The Impact of SARS-CoV-2 on Engineering Education:
Student Perceptions from Three Countries

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Abstract - **The outbreak and rapid spread of SARS-CoV-2, commonly known as COVID-19, has led to a loss of life, widely spread economic consequences, and changed behavior in many, if not all, sectors of society. One such sector is institutes for higher education. Against this backdrop, in this paper, we aim to study how engineering training was affected at the beginning of this global pandemic. The point of departure in the paper is the students' perceptions. Our study is based on survey responses from students from Singapore, Sweden and Taiwan. Three themes were identified in the results: a) issues related to transitioning from the physical classroom to an online environment, b) examination activities, and c) perceptions about the future. As such, this paper contributes with first-hand experiences and reflections on engineering training during a global crisis.**

Keywords - **COVID-19, engineering education, pandemic, emergency remote education, SARS-CoV-2**

I. INTRODUCTION

Pandemics have created human suffering since ancient times. On December 31, 2019, China informed the World Health Organization of an unknown virus that has caused 41 cases of pneumonia in Wuhan, which later got the name SARS-CoV-2, commonly known as COVID-19. Unlike its relatives, SARS-CoV-2 spread rapidly across the world (see, e.g. [1]). Countries have adopted different strategies to minimize the spread of the infection and reduce mortality. As a result, the education systems received widely different rules and approaches, ranging from total closure to almost unchanged activities.

As educators in engineering education, we were interested in how students from countries with different strategies perceived the changes in their education program due to SARS-CoV-2. We have selected three countries with different strategies and courses of the virus, namely Singapore, Sweden and Taiwan. Singapore is a country that, from the beginning, has taken severe measures to reduce the spread of SARS-CoV-2, but was forced to quarantine and transition all educational activities online. Sweden has had a different approach: an open society based on government guidelines, and only the high school and higher education were transitioned from campus to an online environment. Taiwan managed to counter the spread of the infection relatively early, which has led the community and the education system to function normally, though under strict precautions. Therefore, we think these countries are of interest to use

as a base for our study. Our focus is on students within engineering education with some emphasis on the master program in Industrial Engineering and Management (IEM).

It should be made clear that models and results in traditional distance education have long been well documented in educational science. But, as Kirschner [2] points out, the pandemic is not about distance education: we are dealing with a transition to emergency remote teaching. In his webinar, he makes a parable with an operating room in a hospital compared to a field hospital.

At the time of writing, some countries are beginning to alleviate their restrictions. However, we are probably in the midst of the outbreak of SARS-CoV-2. Therefore, at the time of writing, we do not have a complete picture of this global pandemic.

The research on SARS-CoV-2 and its implications is explosive, of course, mostly from a medical perspective (see, e.g. [3] and [4]). However, the number of studies from educational science is growing (see, e.g. [5]). Hence, the topic of this paper is both timely and relevant, since several institutions for higher education in many countries have transitioned to emergency remote teaching to prevent the spread of the pandemic.

II. BACKGROUND

As background, in this section, we briefly describe how the countries of Singapore, Sweden and Taiwan changed their rules and regulations related to their respective education systems with the outbreak of SARS-CoV-2.

A. Singapore

On January 2 2020, Singapore's government started its precautionary measures in response to severe pneumonia cases in Wuhan, China. The Ministry of Health has confirmed one imported case on January 23. From early February, the universities moved large lectures (with 50+ students) online. On March 27 Singapore's government announced that all schools should conduct home-based education one day a week. The government later announced closures of all schools and universities starting from April 8 due to new safe-distancing measures that would act as a "circuit breaker" of the pandemic. This

announcement has shifted all courses to emergency remote education.

B. Sweden

On January 31, 2020, Sweden got its first infection case. A young person who had visited Wuhan was isolated. On March 17, the Swedish government decided that all teaching and examination at the upper secondary and university level be moved online, which was carried out the following day. The abrupt change of activity was only a few days before an examination period that appears in the middle of the spring semester. For further information, see, e.g. [6].

C. Taiwan

On December 31, 2019, the Taiwanese government initiated a series of comprehensive measures immediately after detection on an Internet bulletin post of suspicious cases with respiratory symptoms similar to that of SARS reported from Wuhan, China. On January 20, 2020, the Taiwan Centers for Disease Control officially activated the Central Epidemic Command Center to counteract the emerging public health crisis and to coordinate between different authorities. On February 2, the ministry of education announced all levels of schools postpone the starting date of the new semester for two weeks. Although face-to-face training is not strictly prohibited, universities must undertake regular and comprehensive sanitary measures in all areas. Furthermore, if there were one confirmed case in a class, the course has to be suspended for fourteen days or switched to online learning. If there were more than two confirmed cases on campus, the whole university has to close for two weeks. Up to date (May 24), six universities are influenced. Each university is to decide further precautious measurements, including adapting remote learning techniques, based on their current situation.

III. METHODOLOGY

Surveys were constructed to study how students from Singapore, Sweden, and Taiwan perceived the changes in their education program due to SARS-CoV-2. These surveys resulted in 16 answers from Singapore, 56 from Sweden and 87 from Taiwan. Although we acknowledge that the surveys to the students contain variances, they share a common nominator: to capture the students' perceptions about how the SARS-CoV-2 outbreak affects their engineering training. The material from the three countries is subject to thematic analysis, where our ambition is to capture common nominators within the results.

The following subsections contain descriptions of how data was collected.

A. Singapore

Two universities from Singapore participated in the study: National University of Singapore (NUS) and Nanyang Technological University (NTU). The survey consisted of five questions:

1. After the SARS-CoV-2 outbreak, many universities have switched to online-based teaching. Which software is used for online lectures? Have you encountered any problems when using them?
2. Do you take practical, training courses or internships, and what is affected by current, SARS-CoV-2, circumstances?
3. Do you need to have a different approach to having (mid-term) exams? Have you encountered any problems?
4. Is there any problem for you obtaining course credits and finishing projects, or your degree caused by SARS-CoV-2?
5. How do you think this will affect your career plan after your studies?

The survey was then distributed to educators, with teaching assignments, associated with engineering departments with the request to give it to their students. Additionally, the survey was posted on students' discussion boards.

B. Sweden

Two universities from Sweden participated in the study, namely Mid Sweden University and Umeå University. The data from Mid Sweden University was collected by a survey that was sent to the students in the IEM program who wrote their bachelor's and master's theses. The survey consisted of two questions:

1. Have you experienced any problems related to your bachelor / master thesis after the university switched to online education?
2. Have you experienced any advantages of writing your bachelor / master thesis during the current conditions?

Usually, within the IEM program, students do their master theses in the industry during the last term of their education. The questionnaire sent to the students in Umeå contained the question: "Have you encountered any problems caused by SARS-CoV-2 that affect your completion of the degree project?".

C. Taiwan

We used the same method and questionnaire as for Singapore to collect the data from Taiwan. Eighteen universities were involved while mainly students are from

National Taiwan University (NTU) and students are from, e.g., National Taipei University of Technology.

IV. RESULTS

Here we present the results broken down by country.

A. Singapore

E-learning software of Zoom, Microsoft Teams, Skype and LumiNUS portal (NUS platform) are among the most commonly used in Singapore. Most students reported they did not encounter any problems in these platforms, except for lag and background noise. As the universities announced that most semester examinations would be converted into continual assessments, students have experienced various abrupt changes during this time. Most students replied they were coping fine without any troubleshooting; however, some problems occurred such as it is inconvenient while typing in steps solution, and complexities of video proctoring for assignments and exams.

Major problems reported by the students include new deadlines that were imposed at short notice and no explicit instruction from educators. A modified grading scheme that was used during the pandemic received critique for being more competitive, which would be unfavorable for students who did not cheat in online quizzes. As a result, many are hoping it will not affect them obtaining the degree of study and graduating in time.

Practical training courses within and outside the university was affected during the pandemic. The most severe consequences were early termination for those doing their final year projects and internships. Other effects mentioned was that the students needed to come up with theoretical ideas that would not rely on too much of an experimental basis for their projects or theses. Theses and project reports are now only allowed to be submitted online, and students experience anxiety over not being able to meet and discuss with their supervisors in person. Besides, fewer opportunities for internships are presented, which has generated increased competition for those who are going to apply next semester. We noted that all students expressed worries regarding the current situation in terms of plans after graduation. Some students who originally planned to enter exchange programs may need to reschedule them, though depending a lot on the situation in the world. The foreseeing economic recession in Singapore and worldwide limits the number of job vacancies Getting a job is probably going to be harder since the economy has been affected by certain extents due to the current circuit breaker. Nevertheless, students stay positive since there are other options and alternatives provided by NUS and NTU, as well as the Singapore government. A series of new policies have been generated and announced in early May to help graduates get jobs.

B. Sweden

The major problems mentioned by the Swedish students are lack of social interaction between the educator and the students, as well as between the students. In addition, several students experience problems with their study routines and lack of motivation. Another significant issue is the examination. Most educators do a regular exam that is posted online on the course website. The students can do the assignments under their responsibility and then with a suitable program photograph their solutions and then post them at a predetermined place on the course website, although some teachers require surveillance via webcam. There are students believing that the educators who construct the exam make them consciously more complicated, and many testify that cheating is widespread.

Furthermore, the students experience issues related to data collection, which makes them re-think the problem formulation of their theses. Students who are parents report they spend more days taking care of their sick kids compared to a normal situation, due to stricter rules for kindergarten attendance. In some cases, the transition to remote education has been relatively smooth, while in other cases, students have been unable to access their data for a couple of weeks, which has caused severe delays. One group of students used a multinational company as a case for their thesis, and they say that the change of priorities due to SARS-CoV-2 results in fewer resources on research and education, and more focus on the company's long-term production. Functional remote access is mentioned as important from several students. Another problem reported was associated with accessing the library's databases outside of campus: sometimes the sign-in solutions do not work as intended, which prevents students from accessing research articles etc.

The students report different experiences when it comes to the contact with their supervisor: while some students report that their supervisors respond quickly via email, other students maintain that it is challenging to keep in touch with their supervisors. A few students on a master level were conducting remote education already, and a returning answer in the survey was that these students did not perceive any significant impact on their studies.

On the question of whether there are any advantages with writing the thesis during the pandemic, several students answered "no". Other students perceived that they had more time, freedom, and fewer distractions when writing their theses. A couple of students write that the SARS-CoV-2 pandemic has enabled interesting case studies (related to the pandemic itself, but also transformative areas such as e-business). One student report that he/she was encouraged to use triangulation by including data from more sources during the pandemic. The students mention Zoom, Skype, telephone as examples of supporting technologies used for maintaining the

communication with their supervisor, conducting interviews, and performing presentations.

C. Taiwan

About 12% of the students replied that they still have all face-to-face lectures and do not have any online learning at all; on the other hand, more than 80% of students reported they have had e-learning experiences. Software advised by the Ministry of Education such as CyberLink U meeting, Microsoft Teams, Cisco WebEx, Google Hangouts Meet and Jitsi Meet are all commonly used. Besides, some universities provide their plate forms for both educators and students, e.g. NTU COOL (by National Taiwan University). Other software such as Skype, Zoom, Zuvio, Slido, and Discord was also mentioned, but to a lesser extent. Disruption of the Internet connection during live-streaming lectures is among the most significant issues. Other problems, such as software crashes if there are many users online simultaneously, and non-user-friendly interfaces were also reported. Students also experienced inconvenience if the lecture itself requires lots of blackboard handwriting, e.g. for mathematical calculations. From the students' point of view, some elderly educators lack computer skills, which might cause a barrier for distancing learning. The online environments are also less efficient for group discussion, and it becomes more challenging to interact with educators during the lecture.

Nearly half of students from the survey reported they have practical training courses or internships this semester. Among them, more than 70% of the students said all practicum classes are still held in person, and there is no real effect other than the requirement of wearing masks during the course. Others reported that it had affected them to some extent. One student doing an internship said the company applies the policy that working one week at the office and another week at home. Another example is that students who are doing their internships in the medical industry are asked to work into two teams (i.e. shifts) to avoid unnecessary physical contacts and also avoids rush hours commuting to work. However, it has also resulted in some pre-planned field trips and programs being cancelled. The opportunities in industrial-academic collaboration programs and internships have become limited or suspended, and it has affected students' study plans.

Forty percent of the students replied that all exams are held typically (in actual classrooms) with few adjustments. Students are arranged to take exams in different (more) rooms to avoid crowded and asked to wear masks. On the other hand, more than half of the students reported they have experienced that exams have been switched to online-based or become midterm papers or assignments. Most of the students said they have no trouble adapting to these new methods while some problems encountered such as limited time to upload

answers and time-consuming, and inconvenient activities such as turning on the camera during the exam. In view of the student's perspective, the fairness of online examination is concerned over cheating and grading.

None of the students from this survey is worried about completion of degree or graduation. Concerns come from students who might get lower grades resulting in low motivation attending class. For master projects, it influences thesis writing progress because the students find it hard to meet with the supervisor, and to schedule the master oral defense. In this view, although physically there are not many effects in the education system in Taiwan, mentally and emotionally students find difficulties in focusing on study, knowing that much of the world is going through a significant crisis. Overall, students feel less anxious likely because the pandemic outbreak is controlling relatively well within the island, or they still have time before graduation. Similar perspective as seen from students in Singapore, students in Taiwan reported many career fairs had been cancelled, job interviews have been postponed or in the slower procedure, as such, may affect their job search after graduation.

V. CONCLUDING REMARKS

This paper was written in the middle of a global crisis, triggered by the SARS-CoV-2 (commonly known as COVID-19) pandemic. The purpose was to study the impact on engineering training, as many institutes for higher education has transitioned to emergency remote education. The results highlight students' experiences from three countries: Singapore, Sweden, and Taiwan.

We can see that both educators and students are facing several challenges during this period of emergency remote education. While many students are coping relatively well with adopting new methods, some downsides associated with remote learning can also be found in this study. Some disadvantages are of a more general nature, such as lack of motivation, more distractions (e.g. kids-caring), but it was also possible to identify common themes in the survey answers. Although the strategies to counteract the pandemic differ among these nations, issues experienced by the students share several common nominators. The following themes could be distinguished in the material:

A. Transitioning from the physical classroom to an online environment

The transition from the physical classroom to remote education comes with both up- and downsides, which are two sides of the same coin. For example, the student's report that the transition may cause both better or worse access to, e.g. contact with supervisors. Moreover, problems related to technology are reported, such as background noise, software issues, and similar inconveniences. Interactions with peers are also reported

to be more difficult in the online environment compared to the physical classroom.

B. Examination activities

Examination activities have also been transitioned online in many cases. Some students argue that online examinations are more complicated, and reports about cheating are present in all three cases. The combination of more difficult examinations, together with cheating students, might, therefore affect honest students in a negative way if they receive lower grades than the cheaters. This is, of course, a considerable challenge for the future of the online university.

Since some activities, including examination tasks, are more practical, several students have had to navigate towards more theoretical topics, for example, in their master theses. These transitions come with both negative and positive implications. Some practical tasks are cancelled due to sectors being under lockdown, which may affect the students receiving the required credits for their projects and theses. However, the students are also encouraged to adapt and find ways to navigate in an uncertain world, towards other types of projects.

C. Perceptions about the future

As is already well studied (see, e.g. [7], [8], and [9]), but not less important is that many students express worries about how the pandemic will affect their future careers. As stated by one student:

> "*As a prospective graduate this year, our career opportunities have been heavily impacted.* "

Many students mentioned they might have to postpone their plans studying abroad (for graduate school or exchange program). For students who had been offered a place the exchange programs, there is a vast uncertainty on whether these activities are to be conducted. Students also express worries about foreseeing incoming world economic depression, which may lead to limited in job markets and available vacancies. This will undoubtedly affect students' career after graduation. Interestingly, we also gained some psychological insights from this survey. For instance, this pandemic may make students more willing to take part in international affairs and concern over global issues. One student mentioned he/she originally intended to go abroad for a master's degree but now is worried about the racial discrimination against Asians in many Western countries.

Nevertheless, we also gain some positive feedback from the survey. Several students argue that the pandemic could enhance job opportunities in the fields of civil engineering, bio-medical industry and virus-related research. Furthermore, the already strong areas of E-business and E-commerce have grown even more when people rapidly transition from "physical" to "digital" behavior.

The whole world is still combating the virus, and we do not know how it will end. As educators, we hope this study provides some insights from students' perspectives, and besides, to all educators in the field, bringing up the discussion surrounding emergency remote teaching in engineering education.

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