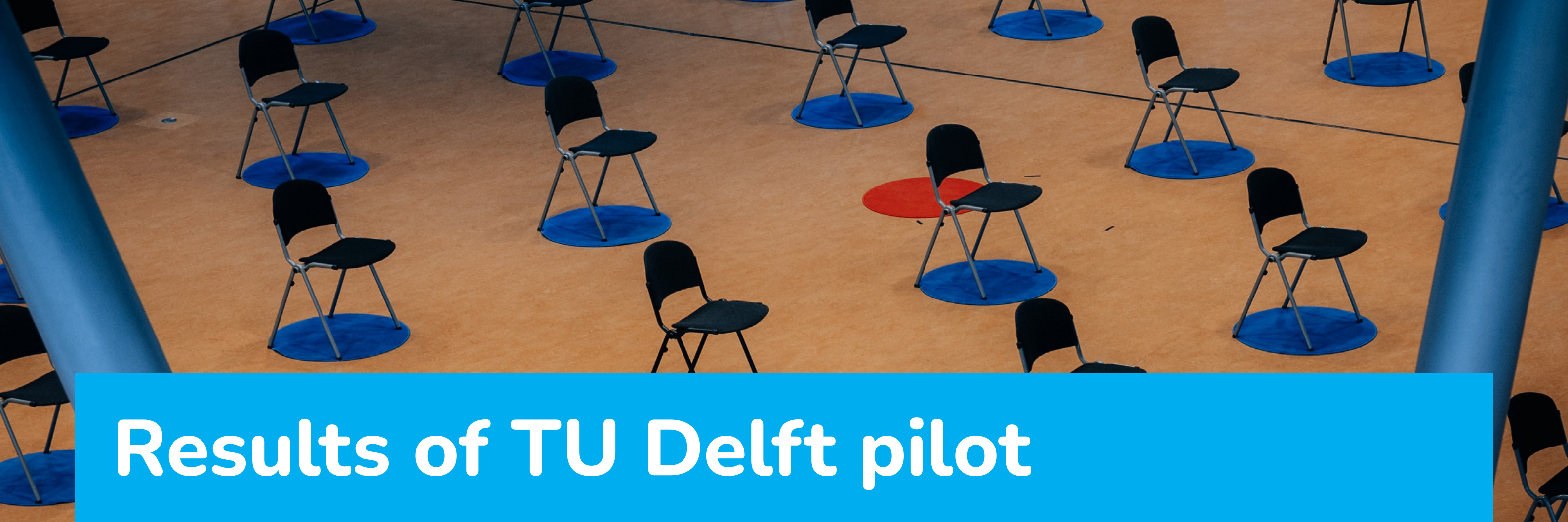

Results of TU Delft pilot

On-site teaching during the coronavirus pandemic

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Foreword

At the end of January 2021, I received a telephone call from the TU Delft Executive Board. I was asked whether I would be willing to coordinate a pilot for the Ministry of Education, Culture and Science (OCW) on the reopening of secondary vocational and higher education as safely as possible.

I did not hesitate for a moment. The coronavirus crisis has been difficult for many students. Most significantly from a mental perspective: being forced to study from home is not what you want from life as a student. But also because online education does not always offer the same quality as on-site teaching. Educational institutions also emphasise the importance of students' physical presence, if only as a means of enabling examining to take place as fairly as possible. So, I was happy to work on a pilot on the reopening of education.

Our TU Delft pilot was one of a total of eight commissioned by OCW. In our weekly progress meetings with fellow project managers, I often felt something of an outsider. Most of the pilots adopted a medical perspective, whereas we at TU Delft took a more technical and behaviour-oriented approach. At the same time, I was convinced that our strategy would ultimately be an important contribution.

As project manager, I had the best role you could ever have in a project. My duties ranged from writing our proposal through to putting together a team and liaising with businesses. I worked with an educational institution in identifying the problems and solutions. We explored how you keep people engaged with a project. Then there were the practical issues, such as installing monitoring equipment in the early hours. The project was

certainly divers – and placed significant demands on my powers of improvisation and creativity. I also became acquainted with new colleagues with whom I am sure I will be working again in the future.

But the thing I remember most about it all is the applause we received from students when we first entered the Dutch Academy of Performing Arts, DAPA, in The Hague.

The gratitude they showed made it clear how important the work we do really is. Students belong on campus, at school, at university: where they can study and collaborate most effectively. I genuinely hope that this research can contribute to that objective.

Dr. Sascha Hoogendoorn
September 2021

1 The brief from the Ministry of Education, Culture & Science

Eight regional consortia were commissioned by the Ministry of Education, Culture & Science (OCW) to investigate how secondary vocational and higher education can open up as safely as possible during, and despite, the coronavirus pandemic. TU Delft was the initiator of a pilot with a more *technological* approach.

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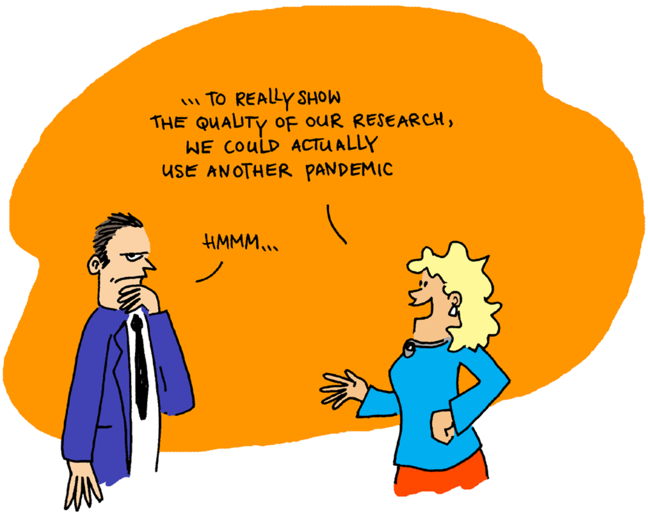
COVID-19 has had a huge impact on our daily lives. The measures taken to restrict the spread of coronavirus were not easy for anyone but may have been particularly difficult for students. They have a strong need to be together in person, to meet fellow students and teaching staff. Online teaching is also usually second-best, however hard schools, universities of applied sciences and academic universities work to improve the quality of online teaching.

That is why, in early 2021, the Ministry of Education, Culture and Science (OCW) called on eight secondary vocational and higher education consortia to set up pilots on reopening education as safely as possible. The objective: to gain a clear picture of what is needed in terms of self-testing and additional measures. The schedule: to achieve clarity before the start of the 2021/2022 academic year. OCW appointed TU Delft as the initiator of one of the eight pilots.

Of course, for OCW it was about more than just the year 2021/2022. Many specialists agree that coronavirus will not be over for some time. Even when coronavirus is behind us, another pandemic can easily rear its head. This is why, in our TU Delft pilot, we started out with a slightly wider question: what can we learn now to manage a similar crisis more rapidly and effectively next time? How can we become more resilient? So, we deliberately looked beyond the start of the academic year 2021/2022 and also investigated what interesting potential solutions there are that can be continued after the pilot.



Focus on technology

Most of the pilots commissioned by OCW focused on testing/self-testing strategies. Testing also featured prominently in our pilot: you can use it to keep the virus out of an educational institution. However, we also deployed technology aimed at keeping the risks inside the institution as low as possible. For example, we developed a monitoring strategy to identify risky interactions: situations in which people spent too long at a distance of less than 1.5 m from each other. We also developed and tested measures aimed at tackling the problems identified, such as a modified floor plan and *bubble concepts*.

This technological approach not only reflects the TU Delft signature, but it also has clear added value. Focusing too much on testing ignores its disadvantages: testing is not mandatory and it is also not permitted to request test results. That means you can never guarantee that testing will keep the virus out completely.

In the following sections, we describe our approach and our experiences with it. We also share some of the lessons learnt.


BTMS
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PROP. WEIGHT
POWER
Brunel

2 Our approach: on-site monitoring

Our pilot was based on a simple principle: to measure is to know. This primarily involves measuring risky interactions inside the gates of the educational institution, in the buildings. By keeping a close eye on that, we can form an additional ‘layer of protection’ over and above the testing/self-testing layer. In this section, we explain our approach.

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A key aim of our project was to learn and gain experience. This is why we did not apply our approach at a single site only, but at seven different locations. These locations were chosen with a view to testing our approach as effectively and widely as possible. For example, variations included the type of education (examination, self-study, or practicals), the type of educational institution (university, university of applied sciences, or secondary vocational), testing strategy (PCR, supervised and unsupervised self-testing) and measures applied.

In all these locations, we set up and tested a monitoring system that enables us to focus on where and when people get too close together. According to experts, a lack of sufficient social distancing (crowding) is an important 'factor in infection'.

The students themselves were also aware of this, as our preparatory research revealed: in open interviews on the subject of potential coronavirus measures on campus, 'social distancing' was the measure most frequently cited by TU Delft students. That gave us additional motivation to focus specifically on that aspect in the pilot. The same preparatory research also revealed that willingness among (TU Delft) students to test for coronavirus – the basic layer of protection – was good from the outset and the willingness to use monitoring systems was reasonably good. See also Figures 4 and 5 on page 17.

Figure 1
The measurement system we used in the pilot is made up of beacons, wristbands, and an app. The app is connected with the back office of the system (cloud solution) via the user's telephone.

Beacons, wristbands, and an app

In order to develop a monitoring system to meet our specific needs, we looked to cooperate with the business community. For the measurement of risky interactions between people, we opted for the solution developed by Norwegian start-up Forkbeard, which uses beacons, a smartphone app, and wristbands. At the time, this solution was still in the development phase, which meant that the system ultimately took shape partly during the course of our pilot.

We installed the beacons in locations where lots of people come together or where we anticipated distancing problems for other reasons, such as in cafeteria, near entrances or in corridors. Each beacon has a range of 20 to 30 m and serves as a 'reference point'. Thanks to Bluetooth and ultrasound technology, the wristbands and smartphone apps can detect which beacon is nearby and what distance it is from other wristbands or smartphones – in other words: what distance people are keeping from each other. This works at centimetre accuracy. The system immediately makes it clear whether people are too close together and, if so, for how long and where (= next to which beacon).[1]

[1] These data are shared with the back office of the system (in the cloud) via the Forkbeard app on participants' smartphones. This can be done by Wi-Fi or via the smartphone data connection, depending on the settings. Neither the beacons nor the wristbands are connected to the internet. The wristbands record their 'interactions' and can be read via Bluetooth. This happens when the wristband connects via Bluetooth to a smartphone with the Forkbeard app.

Figure 2
The Dutch Academy of Performing Arts, DAPA, is one of the programmes where our approach was implemented. The students there were divided into groups, or bubbles, in which the 1.5 m social-distancing rule does not need to be observed in dance classes, for example. If these groups remain at a safe distance from each other, only the affected group will have to quarantine in the event of an infection.

The distance detection happens completely anonymously: the system has been set up to ensure that the data cannot be traced back to individuals. However, we can allocate the wristbands and apps (smartphones) to groups. This is useful if social distancing is not an option in a class or practical. Take, for example, the Dutch Academy of Performing Arts (DAPA) in The Hague: it is impossible for students rehearsing a dance performance to observe social distancing.[2] For them, we created a bubble, a group in which the 1.5 m social-distancing rule does not apply. When monitoring, we watched carefully to ensure that there were no risky interactions between different bubbles. If all groups successfully remain at a safe distance from each other, that means that only the infected bubble needs to quarantine in the event of an infection. The rest of the department can stay open as normal.

[2] Social distancing did not apply to them in any case: when introducing the 1.5 m rule, the government made an exception for dance, if the choreography demands it. That makes other solutions especially useful.

Easy to install, cheap and reusable

The measurement system used in the TU Delft pilot is easy to install: it is simply a question of installing the beacons and configuring the wristbands, the app, and the dashboard. The system is low in cost, does not use local ICT networks and does not need a local power supply. Moreover, the beacons and wristbands can easily be reused. After being used in one building, the system can easily be installed in another building. This enables educational institutions to check relatively quickly whether there are risky situations in several locations and, if so, what measures against them are effective.

Dashboard

Another component of our monitoring system is the so-called Proximity Monitor from EY.[3] This is a user-friendly dashboard that visualises all our measurement data. Have there been any risky interactions? If so, within which risk groups? In which area (= near which beacon) did people get too close to each other? And so on. The dashboard can easily be used to chart trends. How does this Tuesday compare with last Tuesday? What is the pattern during the day? Which locations are the most crowded?

This dashboard provides a fast and effective way of assessing how safe on-site teaching is. An example: in the TU Delft Library, we wanted to increase the number of self-study places from 50 to 250. We used our measuring equipment and the dashboard to check whether that increase was safe. On the dashboard, we were able to precisely monitor and check that increasing the capacity would not result in an increased number of risky interactions.

[3] As earlier, the product was also still in the development phase and was jointly further developed and improved in our pilot.

Estimating and predicting

Using the Forkbeard measurement system and the EY dashboard as our basic tools, we measured whether the 1.5 m social-distancing rule was being respected within the range of the beacons. But the data from the different beacons together also gave us an impression of the building's usage: how busy is it over the day and where is it busy?

In the pilot, we installed more beacons than necessary at various locations, primarily for research reasons. That meant that the picture presented by all the beacons together provided reasonable coverage of the whole building. However, educational institutions will generally prefer only to install the minimum number of beacons necessary. So, in that case, how can you gain an overall impression of how busy it is in a building? In the pilot, we successfully used artificial intelligence to fill in the blanks in the monitoring. We also succeeded in predicting how busy it is in the building: how busy will it be in 15 minutes, an hour or several hours and where? We will return to this in greater detail in the next section.

Interventions

Of course, an important aim of the monitoring process is to intervene when bottlenecks emerge. In the pilot, we developed and tested various interventions.

__Figure 3__
One of the interventions tested during the project is the Proxemy Bubble. The system emits a light and sound signal when the wearer gets too close to another wearer. The Proxemy Bubbles are useful in making people aware of the 1.5 m social-distancing rule.

The interventions that are suitable at particular locations depend on the context. If an area cannot cope with the number of people – making social distancing impossible at that bottle-neck – it makes sense to reduce crowding at that specific location. This can be done by adapting the floor plan or the signage, changing the timetables (e.g. staggering people's breaks) or restricting the number of people allowed into the building at any one time.

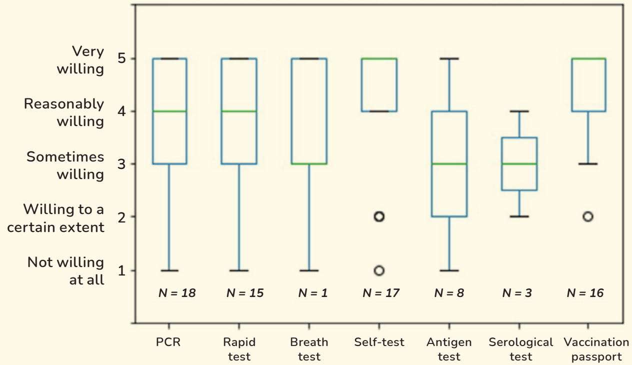
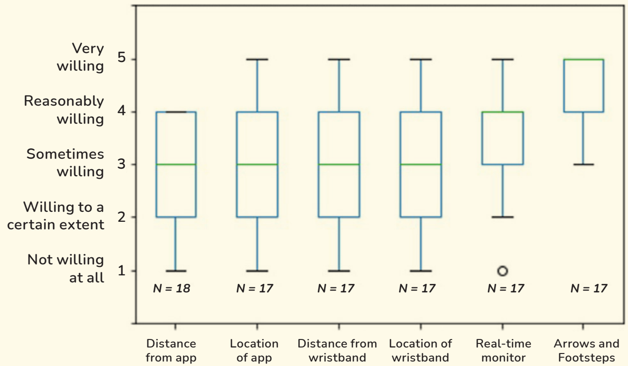


Figure 4 (above)
Students' willingness to use COVID-19 tests to gain access to campus on a scale from 1 to 5 (research conducted before the project).

Figure 5 (below)
Students' willingness to use monitoring technologies to gain access to campus on a scale from 1 to 5 (research conducted before the project).

However, it is also possible that there is sufficient space to observe social distancing, but that people still, consciously or otherwise, fail to keep to the 1.5 m rule. In that case, the intervention can involve informing people, providing feedback, making them aware of their behaviour and/or attempting to influence it. One solution that we tested in this context involved the Bubbles developed by the Dutch company Proxemy. These small devices are hung around the neck on a lanyard and emit a light and sound signal when the wearer gets too close to another wearer. This 'trains' people to keep at sufficient distance from each other.



3 What else is possible with our data?

For our pilot, we put together and tested a monitoring system that provides educational institutions with a cheap and easy way of identifying risky interactions. But we went further than that: our scientists also explored what else may be possible with our measurement data. We made use of artificial intelligence, tested a new model, and developed data tools.

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1. Artificial intelligence for estimating and predicting crowding

In order to measure interactions in educational facilities, we used the Forkbeard measurement system with beacons. These were always smartly positioned, in other words in places where we anticipated 'distancing problems' and where we aimed to determine the extent to which people are keeping at a distance from each other. But what happens if we want to gain an impression of the building as a whole, to see where it is crowded and where there is actually still room?

Installing beacons everywhere is impractical and often impossible. But this is fortunately also not necessary: in the pilot, we made use of artificial intelligence to provide an estimation of

"... OUR MONITORING ALSO PROVIDES A LOT OF USEFUL INFORMATION WHEN THERE IS NO PANDEMIC.

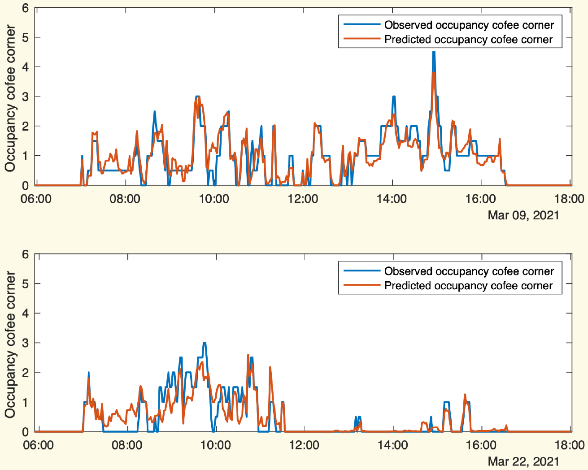


Figure 6
The actual (blue) and estimated (red) level of crowding in the TU Delft Library Coffee Corner.

how busy it is. To test this, we focused on the Coffee Corner in the TU Delft Library. There were two beacons there. But, at the same time, we tried to use the data from the other beacons in the building to estimate how busy it was in the Coffee Corner. Figure 6 shows the results: the blue line indicates how busy it actually was in the Coffee Corner and the red line shows the estimated figure. This clearly demonstrates that it is possible to effectively estimate occupancy using this method.

This precise data supplementation is primarily useful within the framework of our pilot. An impression of how busy the whole building is can help educational institutions to identify other potentially risky locations. The overview this provides is also important in devising interventions. Imagine, for example, that you want to prevent too much crowding at a particular point by adjusting the flow of people passing through it. If you have a picture that gives full coverage of the whole building, you automatically know how to divert walking routes (= where there is still space) and how not to.

There are also other potential applications, quite separate from coronavirus and education. For example, a good overview of the use of the building—we refer in this context to a building's 'heartbeat'—can be useful in determining which

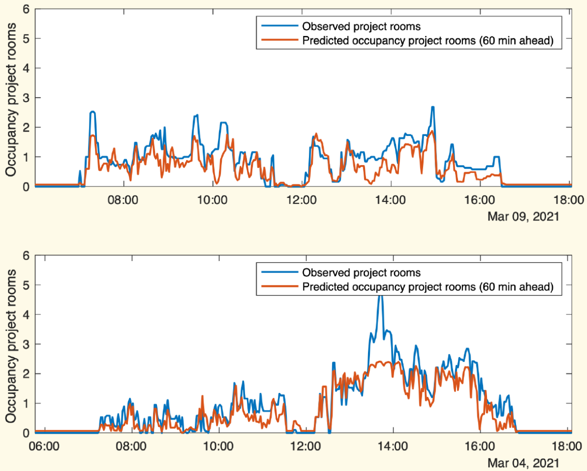


Figure 7
The actual (blue) and predicted (red) level of crowding in the TU Delft Library project rooms.

locations require greater attention when it comes to cleaning, maintenance, and stocking.

There is also a second interesting application of artificial intelligence: it turned out to be perfectly possible to use the available measurement data to *predict* crowding. For this purpose, we focused on the TU Delft Library project rooms. Based on the up-to-date measurement data, we attempted to predict the situation fifteen minutes, one hour and one day in advance. Figure 7 shows that the short-term predictions are in principle very usable.

This information again proves useful in anticipating: where might additional surveillance of walking flows be necessary? Here, too, the applications extend further than the pilot alone. For example, predicting crowding is crucial for crowd management at events and festivals.

2. A new model for charting the spread of a virus

In the project, we worked on a new model for charting the spread of diseases, the Markov Mobility Model. Using this, it is possible to conduct risk analyses based on monitoring data:

'If there are X infected students at school, how likely is it that there will be an outbreak?'

The model investigated in our pilot is unique in that it not only includes the viral process of an infection. This concerns the transfer of the virus between two hosts and the effect (infection and recovery) of the disease on a host. Our model also incorporates the *mobility process* by describing when and where two hosts have been in contact with each other for a sufficiently long time at a sufficiently short distance in order to enable transfer of the virus. That mobility aspect is essential in explaining the persistent spread of an epidemic like the current one.

The new model can cope with the mobility process because it makes use of so-called Markov processes, which we can use to replicate the contingencies of movements and meetings. We tested the application of these processes using data from the pilot in the TU Delft Library. Because the amount of data was relatively modest, the results were less accurate than with the simulations, but still sufficiently encouraging to pursue further.

In any case, the mobility process merits further research and further modelling in order to fully understand the interaction with the dynamics of the disease (the virus process). In that, the researchers will continue to make use of the data generated by our monitoring systems: these data are authentic and easy to manage geographically. The latter is important because calculations with Markov processes are hugely complicated and quickly eat up too much computer capacity.

Once the model has been fully readied, tested, and calibrated, it can also be used in the outside world. The knowledge that this provides will prove vital in nipping future epidemics in the bud.

3. Data tools for analysing behaviour and the impact of measures

In order to measure how many dangerous interactions are taking place between (groups of) students and members of staff, we developed several useful data tools. These tools enabled us to easily filter raw data (e.g. remove brief, safe interactions) and merge data (to calculate risky interactions between individuals and their duration). It is also possible to detect groups, by means of advanced clustering techniques.[4]

These options help us to analyse how students behave in relation to changes. For example, what happens if our fear of an infection increases or diminishes? And what impact do the various coronavirus rules and regulations have on our behaviour?

On pages 24 to 27, we describe a specific case at the DAPA educational institution. Based on input from surveys, we selected and tested a range of measures for this educational institution. We then used our monitoring system and data tools to analyse the effect of those measures. For an example of an analysis using the tools, see Figure 8 on page 27.

[4] The EY dashboard does some simple processing of these data, in order to ensure that they are presented in the right way. The data tools referred to go a step further and offer the possibility of conducting more complex processing and analyses.

DAPA case study: Introducing and analysing coronavirus measures

We tested a range of physical-distancing interventions at the Dutch Academy of Performing Arts, DAPA, in The Hague. This concerned additional measures intended to prevent risky interactions as far as possible. With the help of surveys, the monitoring system, and our data tools, we were able to effectively analyse and evaluate the effect of these interventions.

The project at the DAPA ran from 9 April until 16 July 2021. At the start, several basic rules were already in force, including 1.5 m social distancing, the wearing of face masks in the corridors, restricting contact with others to one's own bubble, one-way traffic on the staircases and keeping to the right in the corridors. In addition, students were keeping their movements through the building to a minimum: rather than students changing classrooms after a lesson, the teaching staff moved instead. During the project, we added several additional measures (interventions) to these basic rules.

What approach did we adopt? We started by identifying the 'spatial bottlenecks', locations where it is sometimes so crowded that it is impossible to maintain sufficient distance. To prevent overlooking any bottlenecks, we also enlisted the help of the students: in a survey we asked them in which areas it was difficult to maintain a distance. This turned out

to be the changing rooms and corridors. The two changing rooms in the Academy do indeed provide very little 'distancing room' for one group, let alone two groups, which was a common occurrence. For this reason, we more than doubled the changing-room capacity by adapting a large classroom for use as a changing room. In the corridors, most problems happened at the start of the day. The doorways to the classrooms were overcrowded with students waiting in the corridors before they were allowed into their class. To cope with this kind of bottleneck, we introduced the simple but effective measure of opening the classroom doors earlier in the morning, enabling students to wait in the classroom until the start of the day's lessons.

After dealing with the spatial bottlenecks, we focused our attention on behaviour. In many cases, there is quite enough room, but students still tend to cluster together, consciously or unconsciously. One intervention involved having students do a simple exercise during their warm-up session, enabling them to experience the exact length of 1.5 m. We also gave them frequent reminders of the importance of social distancing using posters and via teaching staff.

Analysis and evaluation: surveys

We evaluated the measures in several ways. For this, we again enlisted the help of students: we asked about their experiences in follow-up surveys. This provided some interesting insights. It emerged that several classes were continuing to use the changing rooms even after a classroom had been made available to provide additional space. This showed that the mere introduction of a measure does not automatically lead to compliance. As for the intervention in the corridors, it turned out that the classroom doors were not always open when students arrived at the Academy. This shows that the implementation of a measure can fail as well. Conclusion: the monitoring of measures is not only important when it comes to students, but also teaching and support staff.

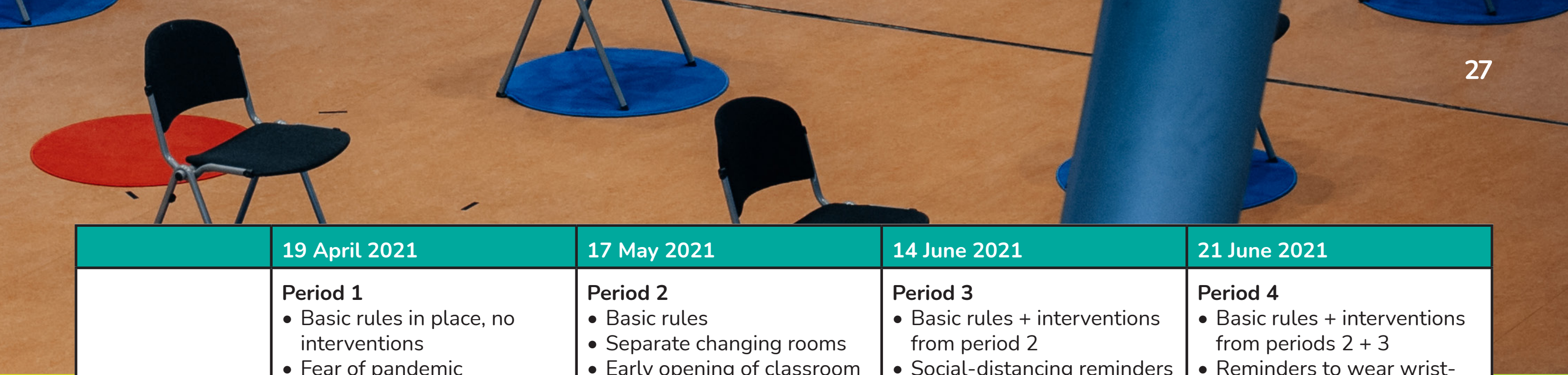
Analysis and evaluation: monitoring system and data tools

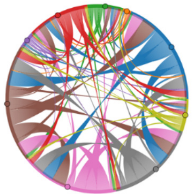
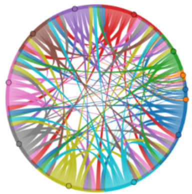
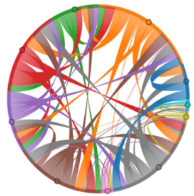
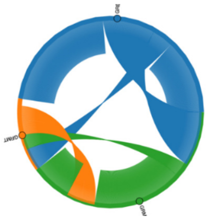
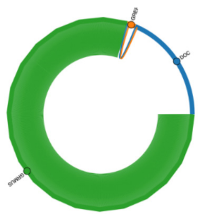
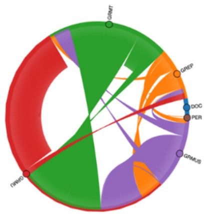
We also analysed and evaluated the various interventions using our monitoring system (beacons, wristbands, dashboard) and the data tools we had developed. Figure 8 reveals some interesting results. The table is divided into four periods, with period 1 serving as the baseline measurement. This was the period when only the basic rules (1.5 m, face masks, etc.) applied. However, this was also a period when there was a great deal of uncertainty and fear about the pandemic. In period 2, we implemented various additional measures: extra changing-room space, classroom doors open to prevent overcrowding in the corridors and exercises to make students aware of what exactly 1.5 m social distancing entails.

In period 3, in addition to the basic rules and interventions from period 2, we mainly focused on keeping the students alert. This was a period in which fear of coronavirus had slightly diminished. In period 4, we continued this, although the difference was that fear of coronavirus had increased again.

The circles in the table represent the interactions between individuals (above) and groups (below). Each colour represents an individual or a group. A ‘jump’ towards a different coloured part of the circle represents an interaction. Notice how the interventions of period 2 resulted in a significant effect at group level: compared to period 1, there were hardly any risky interactions between the groups. However, it is also clear that the perception of risk (fear of the virus) plays an important role: see the image in period 3, when the whole situation seemed to have improved slightly.

Figure 8 (page 27)
The interactions between individuals and groups during four periods in the DAPA test. The different colours represent different individuals or groups. The ‘jumps’ to a different part of the circle indicate interactions.



	19 April 2021	17 May 2021	14 June 2021	21 June 2021
	Period 1 • Basic rules in place, no interventions • Fear of pandemic	**Period 2** • Basic rules • Separate changing rooms • Early opening of classroom doors • Awareness-raising of 1.5 m distancing through exercises • Fear of pandemic	**Period 3** • Basic rules + interventions from period 2 • Social-distancing reminders on posters • Social-distancing reminders via teaching staff • Limited fear of pandemic	**Period 4** • Basic rules + interventions from periods 2 + 3 • Reminders to wear wrist-band and face mask via teaching staff • Fear of pandemic (increase in infections)
Interactions between individuals				
Interactions between groups				

4 All lessons learnt from the pilot

The aim of this pilot was to open up educational institutions safely and keep them open safely. For this purpose, we set up a monitoring system and tested interventions. This approach proved effective – but we also learnt that the solution involves more than technology and interventions. 'Soft' factors, such as communication and effective management, are at least as important. In this concluding section, we outline the lessons learnt.

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1. The measurement system is the basis

Our measurement system worked effectively. It was simple, could be used widely and delivered very useful data. Educational institutions can use the data to monitor safety, assess risks at an early stage and develop appropriate interventions.

Participating in the measurement system was voluntary: students were asked for consent in advance. Gaining consent to monitor students (anonymously) using a wristband or app was generally unproblematic, but that was not all we needed to do. In order to generate data, the students had to actually wear the wristband and activate it when present in the school or university building or had to switch on the app on their smartphone. This can easily be forgotten and it is therefore very important to continue to remind students that monitoring is only possible if they actively participate. See also our (long) lesson about communication later in this section.

Participation using a wristband turned out to be more effective than via the app. You always have a wristband with you and it is visible, which makes it easier to remind anyone not wearing a wristband to participate. In the case of an app, it is impossible to see if it has been downloaded and is on and it is also easier to leave your phone behind at your workspace – for example if you have left your desk for a moment to help a colleague. Another disadvantage of the app was that students were hesitant about using their smartphone for the research for privacy reasons, even though both the app and the wristband were equally privacy-proof. In a later phase of the pilot, we therefore switched to mainly using wristbands.

However, we did continue to use a minimum number of apps (smartphones) because it is only possible to transfer data to the cloud via smartphones.[5]

2. Working with bubbles is effective

At various locations, we divided students and staff into groups or bubbles that were kept apart from each other as far as possible. This makes it possible to limit the number of students and staff that need to quarantine in the event of an infection: only students from the infected student's bubble and the teaching staff who taught this bubble then need to quarantine. Unless, of course, there has been contact between the bubbles themselves – in that case the students from these other bubbles also need to quarantine. Even during a major outbreak of the virus at DAPA, 75% of students were still able to attend safely.

[5] The apps also include the data from wristbands if they come into contact with them via Bluetooth.

3. Link interventions to the cause

In developing interventions, it is important to carefully look at the cause of risky interactions. Risky interactions happen when people do not keep a distance of 1.5 m over an extended period, but this can have various causes. If there is sufficient room for social distancing in principle, measures to limit the occupancy of a building will have little effect. In that case, it makes more sense to consider behavioural change: communication, information and awareness-raising, or systems that issue warnings when people fail to observe sufficient social distancing. But if it is so busy at a particular location that it is impossible to keep sufficient distance, interventions to restrict crowding do make sense. Examples of such interventions include spreading visitors across space and time, preventing stagnation at high-traffic locations and limiting the incoming flow into the building.

In other words, how busy a building is and where an area is located in a building determine which interventions will be most useful. This is also what makes it so important to measure how busy it is and the number of interactions, since this partly determines the type of measures required.

When deciding on interventions, it is also advisable to carefully consider timetables, the type of teaching and other specific characteristics of the department. For example, when are there a lot of students waiting outside a classroom? Where and how do they work in groups, in or outside lessons? Where do they have lunch?

4. Emphasise the benefits of testing

As well as monitoring within the confines of the department, there was of course also testing on entry: if you felt ill or had been in contact with someone with coronavirus, the idea was that you should get yourself tested. But the problem is that testing cannot be made mandatory – and, in education, it is also not permitted to ask for a test result (or at least that was the situation during the pilot). This is why it is important to emphasise the benefits of testing: the ‘What’s in it for me?’ aspect must be very clearly communicated.

The fact that students will respond to this was demonstrated during the ‘flying test’, a laboratory course on the Aerospace Engineering programme at TU Delft. For that, we were able to apply the regulations for civil aviation, where you can insist that people are tested. Because this laboratory course is seen as the highlight of the degree programme, that proved to be no problem at all: 100% of the students did the test. At DAPA

we were totally reliant on the students: would they be willing to cooperate? DAPA is a typical practical programme in which students work together on a dance that they will ultimately perform. That means a single infection in a dance group can immediately stop the show – and this urgency ensured that willingness to be tested was also almost 100% at DAPA. Thanks to this willingness, several asymptomatic infections were discovered at an early stage during the pilot. At the same time, thanks to the combination of our monitoring system and working in bubbles, only some of the students at DAPA had to quarantine after an infection and the majority could continue to attend as normal.

In the case of self-testing, supervision is extremely important. Because the testing at DAPA was supervised online, it was possible not only to precisely determine the willingness to be tested, but also the degree of infection. In the case of a group assignment in The Fellowship building at TU Delft, testing was not supervised. As a result, it was difficult to determine the willingness to be tested and even more problematic gaining any early insight into potential infections.

Another point of concern is that the willingness to be tested can diminish over time. Especially since the end of May 2021, that willingness declined at all locations, even at DAPA. The limited number of infections, the rapid relaxation of coronavirus restrictions and the optimistic stories in the media about a rapid end to the pandemic played an important role in this.

5. Awareness-raising via Proxemy Bubbles

Proxemy Bubbles are small devices that users hang around their neck. They emit light and sound signals when the user spends too long too close to other people. People often do this without being aware of it: when we are having a chat or are helping a colleague, we can easily forget the social-distancing rule. Using a Proxemy Bubble for a few hours is a great help: it makes the user aware of situations where they are too close to other people. Studies are currently underway to determine how long this awareness-raising effect persists.

However, willingness to use this system depends on the type of programme or department involved. At TU Delft, with its technology-oriented students, there was a lot of enthusiasm to participate. At the DAPA, the device reminded the students of a cowbell – and that rather dampened their enthusiasm.

6. Keep communicating

The success of our approach in measuring and intervening ultimately depends on the willingness of students and staff to cooperate. This means that effective and continuous communication is essential in ensuring everyone remains engaged. In our pilot, we divided the communication into different themes: testing, social distancing, participating in the measurement system and observing measures (interventions). This differentiated approach worked well.

For every topic, it is important not only to communicate at the start, but throughout the process. Sharing interim results with students (displaying the dashboard, highlighting the impact of interventions and of repeated self-testing) helps to make things more concrete and is important in keeping willingness to participate strong.

In addition to sharing information, it is also important to collect information from students. Where do they see bottlenecks? What solutions do they see? How do they feel about the interventions? And so on. This can be done anonymously by distributing questionnaires (something we did at DAPA every three weeks), by holding group discussions with students and in personal contacts with a mentor or teacher.

In any ‘communication contacts’ it is vital to keep a clear focus on the target group. Relevant characteristics include the nature of the programme (creative or technical), its level (secondary vocational or higher education), proficiency in Dutch and the background of students. For example: the COVID-19 press conferences given by the Prime Minister featured signing for the deaf but were not subtitled in English until recently. That means that students who do not speak Dutch were less likely to be aware of the coronavirus rules in force and the number of infections. Culture is also a factor in students’ perspectives on COVID-19, the government and social distancing.

Communication about testing

Reluctance to take the first coronavirus test can be high, but quickly reduces once the first test has been done. Expectation management, word-of-mouth advertising and emphasising what might be possible again if people get tested are all important in this. It helps if the communication is provided by someone that the students know well and who is capable of effectively conveying the message.

Communication about social distancing

A distance of 1.5 m is larger than many people think. At DAPA, the warm-up session every morning started with a simple exercise to ‘experience’ that distance. Proxemy Bubbles can also be used to help people experience what 1.5 m feels like.

At DAPA, there were small yellow signs in the corridors pointing out the 1.5 m rule from the start of the pandemic. It turned out that many students had not noticed the signs. For this reason, we had a poster designed reflecting the students’ world of experience, showing at a glance where social distancing was necessary and where not.

However, the main difficulty involves switching from locations where social distancing is not necessary (certain classrooms) and locations where it is (corridors). At the transition points – directly opposite the classroom doors – it is important to communicate effectively.

Figure 9
A poster we developed for DAPA which shows where 1.5 m social distancing is and is not mandatory in the Academy.

An interesting question for any follow-up research could be this: is there any use in explaining the logic behind the different rules for each type of room or is it better to just communicate what the rules are?

Communication about measures

When new measures are introduced, it is important to start by discussing the use of the measures and to demonstrate the impact afterwards. In the pilot, we did this by holding discussions with groups of students. With the help of questionnaires, it became clear which old and new measures had been seen, understood, accepted, and followed. What is clear or logical to one person may not be so to the next person. The questionnaires were anonymous.

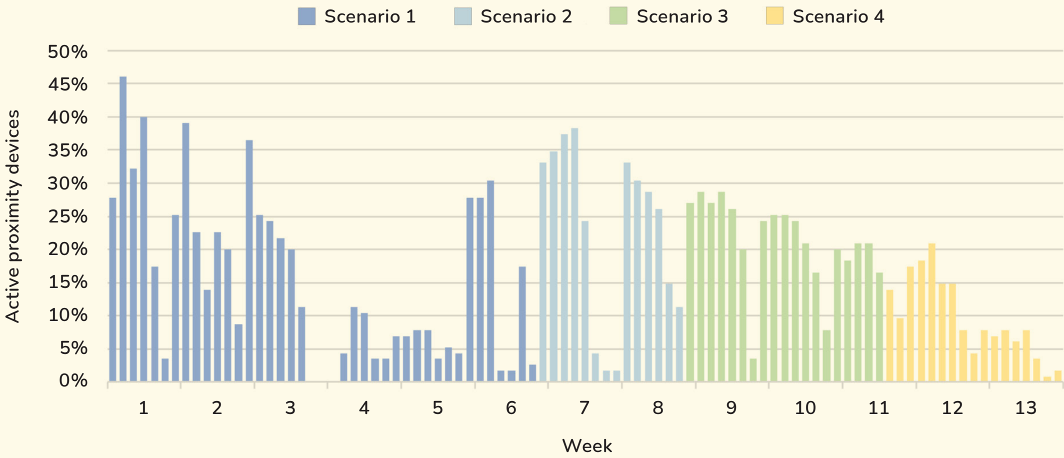

Figure 10
The daily use of wristbands and apps to monitor risky interactions. The data are from the DAPA programme. Each column represents one day in the week and each colour a period (wave) in the pilot. In weeks 12 and 13, there were performances outside the Academy's facilities and there were fewer students in the building at the same time. This explains the sharp fall in usage during that period. Nevertheless, the use of the wristbands was already starting to decline from week 7. That underlines the need for continual communication about the importance of monitoring.

Communication about the measurement system
For our approach to work, it is crucial that students and staff continually connect with the measurement system. This is conditional on effective and ongoing communication, particularly because usage decreases in time.

In addition to highlighting the individual and group interest, pointing out that privacy is guaranteed is also important. The measurement system is completely anonymous and participants are not traceable. Privacy is guaranteed in the same way for the use of wristbands and mobile phones, although users themselves may feel differently: participants prefer not to use their smartphones.

This is a shame, because the wristbands also have disadvantages.[6] Wristbands are slightly more expensive to use than smartphones. When used by different people, they also need to be cleaned between users. They break more quickly and are more easily mislaid, often because people accidentally take them home.

7. Support from the organisation essential

The success of a pilot depends on the extent to which students are willing to participate in it. This applies to testing, participating in the measurement system, social distancing, and following measures. That willingness can be significantly increased if support is provided from all levels within an educational institution, from caretakers through to management. What message is the management sending out and how are teaching staff serving as role models in their contacts with students? To what extent are they informing and helping students to participate in the measurement system and how long do they continue to do that? Are they also monitoring the dashboard and using the information obtained to make interventions? In practice, this kind of active approach demands a lot from the staff of an educational institution who are already under pressure, especially in the time of coronavirus.

[6] In a building, there always need to be at least a few smartphones with the app in order to transfer measurement data to the back office open (cloud). At DAPA, teaching staff and management therefore used the app – and this proved to be sufficient.

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