameters indicated that technology-related changes positively predicted technostress uncertainty, with F (1,206) = 5.898; p = .016; partial η2 = .03. This means that on average, people who experience technology-related changes in their work characteristics are more likely to also experience technology-related uncertainty. Meaning that lecturers who experience technology-related changes in their work characteristics also often experience technology-related stress and uncertainty. Taken together, it can be said that the technology-related changes in work characteristics of university lecturers lead to a change only with technostress uncertainty. All other variables showed no significant effect and therefore also no change due to the technology-related changes.

Table 4

The effect of changes in work characteristics on technostress overload, technostress uncertainty, technostress support and technostress literacy facilitation

	F	*b*	*p*
Changes in work characteristics and technostress overload	.86	.24	.355
Changes in work characteristics and technostress uncertainty	5.90	.45	.016*
Changes in work characteristics and technostress support	2.33	.41	.128
Changes in work characteristics and technostress literacy facilitation	.06	.06	.813

The moderating role of different branches of science in the predictive role of technology-related changes in understanding perceived technology-related stress

In order to investigate the hypotheses further, a UNIANOVA analysis with an interaction effect was carried out first. Here, the independent variable was changes in work characteristics and the dependent variables were technostress uncertainty and technostress overload. For the interaction effect the moderating variable branches of science was used. This UNIANOVA analysis served the purpose of determining the general influence of the branches of science on the relation between changes in work characteristics and technostress uncertainty and technostress overload. The results illustrated that the overall model was not significant with F (1, 208) = 1.110; p = .293 for the main interaction effect of branches of sciences on technostress overload. However, the results illustrated that the overall model was significant with F (1, 209) = 5.228; p = .023 for the main interaction effect of branches of sciences on technostress uncertainty.

In order to inspect the individual parameters more closely and to test the hypotheses, a post hoc analysis with contrasts was performed. Here, the independent variable was changes in work characteristics and the dependent variables were technostress uncertainty and technostress overload. The variables that were used for the contrasts are humanities, social sciences, natural sciences and technical sciences. The Post hoc analysis with contrasts indicated that humanities significantly moderated the relationship between changes in work characteristics and technostress overload with F (3, 214) = 2.091; p = .029. This means that on average, lecturers who teach in the humanities sector are more exposed to technostress overload than lecturers in the other three domains. Consequently, it can be said that there is no significant main moderating effect of different branches of sciences on technostress uncertainty and technostress overload. However, a closer inspection revealed a significant difference between the humanities domain and the other three branches of science on technostress overload. Still, all hypotheses are rejected.

Table 5

The effect of branches of science on changes in work characteristics

Technostress overload	F	*b*	*p*
Changes in work characteristics	.22	-.24	.637
Branches of science	.18	-.10	.181
Changes in work characteristics and branches of science	1.05	.21	.306

Technostress uncertainty			
Changes in work characteristics	.80	.35	.372
Branches of science	.26	.03	.614
Changes in work characteristics and branches of science	.07	.04	.798

Table 6

The moderating effect of different branches of science on changes in work characteristics and technostress overload or technostress uncertainty

	p
Changes in work characteristics and technostress overload in humanities	.029*
Changes in work characteristics and technostress uncertainty in humanities	.832
Changes in work characteristics and technostress overload in natural sciences	.251
Changes in work characteristics and technostress uncertainty in natural sciences	.064
Changes in work characteristics and technostress overload in technical sciences	.662
Changes in work characteristics and technostress uncertainty in technical sciences	.489
Changes in work characteristics and technostress overload in social sciences	.498
Changes in work characteristics and technostress uncertainty in social sciences	.090

The moderating role of age in the predictive role of technology-related changes in understanding perceived technology-related stress

To determine whether age has a moderating effect on technostress uncertainty or technostress overload, a multivariate regression analysis with an interaction effect was conducted. Here, the independent variable was changes in work characteristics and the dependent variables were technostress uncertainty and technostress overload. To measure the moderating effect the variable age was used. The results illustrated that the overall model was not significant with F (2, 203) = 2.387, and p = .095. However, inspection of the individual parameters indicated that age significantly moderated the relationship between changes in work characteristics and technostress uncertainty, with F (1, 204) = 4.738 and p = .031. This means that on average, older lecturers who experience more technology-related changes in work characteristics are more likely to experience uncertainty regarding the technologies they are forced to use. In conclusion, it can therefore be said that the hypothesis H5: *The changes in work characteristics trigger less technostress overload for younger lecturers than for older lecturers* can be rejected and the hypothesis H6: *The changes in work characteristics trigger less technostress uncertainty for younger lecturers than for older lecturers* can be accepted.

Table 5

The effect of age on changes in work characteristics

Technostress overload	F	*b*	*p*
Changes in work characteristics	1.52	1.18	.218
Age	.09	.00	.763
Changes in work characteristics and age	1.16	-.02	.284
Technostress uncertainty			
Changes in work characteristics	.17	.31	.680
Age	4.36	-.01	.038*
Changes in work characteristics and age	.88	.01	.767

Discussion

The purpose of this study was to find out to what extent technology-related changes of work characteristics change the technostress uncertainty, technostress overload, technostress support and technostress literacy facilitation of lecturers at a university or college during the corona pandemic. This consideration stemmed from the fact that lecturers were forced to switch from face-to-face classes to online teaching within a very short time due to the closure of all educational institutes. As a result, the increased use of technologies was assumed and the systematic and organized application showed an increased demand. Due to the changes, technostress uncertainty and technostress overload could arise. But this could also be reduced through the support of the educational institutes with technostress support and technostress literacy facilitation. In order to examine these relationships and determine whether there are any differences between the different branches of science or whether the age of the lecturers played a role, a study was set up in which lecturers from universities and colleges from each federal state in Germany were written to in order to fill out a questionnaire and examine these questions.

The predictive role of technology-related changes in understanding perceived technology-related stress

The main research was: "*To what extent do technology-related changes in the work characteristics of university lecturers lead to a change in technostress uncertainty, technostress overload, technostress literacy facilitation and technostress support?*".

The results illustrated that only one variable, namely technostress uncertainty, showed a significant positive effect with the independent variable changes in work characteristic. This result is not surprising, because Ragu-Nathan, Tarafdar, Ragu-Nathan and Tu (2008) already stated in their article that permanent accessibility, information overload and pressure for the latest applications inevitably lead to technology-related stress. The reason for this is that employees are exposed to more information than they can handle and as a result they feel inundated and unable to set priorities (Ragu-Nathan, Tarafdar, Ragu-Nathan & Tu, 2008) On the other hand, it is surprising that the variable technostress overload had no significant effect with changes in work characteristics, because this variable often goes hand in hand with technostress uncertainty (Ingusci et al., 2021). The reason for this is that technostress overload is mostly triggered by the fact that the demands are too high for one's own capacities. Demands can often be too high if, for example, uncertainty arises (Verhofstadt, Baillien, Verhaest & De Witte, 2015).

Moreover, technostress support and technostress literacy facilitation also had no significant effect with changes in work characteristics. Ragu-Nathan, Tarafdar, Ragu-Nathan and Tu (2008) mention some prerequisites for the moderating effect of these variables to take place. One prerequisite that could play a role here is that the respondents may not be in a positive emotional state with regard to their job and may feel uncomfortable. To suddenly be so dependent on the technologies and the fairly quickly change caught the lecturer unexpectedly. The respondents were therefore perhaps not in a positive emotional state and thus could not benefit from the inhibitor effect.

The moderating role of different branches of science in the predictive role of technology-related changes in understanding perceived technology-related stress

This study hypothesized that there are differences in the perceived technology-related stress in the different branches of science. The four domains natural sciences, technical sciences, social sciences and humanities were examined as moderating variables with technostress uncertainty and technostress overload. The results showed that all hypotheses could be rejected.

It is surprising that there are no recognizable and significant differences between the branches of sciences, since there is expressive literature on the differences between the domains. However, one could think about whether the changes in work characteristics had a bigger impact than the domains themselves. In general, all lecturers had to go through the technology-related changes and therefore all experienced the same changes in autonomy, workload and mental work (Beer & Mulder, 2016). Since everyone has been deprived of their autonomy and thus the freedom of choice as to how they want to continue their lessons in times of the pandemic, all lecturers experience the same workload when it comes to switching to online teaching. This could be one reason for the non-existent differences between the domains.

The moderating role of age in the predictive role of technology-related changes in understanding perceived technology-related stress

This study hypothesized that the older a person gets, the more susceptible they are to technostress uncertainty and technostress overload. The results showed that older people do not experience significantly more technostress overload, but that age has a positive significant effect on technostress uncertainty.

Both Tam (2011) and Hauk, Göritz and Krumm (2019) listed several reasons in their articles why older people are more likely to experience more technology-related stress like technostress uncertainty than younger people. This also includes physical reasons, such as the inevitable degeneration of the body, i.e. the slow loss of hearing and vision, but also the decline in motor skills. However, one could consider the mental abilities of the respondents instead of the physical abilities as an explanation for the non-significant effect of technostress overload. As people get older, many people bring a certain degree of relaxation and self-assurance to their job and are therefore unlikely to be stressed so easily (Schooler & Oates, 2001). In addition, the factor of teaching experience can make a significant contribution here. Thanks to several years of experience in their profession, many lecturers gain a certain degree of confidence within their domain (Schooler & Oates, 2001) and only have to prepare for the changes in work characteristics like work load instead of, as perhaps younger lecturers, also preparing the entire course material and with that mental work.

Scientific and practical Implications

This examination shed more light on the consequences of technology-related changes in work characteristics on technostress overload, technostress uncertainty, technostress support and technostress literacy facilitation. Although many sources have emphasized the effects of technostress overload, this study found that the effect of it is not significant. However, the effect of technostress uncertainty is significant and could thus ensure more awareness. Because what also proved to be true in this examination is that there was a significant correlation between age and changes in work characteristics. Thus, it can be said that technology-related change in combination with age is an important point to which more attention should be paid in the future.

One reason is that more and more digital teaching will be used in the future (Mayadas, Bourne & Bacsich, 2009) and that teachers and lecturers must be prepared to guarantee a good education for pupils and students. Every day new applications, hardware and software come onto the market (Brennen & Kreis, 2016), which the teachers ultimately have to deal with in order to guarantee a successful educational career for the learners. Support from the IT support can therefore give the teachers and lecturers a lot of autonomy in their lessons back. At the same time it reduces the workload and mental work of the lecturers, which then reduces the technostress uncertainty. Exceptional states, such as a pandemic, are rare, but there will always be situations in which the knowledge gained in this thesis will be helpful, as of now the consequences are further limited and measures can be taken more easily. This knowledge is of particular benefit to organizations such as colleges or universities, because here older lecturers can be offered support for possible technostress uncertainty in order to ensure the best possible teaching for students.

Limitations

There are some shortcomings in this examination that require consideration. A general point that needs to be addressed is that this study was carried out almost a year after the start of the pandemic. Since this study focuses, among other things, on technostress uncertainty and technostress overload, the strongest effects may have already subsided, which at the same time affects or falsifies the result. Some non-significant effects or relationships could have remained undiscovered due to the later investigation. Furthermore, the variables showed a non-expressive significant effect and therefore the question arises as to whether a larger sample size might not possibly increase this effect. The sample size of 221 is too small a value to fully transfer these results to all scientific staff throughout Germany. If one digs deeper and looks at the factor analysis, two points come to mind. The first concerns the sample size, which was evaluated by the analysis program SPSS, because here only 188 respondents were taken into consideration. This sample size shows a poor strength for the calculation for factor analysis. The second point results from the aforementioned factor analysis. Because, a total of 10 factors and thus 5 further underlying factors were determined. This point suggests that the items that were used for the variables were formulated too unclearly and thus triggered ambiguity among the respondents. It is possible that the items for the changes of work characteristics also measured changes that took place outside the organization. Moreover, the respondents were reached with the help of convenience sampling. Conversely, this also means that many lecturers did not have the chance to take part in the study, but also that many only took part because they were interested in the topic and wanted to express their experiences. Therefore there is a possibility that the answers were biased. The most important shortcoming that this study contains, however, is that the already existing experiences of the respondents were not taken into account. In the questionnaire that the lecturers received, there was no question about the level of knowledge regarding experience with technologies. Lecturers who already have more experience in the use of technology also have an advantage when it comes to converting face-to-face classes to online teaching. The changes in work characteristics are not as pronounced as with inexperienced lecturers and thus experienced lecturers experience less mental work and less workload, which lowers the risk of technology-related stress. This is an important factor which could influence both technostress uncertainty and technostress overload.

Future Research

For future studies, it is advisable to take into account the factor of previous experience and to include questions in the questionnaire that explicitly ask about it, as well as whether the lesson has already been carried out online in whole or in part. This ensures that the answers that are received can be better distinguished from one another if it is needed because in the future it could be important to analyze these two groups differently from one another. Personal variables play a decisive role. The influence of personal factors was already emphasized in the (Ragu-Nathan, Tarafdar, Ragu-Nathan & Tu, 2008) article. This includes, for example, the age, the gender of the person and the teaching experience. This model should be expanded through previous experience and then incorporated into future studies in order to be able to obtain an examination of the personal situation of a person as precisely as possible. Furthermore, it is advisable to either delete some items from the questionnaire or to aim for a more precise choice of words in order to minimize underlying factors. For the variable changes in work characteristics, it is advisable to reduce the number and thus reduce ambiguity.

A final important point for future studies is that the moderating effect of technostress support and technostress literacy facilitation needs more investigation. The importance of these variables was already explained in the article by (Ragu-Nathan, Tarafdar, Ragu-Nathan & Tu, 2008), because with the support of the organization it is possible to reduce the technostress experienced by employees. All of this happens through the two inhibitor variables technostress support and technostress literacy facilitation. A more detailed investigation of how strong the moderating and thus also the inhibiting effect is could help in the future to support lecturers more effectively.

Conclusion

The aim of this study was to find out what influence the coronavirus pandemic and the associated changes are having on lecturers. The focus was on technology-related changes and the stress perceived by the respondents as a result. Therefore, this thesis was designed to find out to what extent the changes in work characteristic influence the technostress uncertainty, technostress overload, technostress literacy facilitation and technostress support of lecturers. Moreover, the moderating variables age and branches of science were taken into account. This examination was necessary in order to be able to react better to sudden changes in the work situation of lecturers in the future and should help in the future to prevent the pupils or students from experiencing a disadvantage in their development. The result of this study is that the technology-related changes in work characteristics had a small positive influence on the technostress uncertainty experienced by the respondents, with older lecturers experiencing significantly more uncertainty. However, there are no differences in the branches of science in this study.

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