Ain Shams University
Egypt

Rethinking the Design of learning Spaces Post COVID-19

A Thesis submitted in the Partial Fulfillment for the Requirement of the Degree of Master of Science in Integrated Urbanism and Sustainable Design

by
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Egypt

Disclaimer

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Abstract

Owing to Covid-19, studies have been taking place in order to develop the architectural standards of educational spaces, among other building types as well, to meet the newly required safety measures. Researchers are investigating new potentials for learning pedagogies and design of learning spaces.

COVID-19 had evoked many challenges in the educational system that resulted in the closure of nearly 85% of schools all over the world in just a couple of months post its appearance. Leaving us with the responsibility of finding ways to develop the architecture of our schools to be safer and more resilient towards COVID-19 while staying in line with the ongoing development of teaching pedagogies.

This research aims to map the challenges that came along with COVID-19 that affected the education in Cairo, Egypt. This is to understand new needs in our education system and how the architecture can respond to these changes for an improved and safer learning environment. Taking Nefertari International Schools as a sample case study representing the physical built environment of schools in Egypt, this research aims to first investigate the challenges in the learning/teaching experience faced by students and teachers during school closure in the pandemic. The challenges that were accompanied by COVID-19 after schools opened. Second, study the built environment of the school to understand the limitations of our existing educational buildings in comparison to the new needs and challenges that came along with COVID-19. Finally, infer the guidelines or measures needed for the development of our school to deal with the challenge of COVID-19 or similar events.

Keywords: COVID-19, Design of Educational buildings, Healthy Buildings.

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Chapter 1: Introduction

1.1 Problem Statement: Covid-19 as an international crisis.

The appearance of the coronavirus (COVID-19) in December 2019 was an unexpected threat to human health and a big challenge to the medical and health sectors. Little did we know that the virus will not only attack our bodies, but it will also attack our economy and all industries as well. Swiftly accelerating from a disease, into a global crisis that is believed to be the biggest challenge to be faced since world war 2 (U.N.D.P., 2021). The world went paralyzed. Airports, restaurants, offices, public spaces, and even schools were closed. People had no other choice but to stay at home. Covid-19 had become a turning point in our lives. Creating a noticeable shift in our behavior, our mindset, and our routine. In the course of events, researchers and architects are working on investigating the limitations of our resources and our buildings to create better opportunities for the design of spaces.

1.2 Scope of study: Covid-19 and education.

With so many industries majorly affected, Education was among the ones on top of the list. The challenges of COVID-19 on education include its impact on schools, teachers, students, and the pedagogy. A couple of months after the emergence of COVID-19, by late-April, 83% of schools in the world were closed, heavily disrupting the learning process of over 1.4 billion students and their families (UNESCO, Education: From disruption to recovery, 2020).

Students are facing several issues which compromise their learning quality like stress symptoms, less time spent on learning, lack of interaction with their colleagues, trouble adapting to a different learning environment that is limited and incapable of offering the resources needed, and even lack of internet access, for some. (OECD, 2020). Teachers on the other side, not only were affected by the pandemic in ways like job loss, or a cut off in salaries, and a huge increase in the number of working hours. That, in addition to other personal struggles of their own. They also take part of the responsibility of compromising the learning quality for students due to lack of training of online learning methods, lack of experience of how to interact with students virtually and the other obstacles that come with online learning. (Luis Espino-Díaz *, 2020).

Finally, regarding the pedagogy, ever since the pandemic, online learning had become more common and more acceptable by everyone. In a very short time, the mode of delivery has shifted from physical attendance in classrooms and books into distant learning, videos, and e-books. Through this change, the learning inputs had to be re-adjusted to fit the limitations of online learning while achieving the learning objectives.

1.3 Study area background

Situation of education in Egypt

According to CAPMAS data, Egypt is the most populous Arab country, with 101 million as of October 2020, about 31% of the age of enrollment. With an estimation of 23 million K-12 students in 2020, with Greater Cairo accounting for 20% (4.6 million) of the total.

Education is considered as one of the main pillars of Egypt's development. The Egyptian constitution mandates that every citizen has the right to free education provided by the state. In Egypt, there are two types of schools: secular and Islamic. There are public, private, and foreign schools of secular education. Al-Azhar schools, also known as Islamic schools, follow a curriculum that is similar to the national curriculum but places a greater focus on Islamic values and Quran studies. According to a study made by

COLLIERS International, given the total population of 101 million people in October 2020, the estimated student enrollment is 30.7 million students distributed with a ratio of 89.4% to 10.6 % Public to Private, respectively (Allianz, 2021) (COLLIERS INTERNATIONAL, 2020)

Secular Education School Types:

-Public Schools

Public schooling is delivered free of charge by the state and is organized closely to most foreign western educational systems. Kindergarten begins at the age of four, followed by primary school at the age of six, and then high school at the age of fourteen. At this stage, you can choose between undergraduate, vocational, and technical fields.

Public schools teach in Arabic and are unlikely to meet the expectations of expat parents for their children. As a result, most expat families want to send their children to private or foreign schools. (Allianz, 2021)

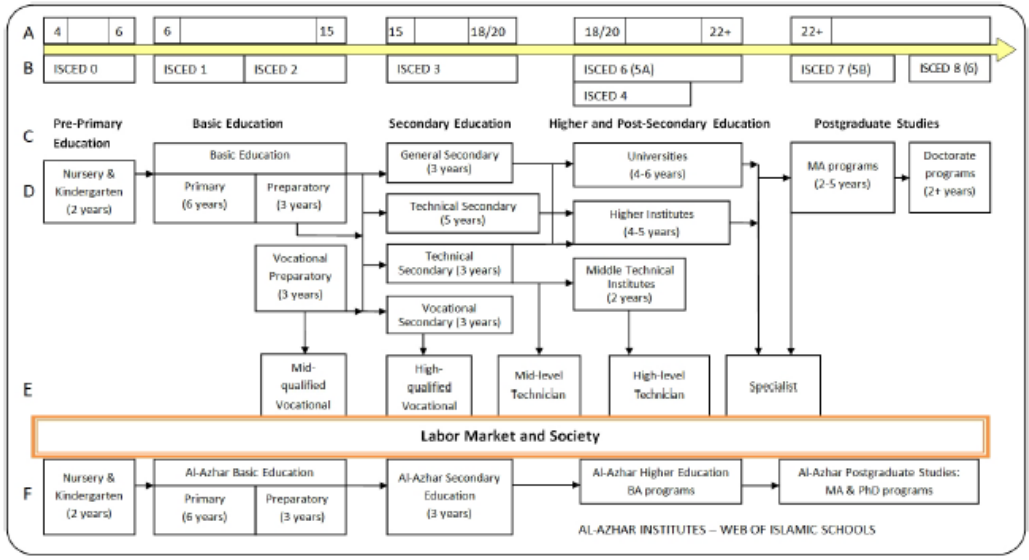


Figure 2: The Overall Structure of Formal Education in Egypt (including ISCED classification*)

A – the age of students' entering & leaving the particular type of the school
B – the ISCED level code
C – the level of education
D – types of schools and their standard duration
E – the level of graduates' qualification
F – Al-Azhar schooling system

Source: Own processing based on WB c, 2006; National Center for Educational Research and Development, 2004, p. 17; El-Koussy, 1991, p. 1642; National Authority for Accreditation of Quality Assurance [NAQAAE b], 2009; UNESCO Institute for Statistics [UIS b], 2007; UNESCO Institute for Statistics [UIS c], 2011; UIS d, 2009;

Figure 1: Structure of education in Egypt. Source: (Malgorzata Stopikowska, 2012)

- Private schools in Egypt

In Egypt, there are various types of private schools. Like public schools, national private schools follow the national curriculum. These schools have better infrastructure and staff because they are funded by tuition. In most cases, students will get a better education here than they will in a public school. Private language schools typically teach the national curriculum in a foreign language, usually English, and then add a second language, such as German or French, in early primary school. Despite the fact that these schools are expensive, children will learn a second language and get a good education. Another kind of private school teaches students according to a religious or educational philosophy, such as Catholicism or Montessori. (Allianz, 2021)

- International schools in Egypt

International schools are private institutions that teach a foreign country's curriculum. The language of instruction is either English or the language of the school's home country. There are also bilingual services available. The majority of foreign schools follow the British, American, or International Baccalaureate (IB) program, although French and German schools are also open. While international schools are costly in Egypt, they provide children with the opportunity to learn a Western education in English or, in some cases, in their native language. (Allianz, 2021)

Although private school students share stands at only 10.6% of the total student population in Egypt, the growth in private sector students has almost doubled in the last five years, at CAGR of 6.3% versus 3.6% in public sector indicating a growing preference towards private schools. Based on Colliers International projections, an additional 11.0 million new seats will be required in Egypt by 2030, out of which 2.1 million will be in the private sector. (Allianz, 2021) (COLLIERS INTERNATIONAL, 2020)

Case study selection

This research takes Nefertari national school as a case study due to the availability of data. The school is located on the Misr Ismalia desert road near the al Obour area of Greater Cairo, where there are 54% of private schools (COLLIERS INTERNATIONAL, 2020). Hence, Nefertari falls as a sample representing the 10.6% of the current population. While this percentage may seem small, it also represents the schools with the growing preference according to the statistics rate of enrollment over the years. Throughout the study, the school building will be studied with regard to regulations for building schools in Egypt to identify in which category it falls and which sample school it represents. By so, we can use the school as a reference for the application of new standards and needs due to COVID-19 for other schools.

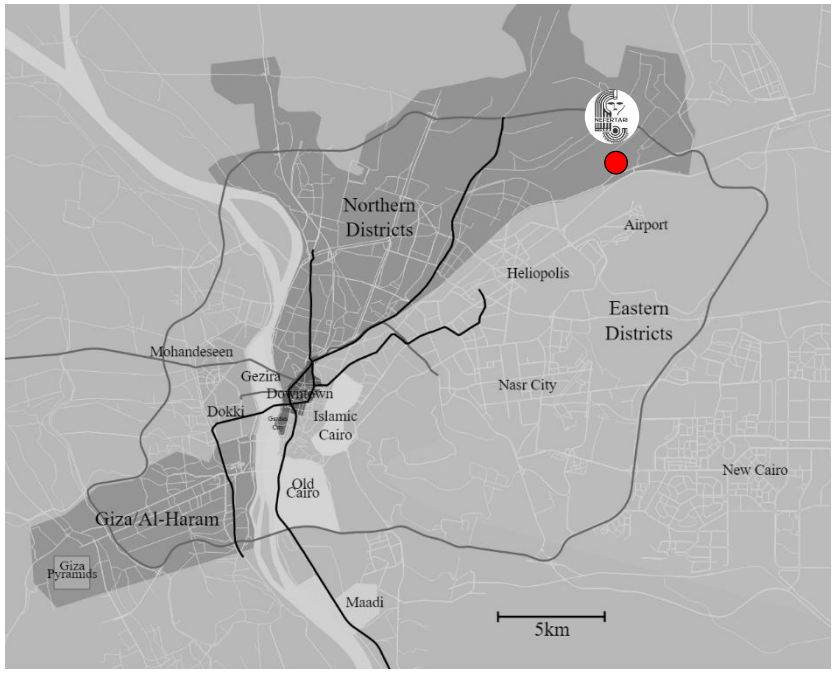


Figure 2 Nefertari school location on Cairo Map. Source: Google maps.

1.4 Research Design

Research Aim and Objective

With all these challenges arising and disrupting our educational ecosystem, we need to pause and question the design of the curriculums, the way we teach and the design of our educational buildings. We need to assess the latter in terms of their compatibility to the expectations of the future of education.

The aim of research is to map the challenges in education due to Covid-19 and study the built environment of a sample school in Cairo to highlight the limitations of the learning space in relation to these new needs and challenges resulting from COVID-19.

The purpose is to explore teaching and design solutions that can not only provide a better educational experience for students and teachers, but also enable us to overcome these newly introduced challenges.

Research methodology and data collection methods

The Sequence of this research starts with first documenting the challenges faced by the education sector in Egypt. Second, exploring potentials for development to mitigate these challenges. According to the challenges faced and the new safety measures declared, limitations appeared in both the pedagogy and the space design of the educational buildings. This research, then, studies the new pedagogies and needs of modal delivery and how it can be translated into the design of the space. Finally, explores the new guidelines for building safe learning spaces in the time of COVID-19 to point out the limitations of the existing buildings for further development.

The first part of the study was covered through desk research and interviews with stakeholders and representatives, Whereas the educational sector stakeholders include the ministry of education, educational buildings' authority, teachers, and students. The first representative, the ministry of education, interviews were held with the deputy minister for education Dr. Hala Abdelsalam and the deputy minister for student activity Dr. Eman Hassan. The interviews were with the intention of understanding challenges that they may have experienced through the time of the pandemic from the

educative perspective, knowing their impression about online learning and their expectation for a change in the vision for education after COVID-19.

The second representative, from the educational buildings' authority, interviews were conducted with the first undersecretary of ministry, general major Eng. Yousry Salem, and the general manager of the construction department of the department in charge, Eng.Rowayda. The interview aimed to gain data about expectations for new guidelines for building schools that may be set in response to COVID-19 and future development strategies for existing schools.

The final representatives, which are students and teachers, surveys were held to acknowledge the challenges they faced during their experience of learning and teaching in the time of the pandemic, get a rejection/ acceptability feedback about new changes and find out their expectations or recommendations for continuation/development of the learning experience in the time of COVID-19.

The second part, the field research, is about exploring the limitations of buildings and potentials for development. Nefertari international school was taken as a sample case study due to the availability of data. The field research is divided into 3 steps. The first step was to understand the references for the building code and to what extent are they in line with the new Covid-19 challenges. The second step is to analyze the built environment of the school and compare it to the guidelines set by the educational buildings authority to understand where the school falls a sample. The third step was to map the built environment with regard to design recommendations for schools in the time of COVID-19 (i.e., Placement of vents, natural ventilation quality, online learning facilities, capacity of classrooms ...etc.).

The third and final part is to explore solutions and design a proposal, a development strategy or guideline for the school that applies the new recommendations for mitigating the challenges of Covid-19 to be used as reference for other schools that fall within the same category as the sample case study.

Chapter 2: Literature review

2.1 Background

The World Health Organization named COVID-19 (Coronavirus Disease 2019) a new infectious respiratory disease that emerged in Wuhan City, Hubei Province, China, in December 2019. The virus quickly spread across the world, causing serious health, economic, environmental, and social problems for every country. About every country is attempting to halt the transmission of the disease by testing and treating patients, quarantining suspected individuals by touch surveillance, banning mass crowds, and imposing absolute or partial lockdown. (Indranil Chakraborty, 2020)

2.2 General impact of Covid-19 on education globally

Schools' closure

The COVID-19 pandemic had forced school closures in 170 countries, heavily disrupting the learning process of more than 1.4 billion students in just a few

months after its emergence. (OECD, 2020). (UNESCO, Adverse consequences of school closures, 2020)

According to UNESCO, challenges accompanied by school closure are firstly, interrupted learning & social isolation. Since on school learning not only depends on the delivery of the curriculum, but it also allows an experience for growth and development through social interaction in and outside the classroom, with their peer students and their teachers. The closure of schools had compromised this interactive experience and education had only been limited to lectures delivered through the screen with even no eye contact. This eventually affect students focusing ability and engagement and thus creativity and productivity. Secondly, other than learning, in some countries and poor areas, schools are places that provide daily nutrition and health care. Many students relied on the discounted or free meals and health care provided at their learning facility and this had been compromised due to the closure in the time of pandemic. Finally, the school closure had created a labor crisis and many staff members; teachers, managers and workers were affected in ways like losing their jobs or having a cut in the salary. (Edeh Michael Onyema, 2020) (Interviews with teachers) (UNESCO, Adverse consequences of school closures, 2020)

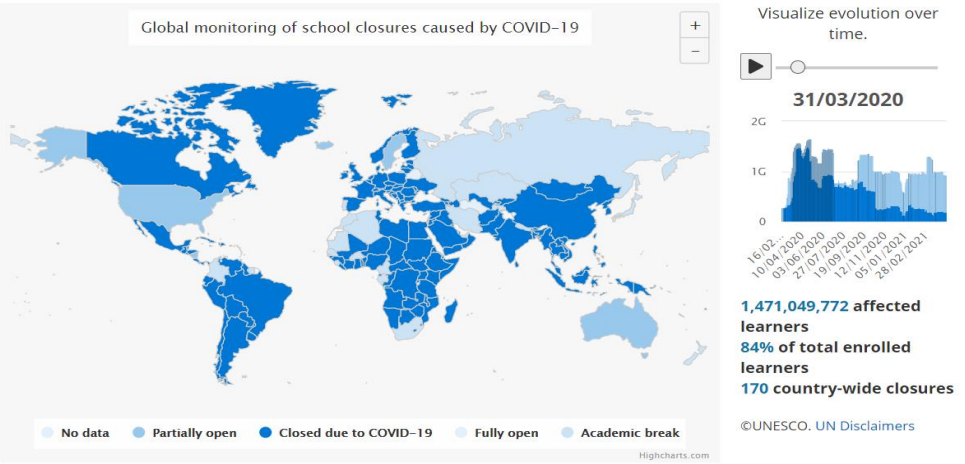


Figure 3 Global monitoring of school closures caused by COVID-19 (March 2020). Source: World Health Organization

A Switch to remote online learning

COVID-19 has forced schools to move from an offline to an online pedagogy. Because of the recession, schools and institutions that have previously been resistant to reform have been more tolerant of new technologies. Online learning was the most convenient way to keep the learning process going through the time when schools were closed. However, online learning has its own drawbacks that need to be considered and dealt with since it has no longer become a luxury, it has in fact become a necessity.

Researchers have named some of the main issues related to online learning which include lack of resources, poor national infrastructure, problems facing students and course delivery problems. While it might sound tempting for students to get their education at the comfort of their home, the reality of receiving proper education from home could be very challenging to many educators, learners, and parents. There are first problems that are related to poor network infrastructure, continuous disconnections, poor digital skills, inaccessibility especially in developing countries.

There is also the problem of the inappropriate learning environment for students, surrounding noises, uncomfortable spaces, and lack of needed facilities. While for some these challenges may be easy to come around, for others in poorer countries or students with special needs may be deprived from education with the prolonged school closure and continuous dependency on online learning.

Also, there is the issue of unavailability of parents. Students in the early stages may be well exposed to technology but they are still incapable of keeping up with the schedules of the classes and attending them on their own without the supervision of their parents, who are unavailable because they have work to attend to and other life commitments. As for older stages, it has been very challenging for teachers to connect with the students and apply different teaching styles, that fit all characters, on a virtual platform. Direct communication and ensuring students focus have become almost impossible to achieve over the online learning platforms.

Moreover, the learning process cannot achieve its full capacity until students put what they have learned into practice. Online content is frequently theoretical, making it difficult for students to experiment and learn effectively. (Interviews with teachers) (Edeh Michael Onyema, 2020) (Dhawan, 2020) (Oyedotun, 2020)

2.3 Impact of Covid-19 on education in Egypt

Sequence of events

The emergence of the virus started in China in late December 2019. Weeks later, education was suspended in China to prevent the spread of the virus and thus bringing back Egyptian students from Wuhan and other Chinese cities.

So far, there were no shocks nor concerns in Egypt and education continued normally. However, the government and the ministry of higher education faced financial problems in the expenses of bringing back the Egyptian students and providing additional grants for those who had to remain abroad, with no expectation of a time frame of when these additional grants could come to an end.

The virus continued to rapidly spread across the globe by February through mid- March, suspending schools and universities in more countries like Europe and the United States. This issue had doubled the financial pressure regarding the return of students. At that time, the virus had reached Egypt. A state of panic started to spread among parents. Education went on as usual, but with a notable drop in the number of students due to parents' tendency to drop their children off from school.

By the end of March and up until May, which was the peak of the first wave of COVID-19 in Egypt, the average number of registered cases were over a 1000 per day and the death rate ranged from 80 to 120 deaths per day according to the World Health Organization Dashboard. The education sector went into a complete state of paralysis, all educational facilities were to be closed for 30 days and until further notice.

Consequently, the entire education system had to suddenly switch into distance learning to ensure the continuation of education. This event had widened the gap between the governmental, private, and international institutions on the quality of education especially in rural areas and outside great governorates.

The international and private schools were the readiest for distance learning. Others went into a shock as they lacked facilities to withstand the needs of distance learning. This issue included access to the internet, computers, laptops, and smart boards. The country acknowledged such a gap and

deficiency in the education system as a whole and decided to cancel examinations completely until they can figure a way to fairly evaluate students given the new circumstances. With the extension of the school closure timeframe, the position of the government was not clear for the end of the current scholastic year. Students remained confused in front the new decisions taken daily from the minister of education, which ended with a cancellation of exams for all, and the lost learning content was to be compensated the following year.

Challenges then began to rise, Interruption in incomes for many groups such as teachers and employees working informally as in private lessons centers and others, private institutions in turn started decreasing salaries due to the major loss they are facing, and students are now living under a great mental stress given the ambivalent situation of the expectations for their future, and the sudden massive change routine accompanied by the global panic and fear of the virus attack.

Months after, from mid-May until August 2020, the first wave reached its peak. Registering over 10,700 cases on average daily in June and a death rate reaching over 600 deaths per day on the World health organization dashboard. The shock continues, all industries are extremely affected. However, the pressure on the educational sector began to decrease as they reached the end of the scholastic year and approached the summer vacation. The main challenges then were preparing for the new year, providing a strategy to overcome this pandemic with the least possible consequences in addition to a compromising plan for the draw backs from last year. The hardest challenges of all were balancing the educational attainment levels of the governmental schools with the international ones due to the difficulty of applying online learning strategies. That, and determining an evaluation mechanism for final exams especially preparatory and high school certificate stages.

In October 2020, the second academic year in the COVID-19 era had started and schools opened with a coexistence plan that is being followed up until the time of writing this research in April 2021. Except for school reclosure by late December 2020 up until March 2021 during the second wave of COVID-19 in Egypt. This coexistence plan depended on maintaining the safety measures of social distancing, wearing masks and constant sanitization of the facilities and a protocol in the case of the appearance of cases. Leaving the managerial decisions of learning pedagogies up for each school on its own.

The current situation of the educational sector is getting stable by day, and each school is coming around to find ways to overcome the challenges brought with the virus, whether by fully depending on online learning or altering the students over weekdays to decrease capacities.

As we approach the third wave, which is considered the most vigorous because of a development of the virus into a more aggressive one according to the World health organization, some schools remained open while others chose to switch fully to online learning, but this is only during the Holy month of Ramadan with no intention of remaining closed afterwards. (ECES , 2020) (Interview with administration staff in schools) (Interview with deputy minister of education of Egypt) (Ministry Of Health, 2020) (Ministry of Education, 2020) (World Health Organization, 2021)

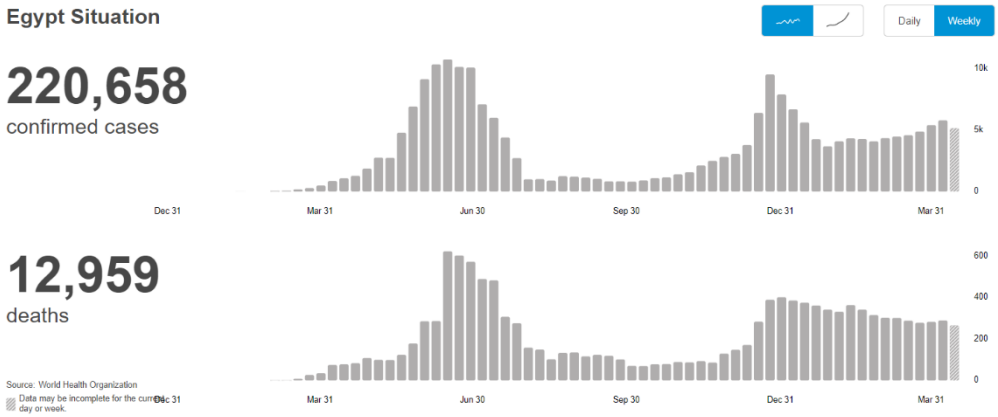


Figure 4 Dashboard of confirmed cases and deaths in Egypt. Source: World Health Organization

Weakness revealed in the educational sector post Covid-19

The COVID-19 crisis has caused many challenges in the education field, but it also highlighted the challenges that already exist. In 2017- 2018, Egypt was ranked 133rd of 137 countries for the quality of primary education on The World Economic Forum's Global Competitiveness Report (Johnson, 2018). The educational sector has not always been the top priority for the Egyptian government and most of the countries' budget instead went for mega projects.

Over the last decade, Egypt had received billions of dollars from external investments, loans, grants, cash transfers, and development projects, but only two initiatives have focused on education, which unfortunately were not even able to fully achieve their objectives of development (ECES , 2020) (Johnson, 2018). As a result of not directing the attention and the budget properly to the educational sector, schools of Egypt especially in the public sector have not been able to properly implement online learning due to lack of equipment and poor network infrastructure. Which had led to an extra increase of the gap between the private and public schools with regard to the quality of learning during the time of the pandemic. (ECES , 2020)

Another main problem that had been highlighted in the time of the COVID-19 crisis, is the overcrowding of the classroom with students. According to the Egyptian Standards and requirements for the validity of school sites and buildings issue 2020, each student's share cannot be less than 1m2 per student for Arabic & national schools and 2m2 for international schools with a minimum area of 38m2 per classroom. A study by the American University in Cairo states that 75% of our schools have classrooms that are overcrowded with students holding over 40 students per classroom instead of 30. (A.Moneim, 2020). This does not only form a threat regarding health and hygiene it also increases the risk factors of having tensions, conflicts and disruptive behavior among students, less personal connection between students and teachers and personalized focus, and more noise inside the classroom. All of which eventually affect the quality of the learning experience offered by the school. (Hachem, 2019)

Given the fact that these standards need to be changed in response to COVID-19 to maintain the 1m distance between each desk and the other, the scope of the challenge had expanded, and more and more schools are struggling to fit the capacity of the students in their classrooms while following the guidelines.

Points of strength in the educational sector post Covid-19

The educational sector had definitely faced numerous challenges with the emergence of Covid-19. Luckily, some of the changes that came along with the situation were in favor of the Egyptian education vision for 2030.

A part of the vision 2030 is to provide quality education especially in public and governmental schools. As the government acknowledged the gap between private and public schools, it had decided to improve the quality of education through integration of technology among many other decisions. (Ministry of education of Egypt, 2014) Before Covid-19, in 2013 the minister of education announced the inclusion of the tablet into the educative system. Ever since, over 2000 governmental schools have received tablets for their students along with an improvement for the internet infrastructure in many governorates. (Leila, 2019)Nevertheless, in the time of the pandemic when remote learning was the only option, the government launched a new learning platform called Madarestna. Where the curriculum was presented via online channels in addition to extra online tutoring sessions. (Interview with teachers)

As Covid-19 enforced the acceleration of online learning, the original plan of integrating technology in the Egyptian education system was of great significance and one of the main reasons the learning journey was resilient and not paralyzed.

2.4 Mitigations in response to Covid-19 challenges in the educational sector

2.4.1 Main challenges

If we look back and analyze the impact of Covid-19 on the education and how the educational institutions responded. We can conclude that capacity was the main driver and the biggest challenge of all. With the need to always maintain physical distancing, our spaces could not absorb the amount of population it once did.

Consequently, educational institutions are either providing full remote learning to fully prevent and social interaction or are altering the attendance of the students over weekdays so they can distribute the student's capacity over more classrooms to be able to maintain physical distancing.

The main driver for maintaining physical distancing comes from the norm of the virus and how it spreads. COVID-19 Virus particles found in an infectious person's coughs, sneezes, and exhaled breath will travel through the air and stay aloft for hours. If a large amount of virus is inhaled, this long-range airborne virus may infect people who have not been in close contact with the infected person in the first place. Bringing fresh outside air into a space will dilute and/or displace any existing airborne virus, lowering the risk of infecting anyone who breathes enough infectious aerosol. (HARVARD, 2020) Therefore, ventilation should be improved inside the learning spaces to match the new needs of the Covid-19 situation.

In conclusion, the main challenges that need to be tackled in order to ensure continuation of in person education through to time of Covid-19 are capacity and ventilation.

2.4.1 Mitigations categories

Authorities, researchers, and architects are exploring new ideas to help mitigate the consequences of COVID-19. When summarizing the types of mitigations and the measures that need to be taken, we can conclude that they are divided into three main categories.

The first category is related to managerial measures. This includes the protocol of how to be ready when cases appear among the school members. Regulations that ensure proper sanitation and hygiene of the facility. Regulations to control behavior, ensure that you wear masks and maintain social distancing. And finally, decisions which may include a need for adjustment of the schedule to manage capacity of students within the building.

The second category tackles the pedagogy and the modal delivery, as we now know for sure, online learning has no longer become luxury but in fact a necessity. Efforts are exerted to find the most convenient ways to apply online learning methods without compromising the learning quality. In addition to online based learning, researchers are also surfing the potentials of taking classrooms outside for hygiene purposes.

The final category, which is the architecture or the design of the built environment, is a response to the first two categories. For example, proper hygiene & air circulation in the facility, maintaining social distancing and having less capacities of students mean that the design of space itself should be considerate of the quality of ventilation in the spaces with regards to the number of students and the area of the space. Maintaining social distancing and decreasing capacities on the other hand requires considerations like the dimensions of the circulation corridors, spacing between furniture inside the classrooms, ratio of area of spaces to the number of students … etc. Nevertheless, applying certain pedagogies require architectural response as well. Incorporating online learning into the system may require some interior redesigning of the classrooms, installing new furniture, ensuring correct placement of equipment … etc. Also, using outdoor spaces for learning needs to consider the relationship between indoor and outdoor spaces, outdoor partitions, and climate response of solids and voids … etc.

2.4.2 First Category: Operational Mitigations (Safety measures & guidelines)

Protocols and precautions vary from one country to another and one school to another. However, classroom precautions according to the UNICEF &the World Health Organization are as follow: (UNICEF, 2020) (World Health Organization, 2020)

1) Physical distancing at schools - Maintaining at least 1 meter between everyone present at school - Increase desk spacing - Stagger school days over the different stages - Stagger breaks to avoid crowd in play areas & corridors - Limit mixing of classes and teachers rotate over the classrooms instead. - Consider the possibility of increasing the staff to serve students in less capacities - Use signages, tapes and barriers to create queues
2) Hygiene and mask wearing
3) Cleaning and disinfecting
- Daily cleaning and disinfecting of surfaces and objects that are touched often, such as desks, countertops, doorknobs, computer keyboards, hands-on learning items, taps, phones, and toys.
4) School preparations and what to do if one of your students displays any of the symptoms - Designate a specific area in the school that is well ventilated and near the entrance as a waiting room where children show symptoms can wait at till their parents pick them up. - Daily screening for body temperature on entry into the building for all staff, students, and visitors to identify persons who are sick. - Children who have the virus or have recently interacted with a covid-19 patient shall be quarantined for 14 days and not return unless with a negative PCR test report.

2.4.3 Second Category: Pedagogical mitigations

1) First Pedagogy: Remote Learning to mitigate COVID-19 challenges

Unlike the regular classroom, remote learning is when the learner and the instructor, or knowledge source, are not physically present. Technology is used to transmit information, such as discussion boards, video conferencing, and online exams.

Benefits of remote learning in the time of Covid-19

The current Coronavirus epidemic is prompting the world to experiment with remote education. There are several signs that this crisis will alter the future of education if remote teaching proves to be a success. There is evidence that studying online can be more successful in a variety of ways for individuals who have access to the proper technology. According to several studies, students who study online retain 25-60% more content than those who learn in a classroom. This is mostly due to the flexibility this pedagogy offers. Students are able to learn more quickly online; e-learning takes 40-60% less time to study than traditional classroom learning since students may learn at their own pace, going back and re-reading, skipping, or accelerating through ideas as needed. Other perks of remote learning are affordability and accessibility. When you enroll in an online program, you may save a lot of money. Since online programs are typically cheaper. Also, you may study or teach from anywhere in the globe with online education. This eliminates the need to commute from one location to another or follow a strict timetable. Furthermore, not only do you save time, but you also save money, which you may use towards other things. (Cathy Li, 2020) (Nasseir, 2020)

Limitations of remote learning

Long before COVID-19, studies have been investigating the importance of social interaction in education. In the early 90's, the learning process was defined as social activity and the concept of educating through having the teachers do all the lecturing contradicts this philosophy. Students need to become active learners and engage in the classroom activities like reading,

speaking, writing …etc. Including students has been proved to increase their confidence and hence, their academic performance (Hurst, 2013).

Other than social interaction, students learn in different styles. One of the basics of teaching is understanding the differences between how students perceive learning. According to the different capabilities of each student, learning styles have been divided into visual, auditory & kinesthetic. The first depends on eye contact, watching the teacher's body language, watching visual content like videos and power points … etc. The second depends on one-to-one conversations, classroom discussions, oral presentations, videos, and podcasts …etc. The final style depends on experience which include hands-on activities, role playing, physical activities or even note taking.

As we can conclude, another problem with fully depending on online learning and virtual platforms is that teachers are limited in applying these teaching basics they have forever practiced which makes it almost impossible for them to ensure that their students have well perceived the course content (interviews with teachers). Students are deprived from their basic needs like eye-contact, peer interaction, activity performance and bonding with their teachers and colleagues.

So, despite the flexibility of remote learning, this pedagogical approach will always be limited and cannot be fully depended on as it lacks the real interaction that needs to occur for the education experience to be whole.

1) Second Pedagogy: Blended learning to mitigate COVID-19 challenges

Blended learning, or in other words, Hybrid Learning, is a modern concept in the educational field that merges between traditional in-class learning and online learning. By integrating multiple delivery modalities, blended learning aims to provide the most efficient and productive instruction experience possible.

Different authors have defined blended learning in many terms all of which revolve around the concept of offering structured learning opportunities that combine more than one instruction or preparation form, either within or outside the classroom, and offer at least some of the material online. Different learning or teaching methods (lecture, conversation, supervised exercise, reading, gaming, case study, simulation), implementation methods (face-to-face or machine mediated), scheduling (synchronous or asynchronous), and levels of supervision (individual, teacher or professional led, or group/social learning) are all included in this concept which mainly uses emerging tools to transform conventional schooling approaches and organization. (IBE-UNESCO, 2021)

Blended Learning Models

In this section, different models for blended learning are explained to portray the pedagogy's ability to facilitate learning continuation in the time of COVID-19. Blended learning can be applied in a variety of ways, with the most common models being a mixture of one or more of the following models. (BLU_, 2021)

The following three models of blended learning depend on increasing classroom efficiency by leaving the lectures for distant learning at home and saving the classes for guided practice and group activities which allow distribution of education on both home and school over the weekdays.

Flipped Classroom

In the flipped classroom model, the conventional arrangement between class time and homework is flipped. Teachers use class time for teacher-guided

preparation or assignments, while students' study at home through online coursework and lectures. This model allows teachers to do more than just give typical lessons in class.

Flex
The Flex model allows students to switch between learning experiences on a flexible schedule based on their needs. In a Flex model, online learning is the cornerstone of student learning. As students work on the course curriculum and materials, teachers provide guidance and instruction on an as-needed basis. Students will have a lot of influence over their learning using this model.

Ala Carte
In this model Students can take an online course from an online instructor of record in addition to other face-to-face classes using the A La Carte format, which gives them greater scheduling flexibility. When schools are unable to have specific learning options, such as an Advanced Placement or elective course, A La Carte courses can be a perfect choice, making it one of the most common models of mixed high schools.

Enriched Virtual
The Enriched Virtual model is a part-time online education that encourages students to complete the bulk of their coursework online at home or outside of school, but still attend school for needed face-to-face learning sessions with an instructor. Enriched Virtual classes, on the contrary of Flipped Classroom, do not always require regular school attendance; some systems, for example, can only require attendance twice weekly.

Benefits of blended learning during COVID-19

Since the start of the pandemic, educational institutions have mostly used three models: in-person, remote, and hybrid. Prior to COVID 19 and until early March 2020, schools used a full-time in-person model, in which teachers and students met in person all the time. Most schools used a conventional approach (i.e., textbooks and blackboard teaching), whereas some used a hybrid approach (i.e., Edu-tech solutions). It seemed impossible to continue in person learning as COVID-19 continued to vigorously spread.

To prevent the epidemic from spreading, most schools closed and transitioned to a completely remote model, with both instruction and teacher-student interactions taking place online. This strategy will continue to be the most appropriate in areas where there is a high chance of transmission to ensure education continuation while prioritizing health over the quality of education given. As the peak of the virus started to decline, schools started opening partially, following blended learning models, so students could return in person for a partial school day or for a few days a week. (Global Education Coalition, 2020)

The main issue hindering the continuation of in person education is the Capacity. The capacity of schools to have in-person instruction varies depending on the local epidemiological situation and the schools' ability to cope with it. The main drivers for capacity variation from one school to another is the availability of physical spaces and availability of staff. Schools with low capabilities for holding big capacities of students tend to drift towards a paralysis in their education and cannot ensure learning continuity if remote learning capabilities are not sufficient as well. While schools which can offer larger capacities for students and have a capacity for switching to remote learning in case of the need for disruption of online learning are more resilient to learning continuation.

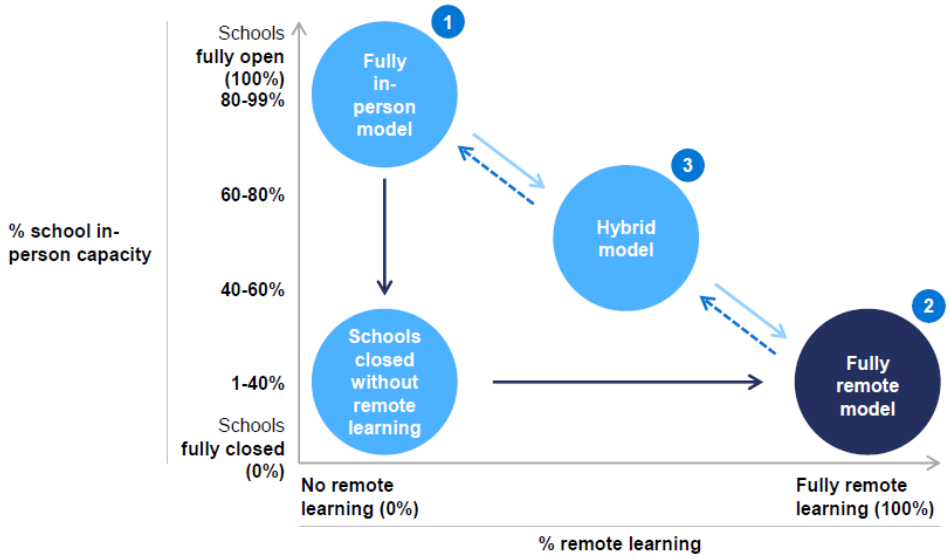


Figure 5 Graph representing school capacity and inclination towards online learning. Source: (Global Education Coalition, 2020)

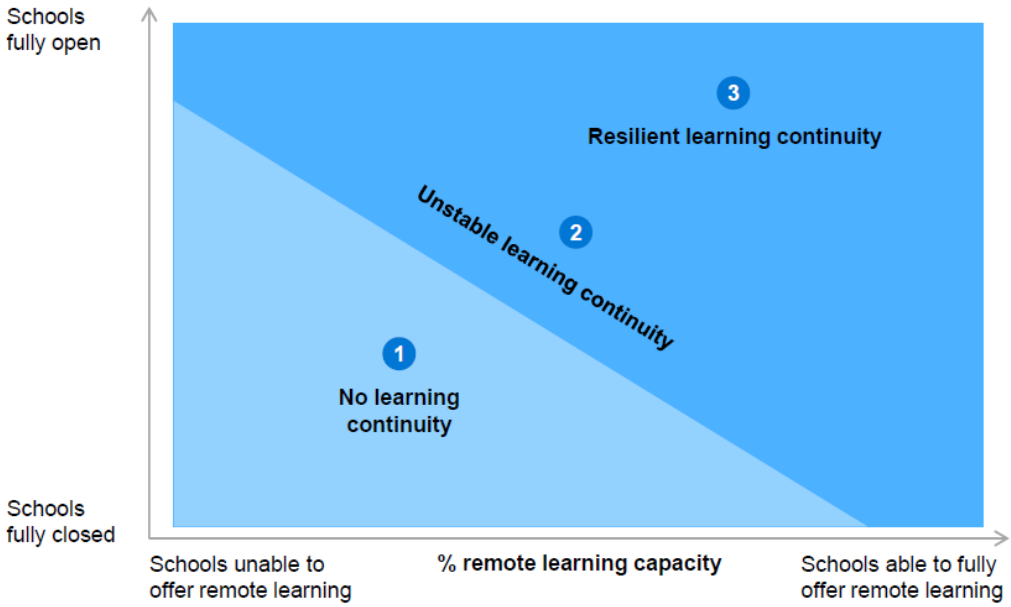


Figure 6 Relation between school capabilities and learning continuity. Source: (Global Education Coalition, 2020)

Limitations of blended learning

From the draw backs of blended learning is that it is highly dependent on technology, so unless executed and implemented carefully, it may be not as efficient. First and foremost, these technological tools need to always be up to date and reliable to ensure equity in education. Second, a lot of training for both students and teachers is required since it has not been the common method of learning, IT literacy may significantly disrupt the learning process. Nevertheless, poor infrastructure and hardship of access to internet proposes unfair opportunities for learning and may as well disrupt the quality of education. Thirdly, as for challenges in practice, students may fall behind in their studies if lecture recording devices are used. Only half of students watched lecture videos on a regular basis, according to a research conducted at 4 distinct universities, while almost 40% of students watched several weeks' worth of films in one session. (KRASULIA, 2017)

Therefore, integrating blended learning pedagogy should be carefully implemented to provide the most efficient form of education. By distributing the curriculum over both online and in-person learning according to the content, blended learning shall hopefully provide safe education experience that is of quality.

2) Third Pedagogy: Outdoor learning to mitigate COVID-19 challenges

As we continue to surf mitigation methods for education in the time of Covid-19, and as we stand in front of the obstacles of the need to decrease the capacity and improve indoor ventilation, we need to think beyond and surf potentials that enrich the learning experience besides providing a safer learning space. Since health organizations are opting for presence in open spaces and since research has been opting for outdoor learning for the various benefits it provides to the student, in this section we explore how to integrate the pedagogy of outdoor learning into our system as the outdoor setup offers better ventilation and can contribute to the capacity issue as it provides extra space to host more students rather than just replicating the traditional classroom setup in an outdoor setting.

The concept of outdoor learning

Moving students to the outdoors for disease risk management is not a new concept. It had been practiced during the tuberculosis outbreak in the 1900's. (Bodor, 2020) Bringing classrooms in the open is a safer option than the indoor closed classroom, as we all know. However, the concept of learning outdoor goes beyond having the same setup of the classroom and the method of teaching in the outdoors. Instead, unlike traditional classroom learning, it is more a living laboratory that encourages engagement with nature, exploring, unleashing potentials and creativity. (Boston university, 2020) Aristotle, the famous philosopher, explained that "education requires three main things: nature, study, and practice." With these core ideas about man's relationship with environment are regarded as the first basis of outdoor learning, new concepts of outdoor education have emerged. These new concepts in a simpler form embody the same concept of experiential learning. This includes activities like outdoor games, open exploration, hikes, field studies, experiments, gardening, or orienteering. (New, 2016)

Benefits of outdoor Learning as pedagogy in general

Keeping children indoors may seem like the easiest way to protect them and control them in a way or another. However, exposing children to the environment and giving them the chance to imagine and learn through

experience may have a significant impact on their wellbeing, their character and even academic performance. (New, 2016) The benefits from practicing outdoor learning include improved physical health and mental wellbeing, environmental awareness hence an increased sense of belonging and responsibility, a dynamic learning experience which increases engagement and promotes confidence in the children.

Physical health & mental wellbeing

Physical education does not have to be the only time throughout the school day when students are permitted to be active. Introducing more outdoor education opportunities could help students to meet recommended daily physical activity (DPA) requirements, which may assist to address the rising problem of obesity and fitness-related ailments. (Christoph Mall, 2017) (New, 2016). Also, being outside may both mentally and emotionally invigorate a learner. Nature's healing power has been demonstrated by a substantial body of data. According to studies done in the United States, the more the child is exposed to the green environment, the more controllable their attention-deficit disorder and depression symptoms are. (Andrea Faber Taylor, 2011)

Dynamic Learning

As it is explained earlier, people learn in different ways and human brains are not fixed. This was a major drawback in depending solely on remote learning, understanding this need for applying different learning styles is one of the main reasons of acknowledging that in-person learning is not replaceable, yet more kinesthetic and naturalistic-oriented students are underserved in the classroom. From the plus points of outdoor education is that it provides a wider context for students to learn at their own pace and in their own style, allowing each to perceive differently as they experience what they are taught. This eventually reflects on their academic behavior and higher performance rates have been noticed with a rise to 27% especially from children who find it hard to focus sitting on a desk in front of a narrative teacher. (Bosch, 2020) (Hurst, 2013) (New, 2016)

Environmental awareness

Children's physical and mental health are not the only issues that are affected when they are isolated from outdoors. It is important to teach children about

the importance of caring for the environment at a young age and being conscious of their ecological footprint to sustain a healthy environment for them and the future generations. If we deprive students from the opportunity of interacting directly with nature, they will grow with a poor understanding of its importance and hence give it less value in their adult life. On the other hand, as children from younger age are learning to plant trees and nurture them, this gives them responsibility and a sense of belonging to the environment and they tend to grow into more eco-friendly users of earth. (Chawla, 2006)

Limitations of outdoor learning

There is no sufficient evidence that demonstrate pedagogical disadvantages for outdoor education. Since this pedagogy offers various settings for education and is supposed to address the difference of learning styles and different characters of students. However, the challenges that come along with implementing such pedagogy appear in the design of the infrastructure and the setup of the spaces where this pedagogy will be implemented. These challenges will be explained later in the research under the section of design strategies and consideration when planning for a learning landscape for outdoor education.

Outdoor learning & Covid-19

The positive impact of outdoor education is not only exclusive to the pedagogical aspect and the children's character development. Integrating outdoor learning into our education system can contribute to handling some of the challenges accompanied by Covid-19 and help continuation of in-person learning safely in the time of corona.

In the early 1900s, learning in open-air settings was an effective technique for preventing tuberculosis and mitigating transmission during the 1918 influenza pandemic. In a few nations, such as England and Sweden, as well as districts in California, Vermont, and Florida, learning outside has been an innovative method to bringing kids together for face-to-face education this school year in post Covid-19 era. Since, the virus spreads mostly by droplets and airborne particles, and the danger decreases fast as distance and fresh air movement increase. Therefore, COVID-19 transmission rates are significantly lower in outdoor settings, according to research 10% of cases may be connected to outdoor transmission. Nevertheless, it is substantial to maintain

all safety measures of mask wearing and physical distancing as disease transmission through contact is not exclusive to indoor spaces. (OREGON, 2021)

Outdoor learning does not only contribute by providing better ventilated spaces, but it also helps with the struggle of the need of reducing capacity of students inside the building as well. Physical distance is now mandatory for schools reopening, and they are not designed to accommodate students at 2 meters apart. Studies expect that schools will be able to fit only approximately 60% of their enrolled capacity in their usual classrooms with the physical distancing. (Green school yards America, 2020)

Although blended learning and staggering schedules significantly contribute to this capacity issue. Also, it seems like the most convenient and fast approach for continuation of in-person education. But studies expect that the economy will not be able to fully comeback unless students are at school full time. (Green school yards America, 2020) Also, eventually we will need to get our normal lives back and our schools need to be ready to accommodate full capacity of enrolled students in a safe and appropriate environment. Therefore, investing in implementing outdoor education is a long-term solution that benefits the quality of the future of education, provides safer learning spaces and helps fitting a higher capacity of students with the physical distancing measures applied.

2.4.4 Third Category: Architectural Mitigations

2.4.4.1 Architectural mitigation of challenges through improving ventilation

The role of ventilation in inducing of the risk of infection inside the classroom

A study was made by the Spanish National Research Council (CSIC) to explore the rate of the risk of infection inside the classroom with and without mitigation measures taken to check effectiveness of each measure. In the scenarios simulated, the variables affecting the rate of infection were, the duration of the classroom, mask wearing and ventilation. During the simulations, the subjects maintain the recommended safe distance, eliminating the risk of transmission via droplets.

Since, Teachers speak more frequently than students and raise their voices to be heard, which increases the amount of potentially infectious particles ejected. An infected student, on the other hand, can only talk occasionally. Accordingly, the simulation study was made given the scenario that infected patient is the teacher, which proposes the highest rate for the risk of infection. (Galloway, 2020)

The method used was the Covid Airborne Transmission Estimator, developed by a group of scientists led by Professor José Luis Jiménez of the University of Colorado, to measure the probability of transmission between people in "at-risk" situations. The aim of this tool is to recognize the importance of measures that prevent aerosol transmission. The equation is not exhaustive, and it does not account for all the countless factors that can influence transmission, but it does show how changing circumstances we can influence can reduce the risk of contagion. Moreover, it demonstrates how the risk of contagion can be reduced by altering conditions over which we have power. (Jimenez, 2020)

Scientists were able to quantify the degree to which the danger could have been mitigated if they had taken precautions to prevent airborne transmission after carefully researching the outbreak.

For a classroom of 24 students (maintaining the recommended physical distancing and the patient is the teacher) Results were as follow:

Scenario (1): A 2-hour classroom with an infected teacher with no measures taken, there is the risk that up to 12 students could become infected. (50% rate of infection) (Galloway, 2020) (Jimenez, 2020)

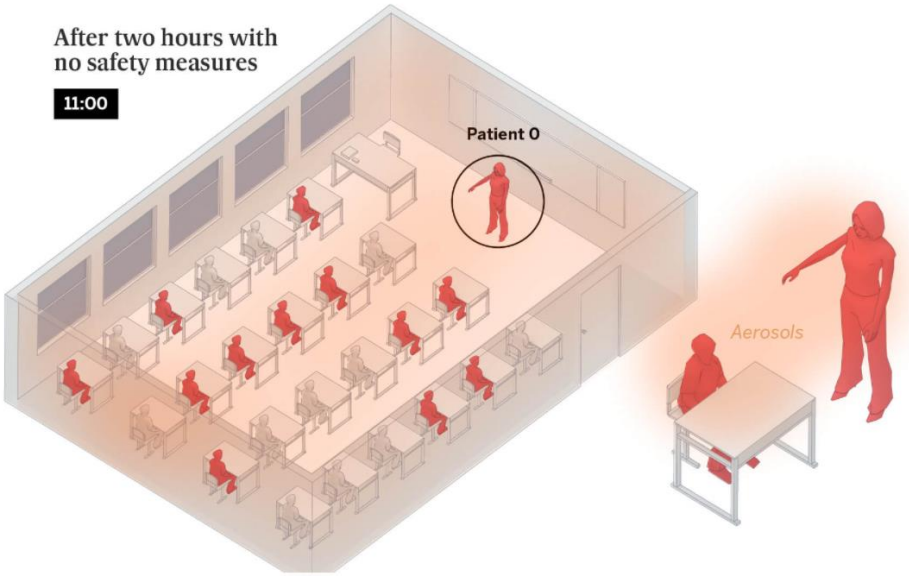


Figure 7 Scenario (1) - No measures taken. Source: (Galloway, 2020)

Scenario (2): A 2-hour classroom with an infected teacher but everyone is wearing masks. The number of people who may become infected drops to five if everyone wears a face mask. Since the aerosols are spread randomly around the unventilated room in actual outbreaks, any of the students may become contaminated, regardless of their proximity to the instructor. (Galloway, 2020) (Jimenez, 2020)

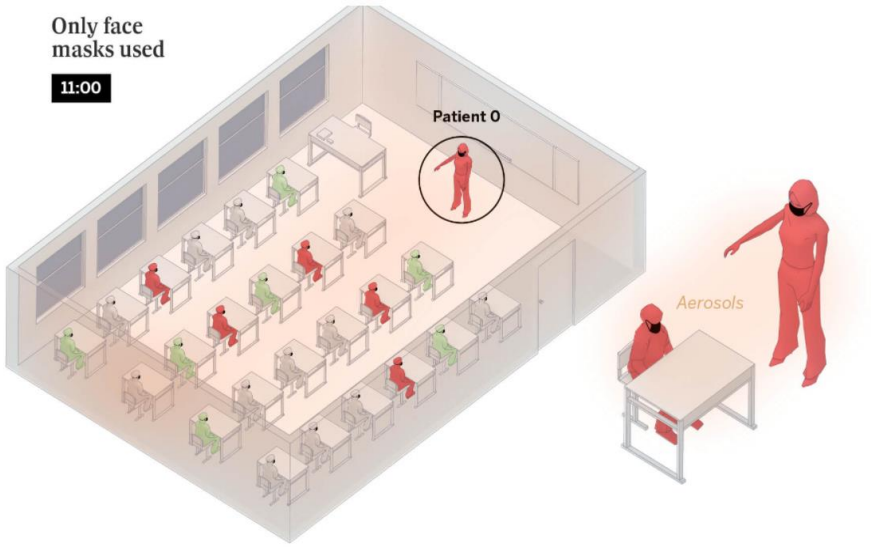


Figure 9 Scenario (2) - Wearing masks. Source: (Galloway, 2020)

Scenario (3): A 1-hour classroom with an infected teacher, everyone is wearing masks and the room in ventilated with fresh air (naturally or mechanically), the risk drops dramatically to 1 patient (Jimenez, 2020) (Galloway, 2020)

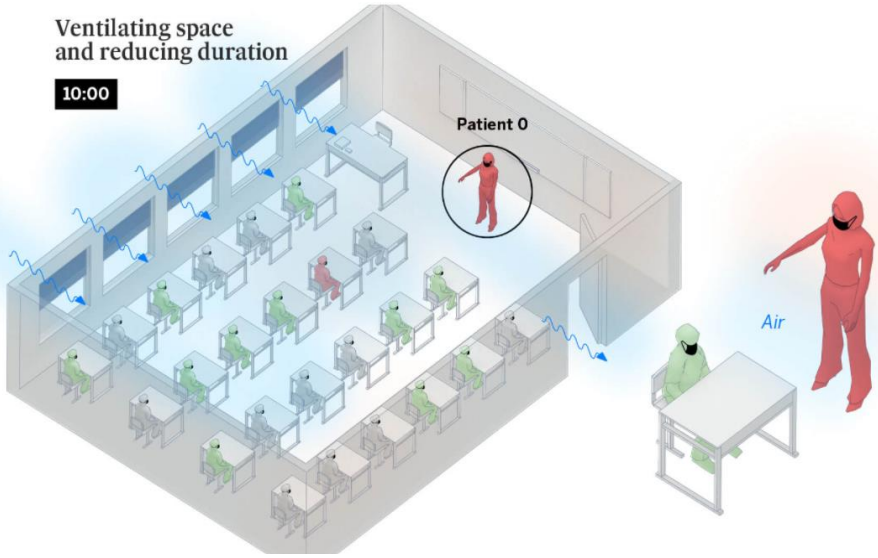


Figure 8 Scenario (3)- Ventilating with fresh air. Source: (Galloway, 2020)

Proper Ventilation inside classrooms

According to the previously demonstrated study, it is clear how ventilation reduces the risk of infection through aerosols dramatically, with the help of mask wearing and physical distancing, of course.

Another study published in the journal of royal society in medicine, explains how ventilation plays an important role in decreasing the risk of infection and how proper ventilation in the classrooms is our gateway to opening schools. The study explains that, in a room with no ventilation, it takes approximately 4 minutes to halve the number of tiny droplets in the air; and, when only artificial ventilation is used, it takes only 1.4 minutes to halve the number of respiratory particles. However, it takes only 30 seconds for the droplets to be halved in a room that has fresh air just by opening a door and a window. Therefore, in order to minimize the risk of contamination, classroom ventilation must be adequate to dilute and filter respiratory particles. This is because things like breathing, laughing, humming, coughing, and sneezing contain and concentrate a vast number of respiratory particles in a confined space. (Kaveh Asanati, 2021)

To be able to provide to proper natural ventilation, studies focus on 2 key factors. The first is the placement of vents and how they direct the flow of virus particles in a space. The second is the rate of renewal of fresh air inside the space.

Recommended rate of renewal of fresh air inside the space

In defense of COVID-19, studies promote incorporating healthy building strategies in their designs. To improve the indoor air quality, studies recommend prioritizing natural ventilation followed by filtration then supplemental air cleaning to eventually target 4-6 air changes per hour (ACH) for classrooms. To measure air changes inside a classroom the equation is

Figure 10 Quality of Air Change Rate Per Hour (HARVARD, 2020)

$$\text{Air changes per hour} = \frac{\text{“clean” air rate}}{\text{room volume}} = \frac{\text{cubic feet per minute} * 60 \text{ minutes}}{\text{length} * \text{width} * \text{height (in feet)}}$$

Figure 11 Equation for measuring air change rate

Methods for improving ventilation

1) Mechanical Ventilation: Placement of vents and virus transport inside the classroom

In the previous section, we discussed the importance of reaching the adequate rate of renewal of air is the most crucial aspect of ventilation in the time of Covid-19. Regardless of the method, mechanical or natural, what is important is the rate change of air. However, studies in post Covid-19 demonstrate that regarding mechanical ventilation, another aspect should be put into consideration which is the placement of vents as it helps directing the airborne transmissions which contribute to the rate of the spread of the disease.

Two studies, focused on the spread of the virus inside a classroom and how could placement of vents and the arrangement of the classroom interior could mitigate that.

The first study done in the university of Minnesota, demonstrate 2 simulated classrooms. Assuming the teacher is the asymptomatic infected patient with COVID-19, which presents the highest risk for the spread of disease since she does most of the talking. In the first, the teacher was positioned immediately under the ventilation system. And the second, the ventilation system was placed at the back of the classroom. The simulations used ventilation systems with inlets and outlets together, side-by-side

As they started the simulation, the researchers mapped the air flow to find locations of virus “hot” spots, or where the aerosols congregated. They noticed that the virus spread much less in the case where the teacher is below the vent.

The researchers also discovered that good ventilation in indoor spaces can filter some of the virus out of the air, but it leaves more viral particles on surfaces. They expected that if they use strong ventilators, they can dispose most of the aerosols through the outlet. Instead, they discovered that only 10% of the aerosols were filtered out in the classroom after a 50-minute simulation of an asymptomatic teacher consistently talking. They instead got accumulated on the wall mostly. (Siyao Shao, 2020)

So regardless the type of vents, HVAC with inlets and outlets or fans, there is no major difference in the rate of disposal of the virus but instead it is about redirecting its spreading within the space.

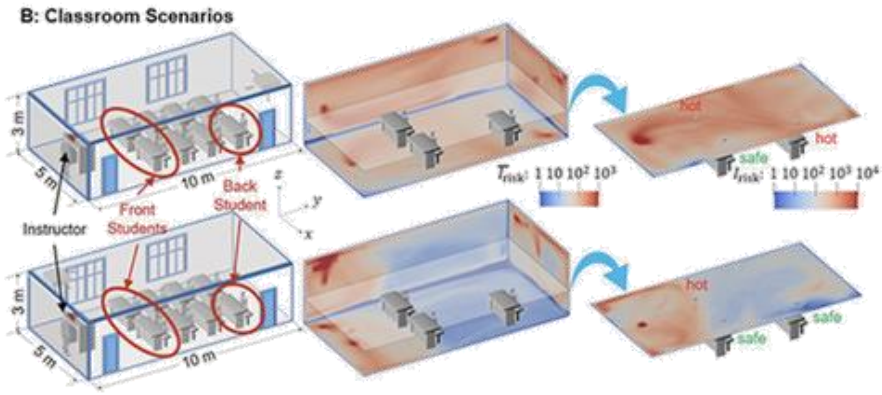


Figure 12- Infectious zones & safe zones. Source: (Siyao Shao, 2020)

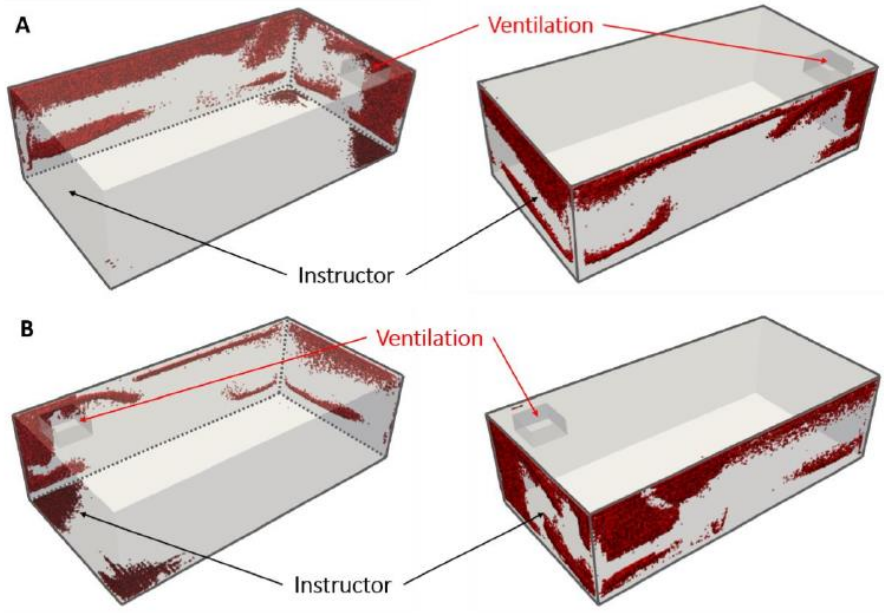


Figure 13 Deposition of the particles on the walls in the 2 scenarios

The second study proposes a mechanical ventilation system inspired by the ventilation inside the airplane as the risk of contracting COVID-19 on a flight is currently lower than from an office building or a classroom. (R Pombal, 2020) When comparing airplanes with offices and classrooms, the effective airplane ventilation system appeared to be the key difference between control measures in an airplane and other enclosed environments which is the HEPA-filtration recirculation system and the high air-exchange rate. (Silcott, 2020) Ventilation systems inside the classrooms or offices offer mixture of fresh and re-circulated air, but the position of the inlet and outlets are located for more natural air circulation such as bottom to top or sideways rather than top to bottom as they are done in airplanes. And since they do not have the HEPA filtration system, the placement of vents needs to be modified in order to effectively dilute and clean the re-circulated air. The research proposes that air outlets are extended to reach clean air above the sitting areas and air suction is placed in a way to take air from the floor through a suspended floor or ducts placed near the floor level of the sitting areas as shown in the figure below. (Kaveh Asanati, 2021)

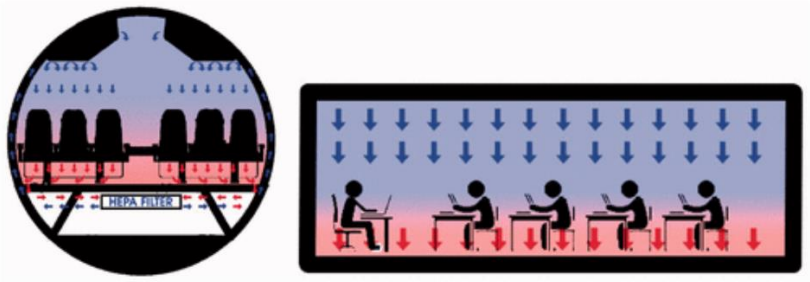


Figure 14- Placement of vents. On Left is in the airplane and on the right is the proposed placement for classrooms (Kaveh Asanati, 2021)

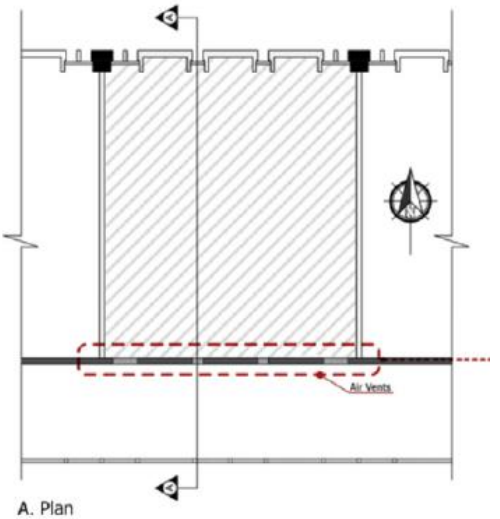
2) Natural ventilation: Case study for improving natural ventilation by retrofitting methods in an educational building in Jordon

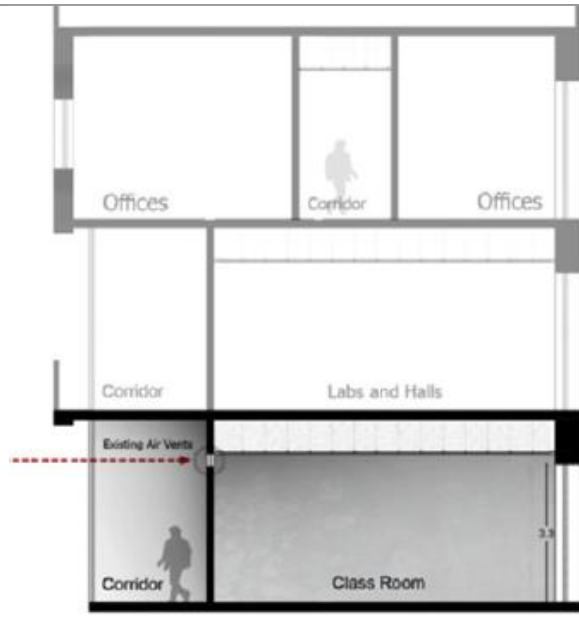
Case Study Introduction

Most schools that are naturally ventilated are designed with typical cross ventilation strategies. With the new needs of Covid-19, we need to explore methods that give a boost to the existing natural cross ventilating systems.

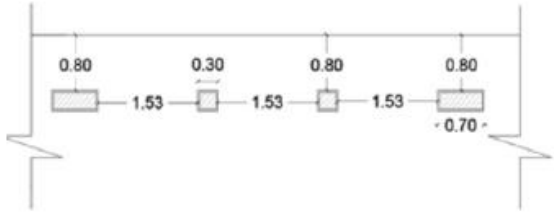
This a case study by the architecture department of Jordon University of Science & technology. It aims to test different natural ventilation retrofitting methods to enhance the indoor air quality to existing classrooms at a university building in Jordon. It is chosen due to the similarity between it and our educational buildings in Egypt. Jordon is a hot arid climate country like Egypt and the architecture of the building, which the study was made on, is very much similar to our sample case study Nefertari. The study included analysis of the ventilation rate, indoor temperature, relative humidity, and carbon dioxide concentration levels by using computer simulation tools. Then, application of a variety of proposed ventilation methods and comparing the results to find the most effective and suitable method for the building. (Shouib Nouh Ma'dbeh, 2020)

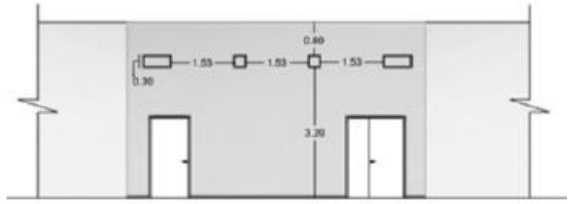
Characteristics of the case study

Category	Info
Climate & architecture	- Hot arid desert climate - Buildings benefits from natural ventilation by stack effect. (i.e. Atrium and windows on both sides of the classroom) - Opening classroom windows is not sufficient to reach thermal comfort during facility operation hours. - Windows are most of the time closed due to the noise factor coming from adjacent spaces which obstruct the cross-ventilating process.
Characteristics of the simulated classroom	- Ground Level - Single loaded corridors - North oriented - Dimensions are 7.1m x8.2m x 3.5m
Architectural drawings	 A. Plan



B. Section A-A





C. Vents Position and Details

Retrofitting methods for improving ventilation used in the case study

1) Case (1): Installing 1 wind tower that is of 5m height from the top to the last floor with a cross-section of dimensions 0.57 x 0.57 m. It has 2 openings, one at the top to catch prevailing wind and one at the bottom which is the air inlet inside the classroom. It is placed on the northern side of the classroom (on the external wall) and the original windows of the classroom are closed.

2) Case (2): Same as case (1) but this time, 30% of the northern windows are open to allow nocturnal convective cooling by letting more cool air inside.

3) Case (3): 2 solar chimneys are placed on the southern side in addition to the wind tower from case (1). these chimneys extract hot air from the classroom, allowing cool air through the tower. The chimneys are 1.5m high with a 30x30 cross section and inclined by 45 degrees. They are made from aluminum and extended 3.15m from the window.
4) Case (4): Same as case (3) but with 30% of northern windows opened to allow nocturnal convective cooling by letting more cool air inside.

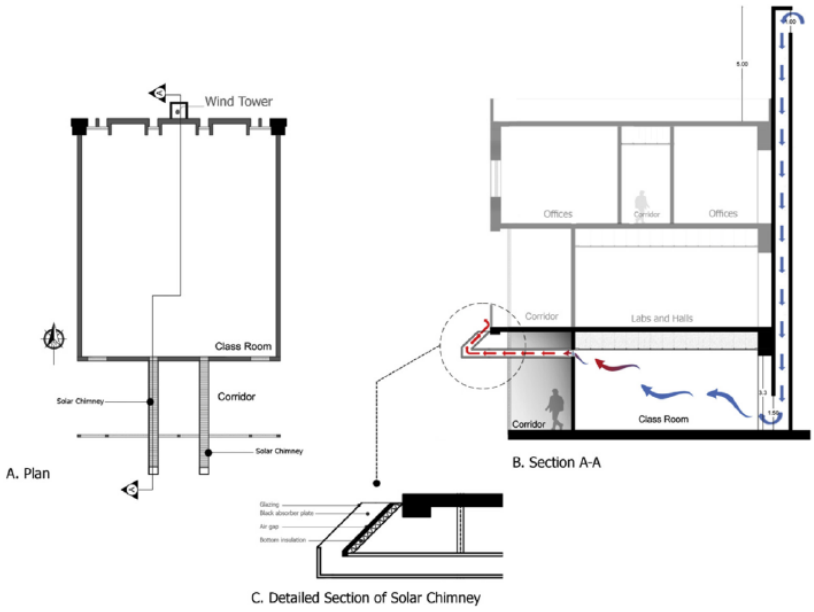


Figure 15 wind tower and chimney positions & details. Source: (Shouib Nouh Ma'dbeh, 2020)

Conclusion & Results

The proposed systems maximized air movement & cross- ventilation in the classroom. It was noticeable that the introduction of more outdoor through window opening as in Case (2 & 4) was more effective. The best results demonstrated were by case (4) with the use of solar chimneys besides the wind tower and window opening.

The study demonstrates that these ventilation optimization methods have improved so many aspects in ventilation which are: Relative humidity, Indoor temperature& comfort hours, Carbon dioxide concentration and Ventilation rate. Other than ventilation optimization benefits, the study explained that these methods were proven to be energy & cost effective. The study calculates the adaptation of case (3) and found that if this strategy was implemented in all 162 classrooms of the university, they would save 39% of the total cooling and heating energy consumed by HVAC systems.

Since this research is concerned with optimizing the ventilation rate to increase air flow inside the classroom, hence decrease the spread of aerosols of Covid-19, the results of interest were ventilation rate and carbon dioxide concentration. The rest of the benefits are a bonus.

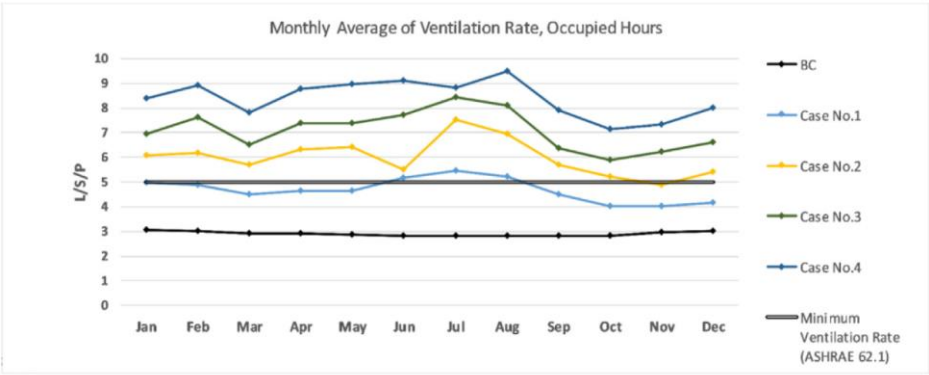


Figure 16 Ventilation rate results

It is noticeable how Case (4) provides the highest ventilation rate that is 3 times more than the original case.

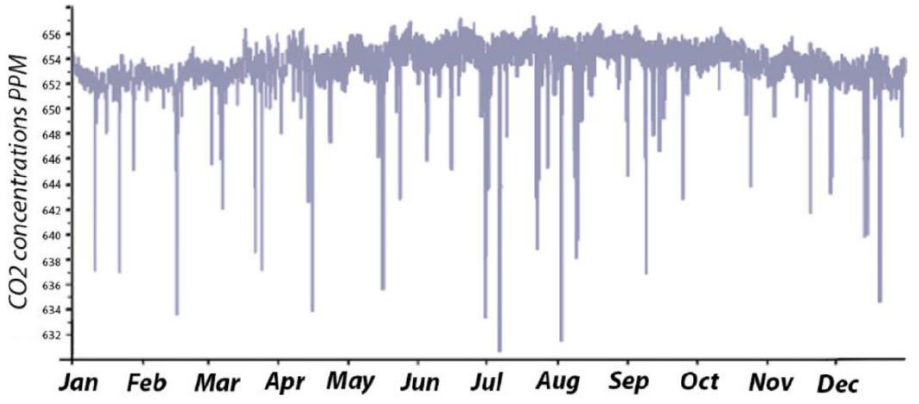


Figure 17 Annual CO2 rate in the original classroom state (Shouib Nouh Ma'dbeh, 2020)

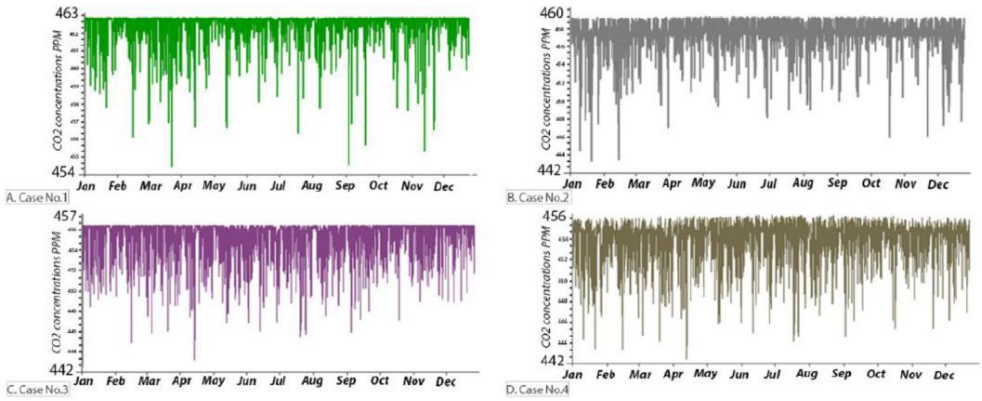


Figure 18 Annual CO2 rate of the 4 cases (Shouib Nouh Ma'dbeh, 2020)

The previous graphs demonstrate that Case 3 & 4 provide the lowest carbon dioxide rate inside the classrooms.

2.4.4.2 Architectural mitigations in response to pedagogical mitigations that help decrease capacity

1) Designing for blended learning classroom for mitigating the issue of capacity

As countries stood in front of the challenge of limited ability to withstand high capacities at their schools to continue in-person learning post Covid-19, blended learning was the pedagogical way out for schools with sufficient online learning facilities.

In this section, we research the guidelines for designing blended learning classrooms for providing the maximum capacity of students while maintaining the required physical distance. As classroom remain the same in size, governments are issuing guidelines that limit the number of students in the classroom giving each student an area of a minimum of 3m2 per student from an area of a minimum of 1.5m2 per student in a minimum of 50m2 classroom size. (Global Education Coalition, 2020) (UNICEF, 2020) (World Health Organization, 2020) . We can mitigate this need for extra space and lost classroom capacity by hiring new or unused spaces of the facility as classrooms, repurposing other functional spaces like halls and theatres, or even building pavilions of outdoor classrooms in the school's playgrounds.

However, in this section, we are concerned with other means for mitigation by adjusting the physical environment of the classroom interior itself.

Design considerations for classrooms before & after Covid-19

Before COVID-19

Long before COVID-19 had made an appearance in our lives, researchers have been working on developing the design concepts for learning spaces. Studies have been investigating new possibilities for designs that allow for flexibility for a wide range of learning styles (i.e., Active learning, collaborative learning, student autonomy … etc.).

As the learning spaces remained the same for many years, pedagogical approaches have been developing with a need of a more flexible, active, and

engaging setup. (Bosch, 2020) However, many of these design concepts can pose challenges in the COVID-19 era, since health institutions are now calling for limiting physical interactions in all spaces; educational spaces included.

These challenges include Firstly, Furniture redesign, since active learning opts for furniture that is flexible and easy to reconfigure for students to be more engaged. This eventually leads to reduced distances between students. Secondly, Common spaces redesign, Libraries and student centers are examples of shared spaces that promote broad-reaching collaboration. High-touch environments are combined with technologies, tools, and furniture to create social interactions. Other communal and meeting environments, such as cafes, are purposefully built to bring big crowds of people together, growing population density and the risk of illness transmitted by shared furniture. Thirdly, reconsidering capacity, many learning areas, such as classrooms and lecture halls, are built to withstand high density. This density makes it more likely for diseases to spread. These characteristics have aided in the creation of environments that inspire educators and students, develop soft skills such as communication and imagination, and improve overall learning participation.

Although several educational institutions made other preparations for health and safety in ways, schools and campuses were not built to prevent disease from spreading. (Steelcase Education, 2020)

After COVID-19

Learning environments in the future will require reinvention. Schools will need to be more responsive in the future, able to easily adapt to potential economic, climate, and health disturbances. Students and faculty's physical, cognitive, and emotional states are strongly bound to their health welfare, so new learning environments must be built with an even greater attention to their well-being.

To reopen schools and campuses, most institutions will need to implement a strategy for the physical environment that follows the new safety protocols and allows people to interact and learn. According to studies made by steel case education, derived from factories and global companies that are designed with health in mind.

There are Three key strategies to consider when retrofitting spaces now or reconfiguring in the near term which are; First, the density: amount of people per sq/m. Second, the geometry: how furniture is arranged. Third, Division: the use for partition, screens, or barriers. (Steelcase Education, 2020)

1) Density
- Decreasing density by removing some seating and chairs
- Integrate technology that allows for fewer students to be physically attendant at schools

2) Geometry
- Re-arrange tables and desks to eliminate face-to – face orientation

3) Division
- Add desk-mounted screens for individual shielding.

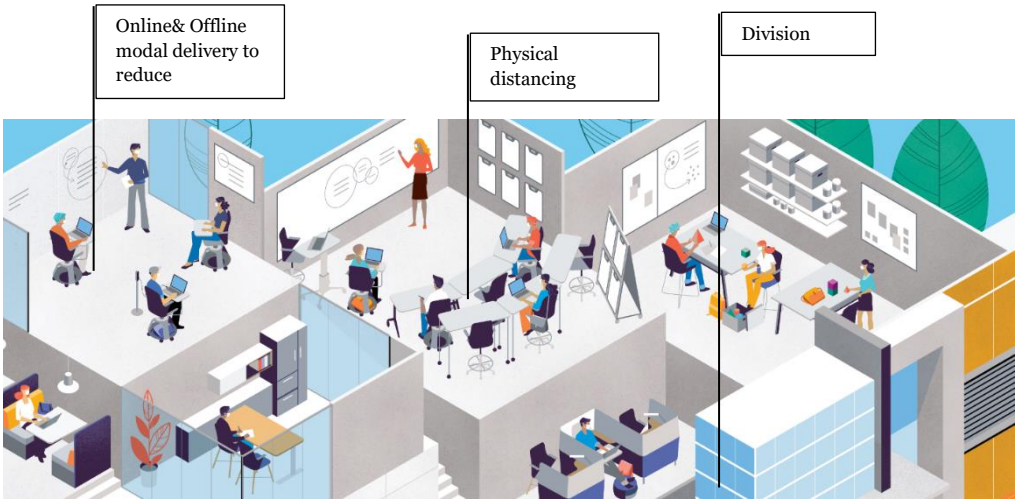


Figure 19 Conceptual Illustration for blended learning classrooms post COVID-19 (Steelcase Education, 2020)

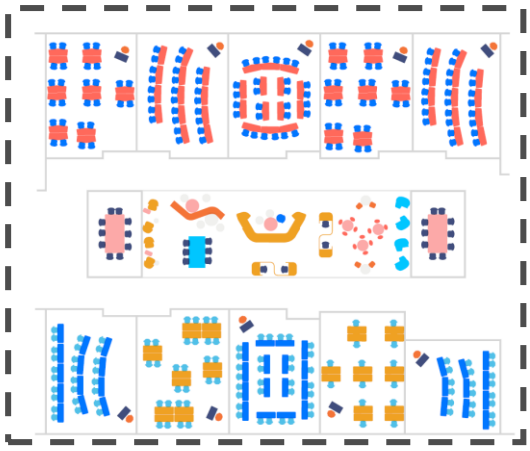


Figure 21 A Sample for a floor plan designed before Covid-19 (Steelcase Education, 2020)

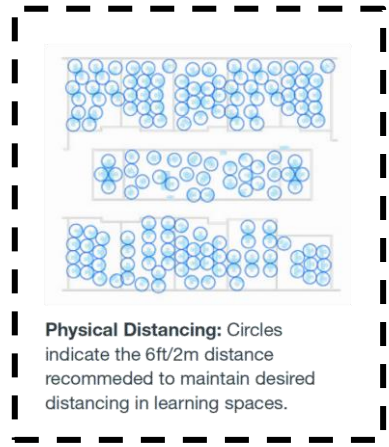


Figure 21 The new constrain of social distancing applied (Steelcase Education, 2020)

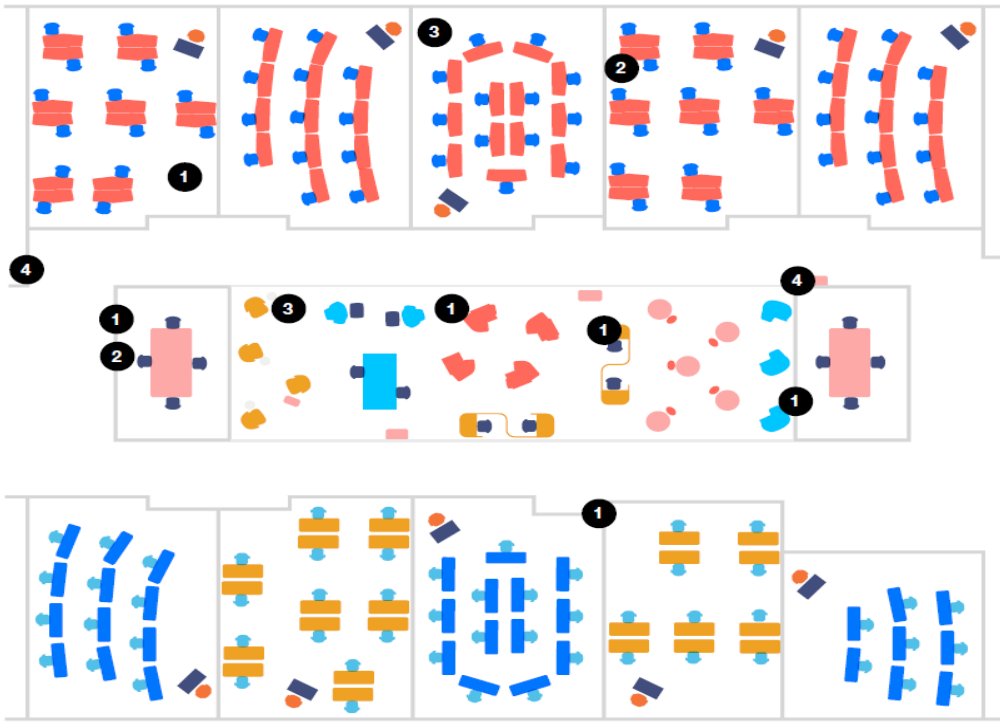


Figure 22 The adjusted floor plan after application of design considerations (Steelcase Education, 2020)

Proposed Design models for blended learning classrooms during Covid-19

Blended learning Classroom model #1

Moveable tables maximize flexibility to support multiple learning modes and adapt with the institution's needs over time. Video technology integrated in the space promotes blended learning, extending the physical classroom for participants unable to be present. Classroom Size: 35' x 28.5' / 971 sq ft (90m2) Student Capacity: Before - 28; After – 12 (Capacity decreased by 58%)

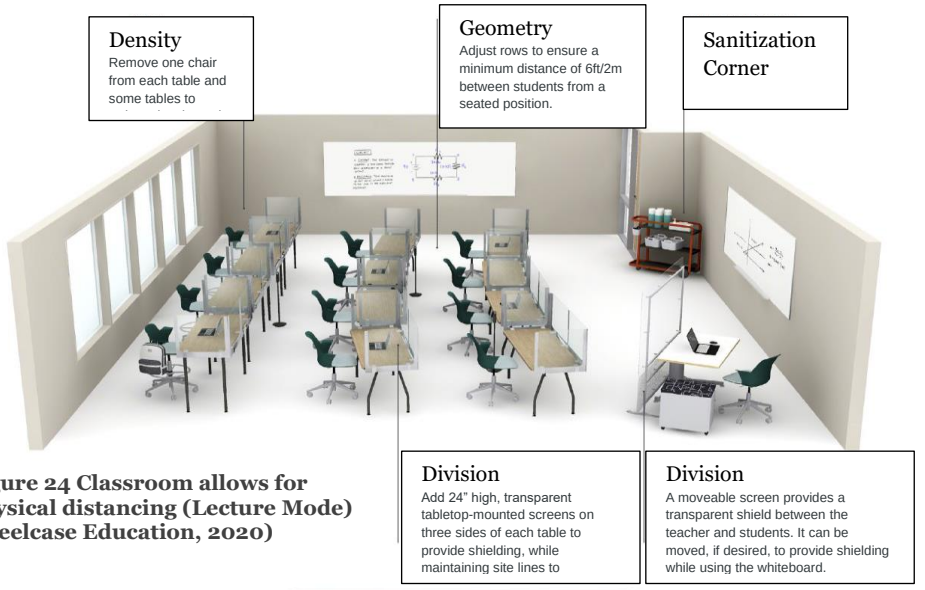


Figure 24 Classroom allows for physical distancing (Lecture Mode) (Steelcase Education, 2020)

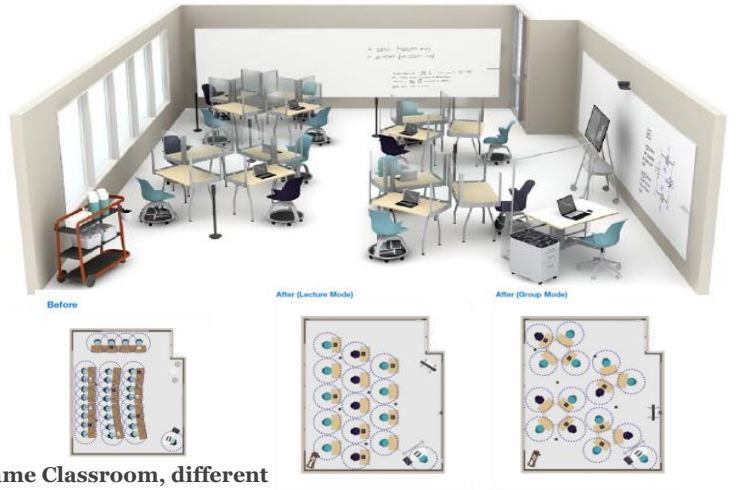
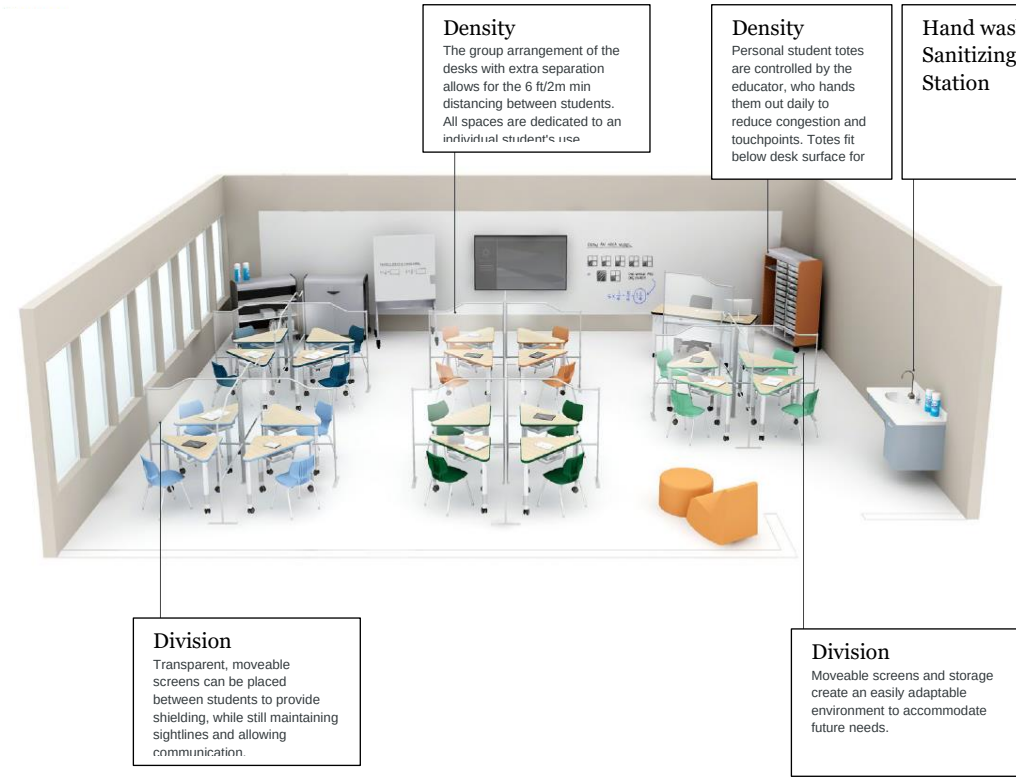


Figure 24 Same Classroom, different arrangement (Group Mode)

Blended Learning Classroom Model #2

A setup for a younger age classroom (K-5) with owned student spaces that arranged for collaborative learning.

Classroom Size: 35’ x 28’ / 956 sq ft (88m2) Student Capacity: Before - 28; After – 20 (Capacity decreased by 28.5%)



2) Designing for outdoor learning for mitigating the issue of capacity

Naturally, as we integrate the experiential learning experiencing in our pedagogy, new design elements are added to the classroom as we know it. Applying these elements in the outdoor is not just about provision of shaded spaces for a miniature of the classroom in the open area, it is about creating different zones and experiences that allow students to learn through exploring and through practice.

In the post covid era, integrating outdoor education is mainly to reduce capacity of students inside the building and offer well ventilated classrooms. In this case the approach is different, and is mostly about creating spaces with seating, lecturing boards … etc. to substitute the classroom. However, this research aims to merge between the 2 design approaches and use the need of moving classrooms outdoors as an opportunity to re-design the landscape of the school outdoor areas into a "learning landscape" in addition to the spaces for traditional classrooms.

Of course, there are things that need to be considered when designing like seasonal climate, outdoor teaching supplies and resources, seating placement, and considering application of physical distancing measures as well.

In this section, we cover the strategies for designing a learning landscape in schools in the time of covid-19, new zones and spaces, new elements in the playground that is not in the traditional one, design of classrooms in the outdoors that maintain physical distancing … etc.

Designing a learning landscape

The Learning Landscape refers to the overall environment of students' learning experiences as well as the wide range of learning settings accessible today, which are changed from the traditional learning setups we know. Spaces are redefined from specialized to multipurpose, formal to casual, and physical to virtual. The Learning Landscape method, like a lively urban environment, aims to recognise this richness and increase interactions between people, places, and ideas. (Dugdale, 2009) learning Landscapes are

more than a playground; they are the core of urban communities. Unlike traditional playgrounds which is commonly an asphalt yard with adjacent courtyards of different sports and some shaded areas, a learning landscape integrates different materials, experiences, visually pleasing landscape sceneries. It also encourages interaction with nature, exposure to different textures and materials and activities that are beyond sports.

Traditional playground planning Vs. Learning landscape planning

As we understand the conceptual difference between the learning landscape design approach and the traditional playground design approach, we needed to understand how to plan differently for each. The following is a table comparing between the two planning approaches by Shirley Dugdale who is a space strategy consultant experienced in visioning for new models of learning environments and libraries.

Conventional Campus Planning	Learning Landscape Planning
Campus-focused	Learning Landscape context-aware
Looks backward, relying on planning standards and benchmarks	Forecasts changing needs of users, based on research and engagement with special tools and methods to envision future models
Linear process, from analysis to conception to implementation	Nonlinear process, emphasizing co-creation of concepts with users, pilot projects, ongoing refinements, and incremental implementation
Produces a "plan" to be implemented	Produces a set of strategies and concepts, to be applied, tested, refined, refreshed, and reapplied
Based on needs assessment by school and department	Engages hybrid groups to complement needs assessment process and build consensus around solutions
Conceived spaces are more important than the activities within them	Activities drive the planning process: space is conceived to support them
Prioritizes formal instructional space	Focuses on planning informal as well as formal learning environments
Focuses on classroom experience	Plans networks of physical and virtual learning spaces for distributed, hybrid, and social learning experiences
Single-use space types	Mix of specialized and flexible, multipurpose spaces supporting blended activities
Specialized spaces assigned by semester	Specialized spaces booked on demand
Single-owner model	Layered ownership model, from public to invited to private space

Figure 25 Conventional planning vs. learning landscape planning. Source: (Dugdale, 2009)

Outdoor Planning strategies for outdoor classrooms post Covid-19

A study made by a U.S. Company had concluded the design strategies needed to take the classrooms outside in the time of Covid-19. The study includes the site considerations, educational institute resources and Covid-19 restrictions.

Planning assumptions & Considerations

In order to design the spaces, the designer needs to collect data and do a site analysis to cover the following. First, the number of students in each group, availability of staff to be present with each group, creating compact spaces that respect the physical distancing. Movement should also be considered since you cannot constrain children's moving pattern in the outdoor so buffers for zoning might be needed. Finally, understand and assess the quality of the physical characteristics of the variety of spaces in the school to determine capacity, feasibility and if climate adaptations were needed.

After collecting data about the site and understanding all the available resources, to create a program with areas of spaces the designer needs to have the following considerations in mind when planning. The first consideration is imagining spaces that provide equity. How can the outdoor learning be used to meet all students needs and how can it support and nurture children especially after the trauma of the pandemic? Second, set an indoor-outdoor strategy that adds capacity to the indoor spaces, aiming to accommodate 100% capacity of enrolled spaces on daily basis. Third, make best use of the outdoor resources like existing seating, shelter, gardens, or others and try to connect them with the missing resources that may be found in indoor spaces instead of installing everything from scratch. Fourth, study the regional seasonal climate during the school operation months. This is to prepare to harsher weather conditions or to understand the limitation of the spaces for providing the privilege of outdoor classrooms at all times. Fifth, seating placement should not only be considerate of the number of students and the existing infrastructure, but orientation also needs to be studied carefully to provide comfortable sunlight and an audible undistracting setting for students. Sixth, in some cases, schools may be located in a neighborhood that can allow for extending to adjacent areas like local parks, parking areas or vacant lands. Finally, assess educator's availability besides the number of students so that spaces suffice the available staff (Green school yards America, 2020)

Potential Outdoor Classroom designs

The following is a set of arrangements for an outdoor classroom that respect physical distancing constrains.

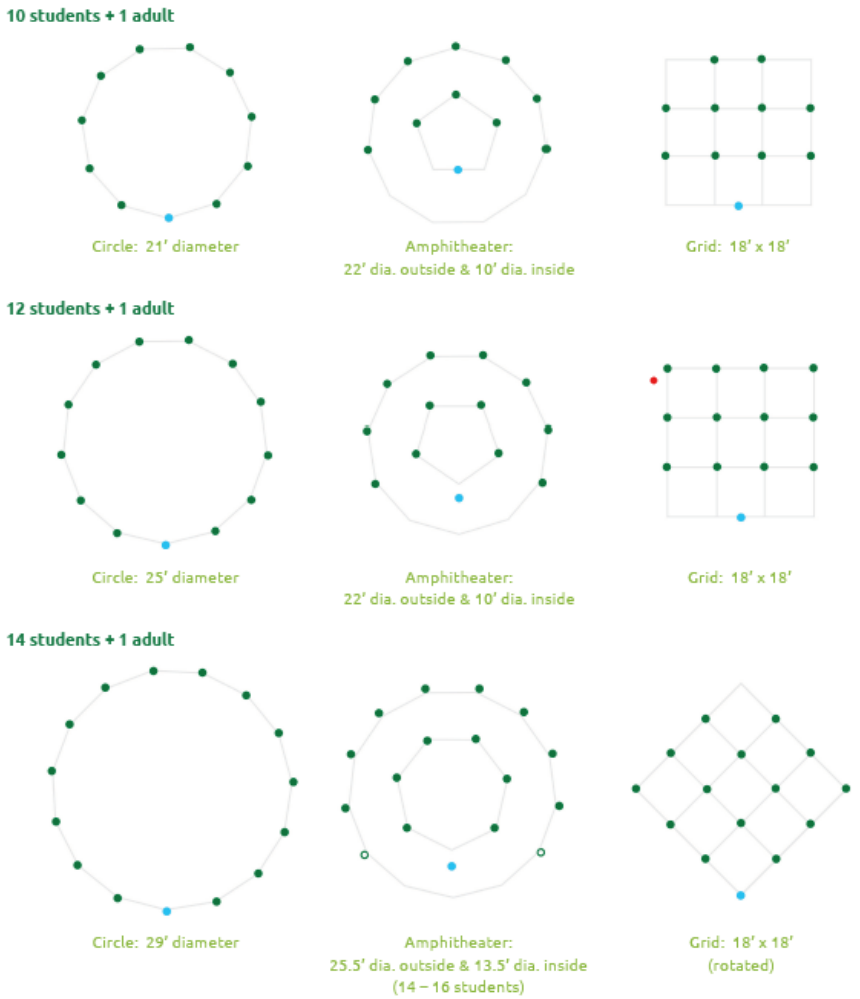


Figure 26 Classroom Arrangements (Green school yards America, 2020)

Case study demonstrating learning landscape planning

To put the concept in practice, the following is a case study as sample to demonstrate how the design for landscape differs than traditional design. The design was made by a company named Learning Landscapes and it was prepared for an elementary school in Colorado. (Learning Landscapes, 2013)

Introduction & Site Analysis

Green Mountain Elementary is the case school which will have its playground redesigned from being a conventional playground into an educative learning landscape. The surrounding area is mostly an urban neighborhood. The reinvention of the playground is expected to be a unifying factor proposing a community for the neighborhood in the school. As for the site issues, first is the drainage, where the play area collects most of the water runoff from rain and snow events. Second, safety issues are identified as the materials of the playground (gravel, asphalt) form slipping hazards and are painful for children to fall upon. Third, the school is not accessible to those with disabilities except for the entrance pathway. (Learning Landscapes, 2013)

Existing Playground Conditions

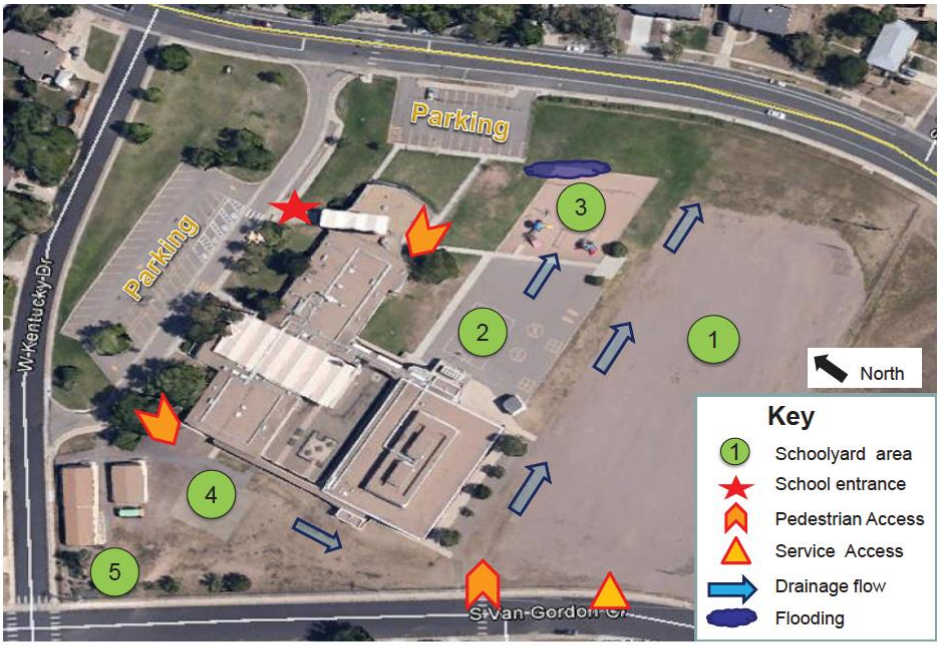


Figure 27 Existing Site Conditions. Source:. (Learning Landscapes, 2013)

As seen in the picture above, there 5 zones in the playground

1) Gravel Field
   The existing field is 1.9 acres of sterilized gravel. The playground is not useable as a recreation field because of daily casualties of hurt students. The drainage carries the gravel onto asphalt and sidewalks creating tripping hazards.

2) Blacktop play area
   A spacious 12k square feet asphalt area enough for the student population at the school. It mostly consists of small sport courts adjacent to each other.

3) Play Equipment area
   This area is fairly in good shape. It is 15 years old and well maintained. However, they need it to be accessible by the disabled.

4) West & Courtyard
   This zone is underutilized and undeveloped. It is mostly asphalt, unshaded and lacks any sort of activity spaces.

5) Sara's Garden
   This is an organic garden where student learn to transform dirt and weeds into organically grown fruits, vegetables, and flowers. The teachers enjoy using this space for hands on learning experience and they hope for it to expand.

Planning & Designing process

When the design committee first met with the school representatives to discuss the design, they first agreed on the overall approach and aim of the playground. The client needed the new design to focus on student engagement, be student driven and provide an environment for an authentic learning experience.

The planning process started first by a participatory approach where students were able to sketch their hopes, dreams, and their vision for the school. Also, higher grade students participated in the research phase where they conducted surveys with other students to gather as much data as possible about the imagined playground.

After collecting the students design vision, the committee then transformed them into a list of design elements. In addition to the student's feedback and the client's preliminary vision, the committee had concerns of its own that were determined in addressing. These problems were related to the safety of children, the lack of shaded spaces in the playground, and the lack of activities that allow for outdoor education. Finally, the design committee integrated all the needs and wishes and translated them into the design proposal of the master plan explained in the section below. (Learning Landscapes, 2013)

Design Proposal

Design Description

The new design is focused on educating the entire child, with an emphasis on students' social-emotional development as well as academics. The schoolyard represents the link between the children at the school and the community at large. It is designed to give pupils a sense of pride in their surroundings, allow them to engage with nature, and provides a perfect setting for socializing and motor skill development. The playground design elements shall give equal access to play equipment for students of all grades and mobility levels, as well as realistic learning experiences through exposure to nature, ecosystems, and plant life. (Learning Landscapes, 2013)

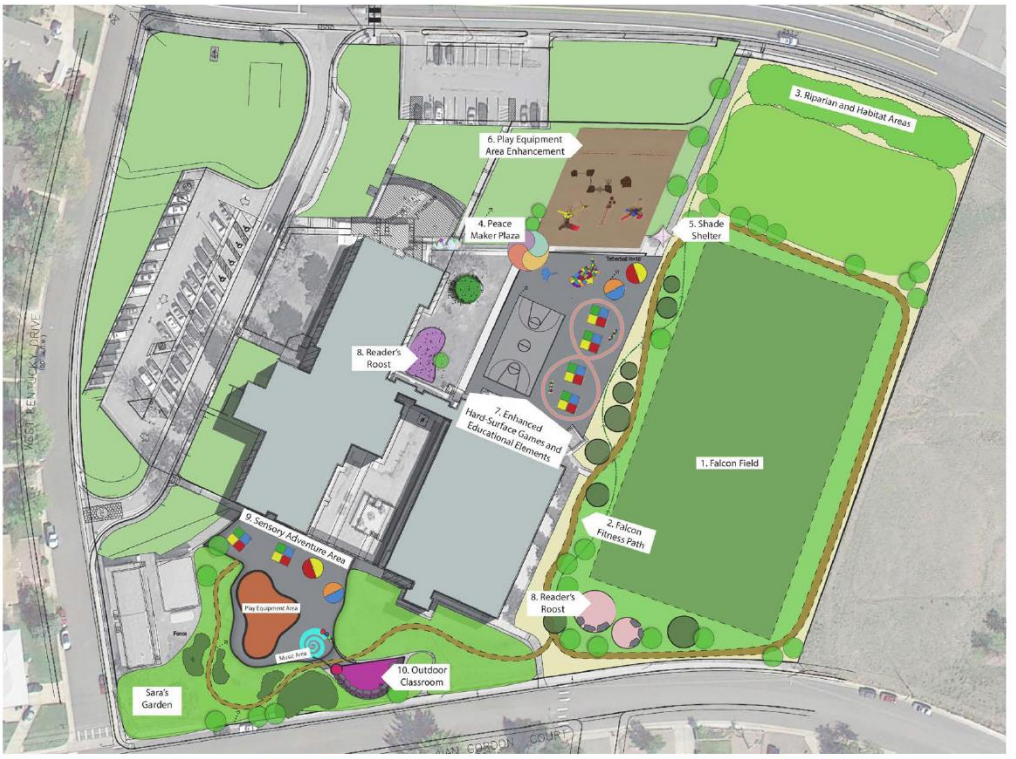


Figure 28 Master plan design proposal. Source:. (Learning Landscapes, 2013)

Suggested changes to the schoolyard to achieve the design team's vision and objectives

1) Falcon Field
   The present gravel field at Green Mountain Elementary will be replaced with a multifunctional secured environment grass field. The current field will be regraded, irrigation will be installed, and appropriate drought-resistant high-traffic sod or seed will be installed. (Learning Landscapes, 2013)

2) Falcon Fitness path
   A 1/6th mile fitness path is installed with stabilized crusher fines surface for recess, physical education lessons and for the community in the evenings. (Learning Landscapes, 2013)

3) Riparian Habitat Education Area
   This zone will follow the natural drainage pattern to the schoolyard's south east corner. The area will be planted with native plants to aid in storm water management and provide kids with an engaging chance to learn about ecosystems, biology, and ecology. (Learning Landscapes, 2013)

4) Peacemakers' Plaza
   Peacemakers' Plaza will greet kids and members of the community as they enter the schoolyard. Peacemakers' Plaza will serve as a location for kids to practice positive conduct and settle conflicts by following a "road to peace." The plaza will also serve as a location for the school to thank contributors for their support of the playground project. (Learning Landscapes, 2013)

5) Shade Shelter
   The shade shelter will act as the schoolyard's aesthetic focal point and key meeting spot. Seating and instructional items will be located

underneath the shade structure. Under the shade structure, students will be able to play and learn. From the observation deck, teachers, employees, and community members will be able to see all parts of the playground. (Learning Landscapes, 2013)

6) Play area equipment enhancement
The school's current play equipment buildings were in good shape, but the area needed accessible surface and climbing structures to challenge the school's oldest kids. (Learning Landscapes, 2013)

7) Enhanced Hard-Surface Games and Educational Elements
The basketball court will be widened, and new tetherball, four square, and hopscotch courts will be added to the school's play area. Color and educational aspects will be added to all asphalt games. Colorful maps, number lines, and other educational aspects will be put to the asphalt and hard surface areas in addition to games. (Learning Landscapes, 2013)

8) Readers' Roosts
The playground is scattered with Readers' Roosts, which are activity nooks. These nooks will be made out of natural elements like tree stumps, stones, and plant life, and will serve as both natural play spaces and quiet meditation spots for 1-5 kids. Teachers can use these places for small group activities, reading, and journaling, and students can utilize them for quiet time. (Learning Landscapes, 2013)

9) Sensory Adventure Area
It will have age-appropriate play equipment, pour-in-place rubberized safety flooring, and a garden to increase kids' tactile connection with plants and establish a closer engagement with nature. Students will be exposed to a range of textures, colors, and noises in the Sensory

Adventure area. Outdoor music equipment will be available, as well as small group reading, writing, and meditation places. For further protection, the space will be enclosed, and it will benefit both pupils at the school and youngsters from the neighboring neighborhood. (Learning Landscapes, 2013)

10) Outdoor Classroom

Teachers will be able to take a class outside for true experience learning in the outdoor classroom. The semi-circular arrangement of natural rocks and geologic features placed in the outdoor classroom provides each student with vision. To improve the outdoor experience, the outdoor classroom will be surrounded by shade trees and habitat areas, which will offer shade and provide children quick access to natural components for observation. (Learning Landscapes, 2013)

Gallery of the new spaces in the school playground

Before

Figure 30 Gravel Field

Figure 29 Black top Play area

Figure 32 Sara's Garden

Figure 31 West area & Inner Courtyard

Figure 33 Play Area

After

Figure 34 Falcon Field

Figure 35 Falcon Fitness Path

Figure 36 Riparian Habitat area

Figure37 Peace Maker Area

Figure 34 Shade Shelter

Figure 39 Equipment area

Figure 38 Outdoor Classroom

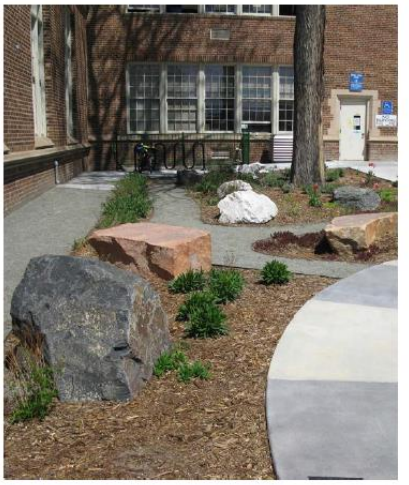


Figure 37 Readers' Roosts

Figure 36 Sensory Adventure area

Figure 35 Games & Education

Conclusion of case study outcome

This case study demonstrated the direct relationship between the adopted pedagogy and the architecture of the outdoor spaces. It is clear in the pictures that the traditional planning for outdoor spaces in schools offered spacious asphalt courtyard with no zoning of activities and no potential for learning spaces. On the other hand, when designing for learning landscapes, new textures and materials were used in the spaces, new ideas for furnishing, minor zoning of various activities and introduction of outdoor classroom area all of which provide a better potential for learning through engagement, experimenting and exploration.

Chapter 3: Mapping and data gathering (field work)

3.1 User investigation

The first part of this research aims to map the challenges, responses, and future expectations in the education sector in the time of COVID-19 from the perspective of the stakeholders. As concluded from the literature review, challenges included problems from the sudden switch to online learning. Schools were not prepared, the infrastructure of the internet is not efficient, teachers are not well trained to teach online, students are unable to focus at home, the curriculum does not fit the limitations of the online learning mode of delivery and the list goes on. Another main challenge was related to school opening in the time of COVID-19. How to maintain physical distancing and safety measures, while serving the same capacity of students the school once did, was the greatest equation that each country and each school was trying to balance. Efforts to reduce risk of infection inside the classrooms like constant sanitizing, decreasing capacity of students, enhancing ventilation, switching to blended learning scenarios and many others were implemented for that cause. As studies prove that these mitigations do help in reducing the risk of

infection, this part of the study is interested in exploring the feedback of these mitigations from the stakeholders and if the actual challenges faced differ from what the studies assume.

The feedback shall cover the main challenges they faced, their acceptability of certain measures, their opinion about its convenience, and future expectations for education in the post COVID-19 era from the stakeholders and beneficiaries who are the general authority for educational buildings, the ministry of education, students, and teacher.

Interviews at the general authority of educational buildings

As I interviewed the first undersecretary of ministry, general major Eng. Yousry Salem and the general manager of the architecture department at the authority, Eng. Rowayda and asked them about the challenges they faced during the time of COVID-19 regarding the architecture of the buildings, they both claimed that the issue was never in the design of the building but instead in the behavior of how the buildings are used. Eng. Rowayda explained the situation by mentioning that the Egyptian government since 2007 has been sending architects from the authority to compare the Egyptian building guidelines and the school programs with international ones from Japan, Germany, and Austria. According to the results of this comparison, the guidelines and programs are almost identical and provide the same regulations for ventilation, orientation, areas of spaces and the minimum designed area for each student.

Also, when I mentioned the incapability of public schools of Egypt to implement online learning and if that was a result of a limitation in the design for infrastructure of networks in the building. Her response was that no school is built nor takes accreditation (since when was not mentioned) without being provided the infrastructure for implementing the online learning facilities like the internet, smart boards … etc. And that integrating technology in education was a part of the strategy preparing for the vision of Egypt 2030.

In her opinion as a representative of the authority, the problem is caused due to the misuse of the building. She explained that due to high population, the ministry of education in Egypt had to overcrowd the classroom with students. Accordingly, the 40m2 squared classroom that is supposed to hold an average

of 35 students, ends up holding 60 and often reaching 80 students. So, when the minister of education announced that classrooms shall hold 50% of its original capacity, this remaining percentage was still above the design original intent capacity limit, hence the impossibility of maintaining physical distancing nor providing adequate ventilation.

Other than the capacity, as we discussed ventilation, she mentioned that all public and national schools were designed to be naturally cross ventilated by having windows on both sides of the classrooms (over the playground & over the corridors) and orientation is a maximum of 25 degrees north- east or north-west. And that these standards are parallel to the German code for educational buildings. There are no plans, so far, for changing these regulations in response to COVID-19 since it is believed to be a temporary situation. In addition to that, it is not applicable to increase classroom areas since there is already shortage in the land provided to build schools and that they need to be as efficient as possible. Neither it is applicable to make installing the HVAC or filtration systems in ventilation an option due to its high cost and need for regular maintenance which will eventually not be provided. However, if there are changes that are recommended by researchers that do help reduce the risk of infection can be considered by the authority as long as they are cost efficient, reasonable and can be applied within a couple of months before the beginning of the new academic year in September 2021.

Interviews at the ministry of education

In the ministry of education, interviews were held with the deputy minister for education Dr. Hala Abdelsalam and the deputy minister for student activity Dr. Eman Hassan. The main purpose of the interview was to validate the challenges found from the literature review, explore other possible challenges, get feedback on their experience with online learning.

As we discussed the previous points, I was surprised with the resilience of the education sector in Egypt during the time of COVID-19 as they were able to continue both the learning process and the activities. They both explained that the sudden switch to the online mode was extremely challenging especially given the circumstances of the state of panic in fear of the virus.

However, Dr. Hala had confirmed that including technology in the education was a part of the plan for developing the education and COVID-19 had only accelerated its implementation. Although they do not intend to depend fully on technology or online modal delivery as a main mode of delivery, because the lack of social interaction makes students lose confidence, she explained. However, they do not see any other option than blended learning and getting for remote learning in case of the need for school closure at any time. The biggest challenge though was with the early primary stage as they were not able to implement any online learning strategies with them. So, instead, they cancelled their examination and ended their academic year earlier than its original duration.

On the other hand, regarding the school activities, Dr. Eman was proud of how during the time of the pandemic and school closure, they were able to keep the activities going and not suspend them. Competitions for individual performance activities like drawing, singing, dancing … and many others were held on social media platforms by submitting videos of the performance and the winner is the one who gets the most likes or shares. As for group activities and non-performance activities, like theatre and journalism, respectively, were still held but by submission of a C.D. of the performance to the ministry of education to be reviewed and winners were announced on the social media platforms.

Interview conclusion

What I concluded from these two interviews were acknowledging the fact that there are no expectations for developing the curriculum or the education system to response to COVID-19 since it is seen as a temporary situation. Online learning has rescued the learning process from paralysis, however there is no intention to depend on it fully. Integration of technology is still a priority and blended learning is a great potential the issue of overcrowded classrooms but not in the early primary stages. Activities on the other hand were not to continue to be performed online as soon as the COVID-19 nightmare is far gone and is no longer an issue.

Questionnaires with students & teachers

This phase of data collection aims to explore the difficulties that students and teachers encountered during COVID-19. It also aims to test the likability and convenience of online learning from their experience during the pandemic. And finally, check if the safety measures were actually practiced and if schools realize the importance of the role of ventilation in decreasing the risk of disease spreading or not.

The surveys were answered by 74 students and 49 teachers from different schools national and international where 2 students' responses were from a public school.

First section of questionnaire responses: online learning.

The first concern was about online learning & shifting to remote learning and since it is becoming a possibility to alter in person learning in the future, we needed to know if students are really against remote learning or do they prefer it. It is expected that students benefit from learning at home as it is believed to be more comfortable. However, learning from home is not considered as the best-case scenario since it deprives the child from the privilege of learning through social interaction and connecting with his peer students and his teachers. Also, online learning could be more challenging in developing countries since the network infrastructure does not provide the stable internet the education system needs to fully deliver the learning content online and because teachers are not trained to teach virtually nor does the curriculum fit in the limitations of the online learning platforms. Studies on the other hand, claim that blended learning is the best compromise to the situation to keep in line with ongoing trend of depending on technology in learning and to decrease the capacity of students at schools without depriving students from the in-person learning experience. We needed to test the likeability of this concept to both students and teachers as a feedback from their experience during the pandemic.

According to the responses it is concluded that the online learning has not been a smooth transition in the educational sector for majority of the schools, from the teachers' point of view, which are considered top education level (national & international), neither are teachers prepared and trained to teach

virtually nor is the school equipped with the needed facilities nor is the country able to provide a stable internet connection for the education to depend on remote learning fully. As for remote online learning as a modal delivery, it is not convenient nor practical specially in the early years, also it is believed to be an unfair method of evaluation and does not fully represent the students' actual level of comprehension or state of education. Nevertheless, it does not fully deliver a learning experience/ environment that is adequate to acquire the necessary learning fundamentals as it lacks the basic need for human interaction. As for students, the feedback was the same, and they were negatively affected by the instability of online learning during the time of pandemic and the inability of attending school had significantly affected their academic performance. That in addition to not being comfortable at home and the high need for social interaction with their peers and teachers.

However, given the circumstances, blended learning is highly encouraged by both teachers and students as it is seen as a compromise to ensure continuation of in person learning in a safer way and efficiently using the help of technology without allowing it to degrade the quality of education but rather improve it.

Second section of questionnaire: responses about safety measures and the human behavior

The second concern was related to the actual implementation of the safety measures. As we know that in the time being we can only be able to decrease the virus spreading is through following the protocol of mask wearing, maintenance of physical distancing and constant sanitizing. Unfortunately, these measures are against our natural dynamics of the tendencies of the human behavior. It is almost impossible for human beings to always communicate at distance and constantly have a mask over their faces, too.

As for ventilation, it is believed that proper ventilation is another quick solution that can help decrease the spread of disease. Although, school buildings are designed to be well ventilated naturally, according to Eng. Radwa's statement, but that is in the case of having all openings always opened which is again kind of impractical since other challenges are companied like harsh weather conditions, noise, and distraction. And even

that, the standards most schools built according to do not even provide the recommended air rate of a healthy environment which is minimum of 4 ACH. (HARVARD, 2020) (Fisk, 2017)

As expected, students are not able to always keep physical distancing nor are they able to wear masks all the time. Sanitizing in most schools is done on daily basis even though it should be on hourly basis between classrooms. And finally, the cross-ventilation system in schools is not efficient especially in the time of COVID-19 since it is not practical to keep doors and windows always opened, hence lower air rate change.

3.2 Site investigation

After understanding the challenges and the dynamics of the behavior of the stakeholders in the education system. We need to research approaches, guidelines, or design potentials in our schools, especially classrooms that could provide a safer environment for in person learning in the time of COVID-19.

To be able to do so, First, we need to study the code for building schools in Egypt. As acknowledged earlier, one of the main factors to be considerations when re-thinking the design of educational buildings in post Covid-19 is the ventilation aspect. Also, as conducted from the interviews, the Egyptian standards for building schools match those of European standards (German) and there are no intentions for adjusting them in response to Covid-19. Accordingly, we are going to examine references for these standards with regards to ventilation, check if the German standards are calling for improved ventilation in schools after Covid-19 and finally, highlight the gaps in the Egyptian code or limitations in the design considerations that need to be considered for post Covid-19.

Secondly, a sample school (Nefertari) has been chosen to be studied to be able to find gaps which we can develop to provide safer classrooms. And the choice was made upon availability of data and the convenience of reaching out to its staff and students. The school falls under the category of national private schools which as an education system represents only 10.6% of the population of schools in Cairo. However, when opening the book of regulations for school buildings in Egypt by the authority of educational buildings, the code for building national schools is almost identical to that of public schools.

Accordingly, the first part of this phase is rechecking to what extent does the physical built environment of the school match the code, so we can understand how much of a population does this school represent with regards to architecture rather than the system of education. With reference to the literature review, potentials for developing our classroom into a safer one from the architectural aspect, depends on the quality of ventilation which is affected by areas of classrooms, corridors, and capacity of the students inside the classroom.

The second part is about is comparing the results of these findings which represent schools of Cairo, Egypt to the proposed measures in the design of

classrooms. This is to highlight the gaps in our buildings that need to be further developed to provide a safer experience for in person learning to our students.

Assessment of the standards for building schools in terms of ventilation

To assess the standards for building schools of Egypt, first I needed to understand the references for these standards and on what basis are they designed. Unfortunately, no sufficient studies were found that justify these standards in Egypt and most studies were oriented towards thermal comfort analysis of the indoor spaces of the school. Since, according to the interview with Eng. Rowayda, these standards are derived and are to match European standards like Germany and Austria. Consequently, I researched the references for standards of school buildings in Germany and checked if standards were mainstream over all schools in all locations or are there adjustments that serve certain schools with different needs.

Design standards references in the German Building Code for school buildings

According to the federal environment agency in Germany, most school buildings are planned and constructed in such a way that natural or "fresh air" ventilation through windows shall be sufficient. However, in unfavorable sites, which have significant noise pollution from the surrounding area or excessive air pollution it is mostly common that windows are shut and there for do not provide sufficient air ventilation. In a classroom with standard class numbers, numerous air changes per hour are necessary to extract enough carbon dioxide created by the students exhaling from the air in the room. Natural ventilation with closed windows cannot provide the required air exchange of roughly 25 to 30 m3/h per person. Therefore, in these cases when natural ventilation is not adequate, mechanical ventilation options are to be installed to ensure sufficient air replacement even with the windows closed. Also, prior to applying ventilation systems, it is recommended to limit the influence of possibly high noise levels from outside (e.g., road noise, aviation noise) on classrooms when employing ventilation via windows or air vents in exterior walls. In that case, installation sound-absorbing ventilating windows or sound-insulated ventilation ducts is added to the school requirements. (UMWELT & GESUNDHEIT, 2008)

Observed limitations in the Egyptian building code of school buildings

Unlike the case in Egypt, there are no obvious guidelines that ensure a certain rate of air change inside the classroom. Instead, there are a set of requirements for areas of window openings, orientation, and areas of spaces regardless of the climate which differs from one governorate to another, regardless of external factors like sun angle and glare, and noise factors from adjacent areas. The accreditation of a building is given to those match these requirements without considering the operation. Therefore, a school building can match the standards and still not provide proper ventilation per person due to crowding of students in classroom or closure of doors and windows for external factors like weather conditions or noise and still gets approval and accreditation.

Changes in the design of school buildings in response to Covid-19

From the interviews at the building authority, it has been confirmed that are no future expectations for changing or adjusting any of the regulations in response to covid-19 since they claim that there are no design challenges and that it is all operational. Unlike in Germany, although the schools are supposedly designed naturally ventilated and given situations when this ventilation is not enough to provide appropriate air change rate, external systems are added in order to improve that aiming to reach adequate ventilation even with windows closed. According to the BBC news, in response to covid-19 and after realizing the significance of ventilation in diluting the virus and reducing the risk of disease spreading, the German government invested approximately 500 million euros in October 2020 to improve ventilation systems in public buildings; schools included. In addition to improving ventilation systems, the UK's Health and Safety Executive suggests utilizing fans to disperse pockets of stale air in rooms and employing a fresh air source. And make sure that windows are opened between classes to maximize fresh air indoors. (BBC News, 2020)

Case study analysis Phase 1: Studying the built environment in reference to the building code

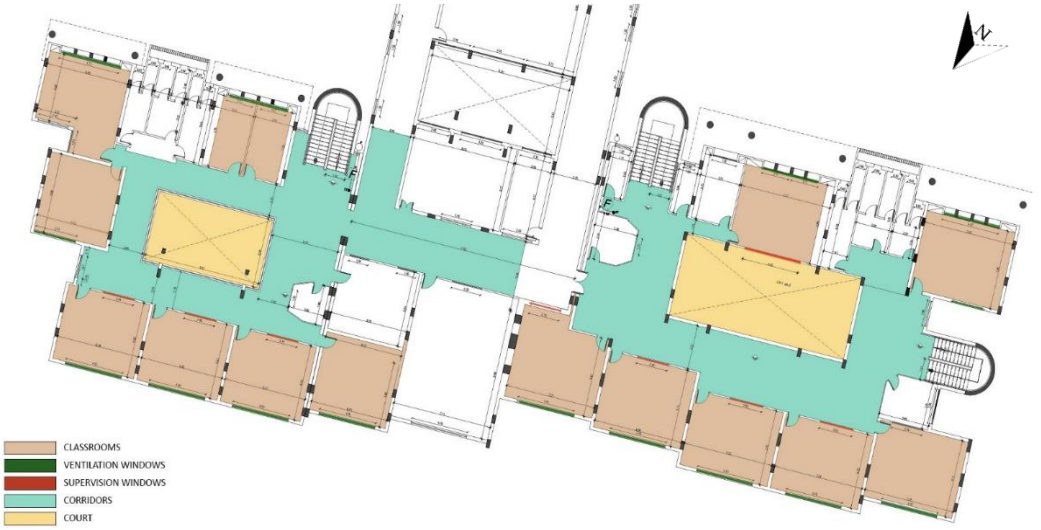


Figure 40 Color coded first floor plan. Source: Author

Figure 39- Classroom sample. Source: Author

Table 1: Comparative analysis of the built environment with reference to the code for building regulations.

Category	Reference regulations	As Built	
Building Orientation	25° North east or North-West	25° North east	✓
Area of Windows	Not less than 18% of the classroom area divided on sides of the classroom Min. 5m2 total	7m2 of 39m2 occupies 18% And is divided on both sides	✓
Classroom	. Area not less than 38m2 . Max length is 5.8m . Door width not less than 1m	Min class dim = 6.5x6= 39m2 Door is 1m	✓
Capacity	Min. 1m2 per student	26 students (i.e. 1.4m2 per students)	✓
Corridors of classroom area	Min. 2.4m width	2.7 is the minimum width	✓

As mentioned before, this analysis was to investigate the percentage of the sample Nefertari school represents with regards to factors affecting ventilation.

According to findings, the school represents the public and national school standards for areas and dimensions of the classrooms, corridors, and windows which cover over a 90% of school buildings in Cairo. It on the other hand, does not represent the capacity of students inside the classroom. The space for each student is more than the recommended with an extra of 40% for each student giving 1.4m2 per student instead of 1m2. However, this point of comparison will not affect the sample representation for 2 reasons, the first is because public schools are overcrowded and do not follow the regulations and second is because this capacity rate has changed since we need to apply the physical distancing measures which will give students a 4m2 area each, inside the classroom.

We can then consider the school as a representative of the learning classroom typology for most of the school buildings in Cairo.

Case study analysis phase 2

The second part of the study is analyzing the building situation with regards to the mitigations proposed in the studies that are responsible for decreasing the spread of airborne disease inside the classroom.

Ventilation rate

The first and most important aspect for reducing airborne transmission of disease is the proper rate of ventilation. And as mentioned before, the recommended healthy rate of ventilation is more than 4ACH (HARVARD, 2020), in this section we examine the rate of ventilation of a sample classroom in the school at its best performing state of natural ventilation to see if it is sufficient or needs improvement.

In this research we are concerned with studying the built environment of Nefatari schools to use it as sample reference of how to take convenient measures to mitigate the virus to be able to open schools during the time of COVID-19.

ACH is calculated by adding the total amount of "clean" air entering the room and dividing it by the room volume. The "clean" air in a classroom is calculated as the sum of the ACH from ventilation (e.g., outdoor air supplied by a mechanical system or open windows), from filtration of recirculated air by a mechanical heating, ventilation, and air conditioning (HVAC) system (accounting for the efficiency level of the filters in the system), and from air cleaning provided by a portable air cleaner with a HEPA filter. (HARVARD, 2020)

Since most schools in Egypt depend on natural ventilation, excluding international schools, according to the regulations from the authority of educational buildings. This study will focus on measures that increase the air rate naturally without mechanical systems. Which will be calculated by measuring the air flow in cubic feet per meter (CFM) by using a digital anemometer, excluding the air coming from filters or mechanical systems since they are not applicable.

To do so, we will measure the air flow rate inside a classroom at its most efficient state for ventilation, which is open windows & doors.

The purpose of this exercise is to investigate the average rate change of air in our classrooms in our schools that are built according to the country's standards and regulation.

Calculations were made in May 2021.

Air rate change calculation equation is:

$$\text{Air changes per hour} = \frac{\text{“clean” air rate}}{\text{room volume}} = \frac{\text{cubic feet per minute * 60 minutes}}{\text{length * width * height (in feet)}}$$

Clean air rate is Air velocity (distance traveled per unit of time) is usually expressed in Linear Feet per Minute (LFM). By multiplying air velocity by the cross-section area of a duct or a window in case of fresh air.

Window area= 4.5X1.2= 9 m2= 96.8752 square feet (Architectural drawings)

Wind speed inside the classroom with windows, doors, and fans opened= 1.9 foot/min (Average anemometer reading)

Room Volume is: 6.5m X 5.5m X 3.05m = 109.375m3 = 3862.541673 cubic foot (Architectural drawings)

ACH per hour = 1.9 X 96.8752 X 60 = 11043.7728/ 3862.541673= 2.85

So, for the first point of analysis, the average rate of ventilation was below the recommended healthy rate of ventilation per hour with an average of 2.85ACH while the recommended is a minimum of 4ACH.

Materials & Placement of vents

As mentioned before, research that studied the transportation of the virus inside the classroom claim that the placing of vents plays an important role in that matter. (Galloway, 2020)Whereas if vents were placed above the teacher the rate of transmission is decreased significantly. Nevertheless, it is claimed that even the strongest ventilation systems with inlets and outlets do not filter the virus out, they instead dilute it with rate of air renewal and most of the existing airborne virus is accumulated on the walls of the classroom. (Siyao Shao, 2020) In this section we examine the location of vents in the school and the materials of the surfaces inside the classroom to check if they are suitable for washing and sanitizing.

As shown in figure 29, regarding the placement of vents, there are 5 fans + 1 behind the camera that are placed in every corner of the classroom which can only lead to over flooding of the air with the transmitted airborne virus. As for the materials, the walls are half cladded with ceramic tiles and the desks are made from coated metal and coated wood which makes them easily washable as well, and that is highly encouraged.

Figure 41- Classroom with fans. Source: Author

Summary of site analysis

Point of Analysis	Result	Comments
Air Change rate	2.85 ACH	In the most efficient state of cross-ventilation the air change rate is significantly below the recommended. Therefore, external means for increasing ventilation inside the classroom is needed to be considered.
Placement of vents	Placed in every corner in the classroom	Vents are placed in a way to provide full coverage of the classroom with no directionality. Instead, they need to be allocated in a way to decrease the spread of disease by controlling the flow of disease transmission inside the classroom.
Materials	Coated metal, ceramic tiles, and coated wood.	The materials of walls and furniture are suitable for regular cleaning and sanitizing. Although this may not be the case in most schools, however it is recommended that it is.
Furniture	Single student desk	Single student desks are more flexible than group desks in terms of keeping physical distances between students.

3.3 Conclusion of field work findings

The findings of the challenges posed in response to covid-19 in the Egyptian context were to be summarized into the following main points. First, the new constrain of physical distancing forced a need to decrease the capacity of students. The challenge was to provide spaces with less capacities to the same enrolled number of students.

Second, the health factor, ventilation plays a significant role in controlling the rate of disease transmission. It was found that ventilation aspect in our school designs was not enough neither before nor after Covid-19. However, the issue was not exclusive to only the physical built environment but to the behavior and operation of the building as well. Meaning, although classrooms were designed to be cross ventilated, from practice it was found that windows and doors are often closed because of other external factors and that in most times the ventilation system does not provide the adequate rate of air change needed.

Third, the acceleration of integrating technology into the pedagogy. By the emergence of Covid-19 all schools had to switch to remote learning which compromised the quality of the learning experience as it deprived students from social interaction. Nevertheless, it had highlighted the gap between public and private schools when it comes to facilities and readiness to switch to remote learning. Also, it had accelerated the need for dependance on online technology since now schools are always at the edge of expecting to switch to remote learning depending on Covid19 situation of their country. The challenge now is reaching a win-win situation where schools efficiently depend on technology without depriving students from the hands-on learning experience nor from social interaction and the benefits of it.

Chapter 4: Discussion

4.1 Potential for developing the education in Egypt revealed with Covid-19

This research started with the hypothesis of believing that the main reason behind the need for schools' closure in the time of the pandemic was due to limitations of the architecture of our schools in Egypt that were revealed post Covid-19. According to this assumption, the aim of the research was to further investigate the issue of the challenges faced that are hindering schools opening in the time of Covid-19 and to explore potential in developing the physical built environment that may also parallelly improve the quality of education in Egypt.

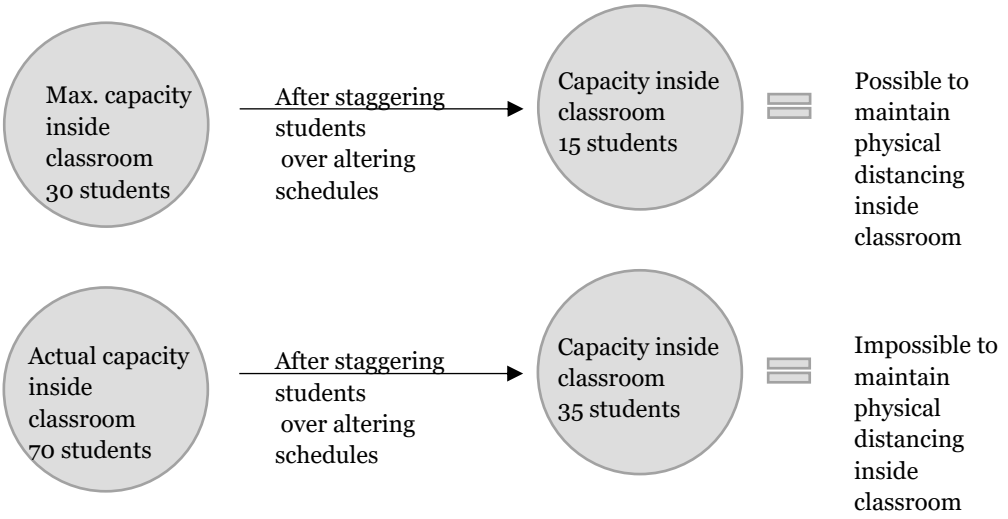
Speaking as a student, I have experienced some of the limitations of the educational system in Egypt especially in the design of curriculums and the teaching methods. I have never expected though that these long existent limitations may actually become an issue contributing to the challenges faced in the time of Covid-19.

As explained in the literature review, the main issue for schools reopening was the challenge of serving the same number of students and maintain physical

distancing. Capacity had to be reduced and so staggering of schedules to distribute the capacity was the solution along with the dependance on technology for remote learning which of course came with draw backs, but it was the fastest way to handle the situation then. As studies worked on understanding the norm of the virus and researched mitigations to help schools re-open, ventilation was the most significant aspect as it was proven that fresh air dilutes the virus and decreases the rate of its spreading.

After exploring the challenges in the Egyptian context, one of the biggest issues faced that contributed to worsening the impact of Covid-19 on education, was the operation of the educational sector itself. As mitigations called for a decrease of capacity through blended learning methods which were supposed to half the capacity inside the classrooms, the situation in Egypt was that some classrooms especially in public schools were overcrowded with almost double the capacity resulting in having overly crowded students even after halving them.

The following is a diagram explaining the capacity handling situation through staggering schedules and depending on remote learning.



According to this observation, it was clear that decreasing capacity was a root problem in the Egyptian education system in the first place and had nothing to do with the design of the building itself or the area of classroom. It was an issue related to the increase of population and shortage of land (Eng. Rowayda interview,2021). Consequently, I explored other mitigations that could help

decrease capacity of students inside the classroom which provide additional spaces. Research proposes the use of existing spaces like theatres, labs, and playgrounds since they are used limitedly for certain activities. The positive aspect though of mitigation through staggering schedules, is the implementation of online technology in education. The Egyptian government in the past years had been planning for this concept for the future of education. The emergence of Covid-19 not only had accelerated this implementation it had also highlighted the limitations and potentials of such pedagogical approach which is very useful for designing the future of the Egyptian education. Some of the observed limitations, as mentioned by Dr. Hala Abdelsalam, is the acknowledgment of the impracticality of this pedagogy in early primary years and the impossibility of fully depending on technology and rather considering strategies for efficiently integrating it.

Regarding the aspect of ventilation, the Covid-19 had changed the standards for proper ventilation inside the classroom. Before covid-19, ventilation with consideration to mostly thermal comfort, sick building syndrome avoiding, and hygiene purposes. The Covid-19 later imposed a requirement for a certain air rate change which is proven to decrease the rate of disease spread as explained in the literature review.

After studying the ventilation situation of classrooms of Egypt, again some of the root causes of the poor ventilation were not exclusive to the building design solely. First, the code for building schools appeared to be ignorant of all factors that may decrease the efficiency of the design intension. The code is designed to match international standards but with no actual reference of certain requirements of air rate change or thermal comfort or so. It is ignorant of the fact that Egypt has 8 different climatic zones and what may suit one may not be enough for the other. Also, it is ignorant of the user behavior, from interviews and questionnaires, we concluded that at most times students and teachers needed to close the windows and doors for external factors nonrelated to the building. Although some schools have the privilege of provision of mechanical ventilation to compromise that, but others do not, and proper ventilation is crucial long before Covid-19's appearance. So, the first step into addressing the problem of ventilation in Egypt in response to Covid-19 is to first re- assess the design of the building code to be compatible with all locations and considerate of all factors affecting the quality of ventilation. The second step is thinking of the quality of ventilation in the time of Covid-19 and to develop existing buildings to offer ventilation that provides safe learning spaces in the time of Covid. And in this matter, research had

proposed mitigations for ventilation improvement naturally and mechanically or even take education outside. When exploring the potential for taking education outside, it occurred to me that this proposal as much as it will help decrease capacity by using more existing space in addition to offering well ventilated spaces, it also could be a chance for the Egyptian education sector to re-think the designs of the curriculum and include more experiential learning pedagogies which will improve the quality of education and the learning experience for students as explained earlier.

Other than ventilation and capacity, after analyzing the norm of the virus movement in indoor spaces, the virus was found to be accumulated over surfaces for long hours. This acknowledgment made me consider the choice of materials used for finishing of the interior of the spaces and the materials of the furniture as well to be washable and easy to clean.

In conclusion, indeed Covid-19 had imposed many challenges and had even brought up issues of exiting problems in the Egyptian education sector, but it had also given space for opportunities of development. The government's efforts in the past years for development of education had been proven to be sincere and luckily some of the plans and strategies match the proposed mitigations in the time of Covid-19. However, these plans for development may not be inclusive of other aspects like prioritizing the provision of healthy buildings. But as the worldwide situation is calling for changing and developing schools design considerations, we can use this international movement into our favor and develop not only the buildings to be healthier but to adopt different pedagogies that improve the quality of education as well.

4.3 A vision for design of educational spaces post Covid-19

As discussed earlier in the research, designing for educational spaces post covid-19 can be a gateway to enhancing both the quality of the design of the space as well as the adopted teaching pedagogy. As studies for an improvement in the classrooms to be safer and hygienic, this study calls an addition of a change in the pillars considered when designing educational spaces in Egypt to mitigate the challenges existent in the educational sector and the ones that were newly imposed.

The vision for the future of learning spaces in the time of Covid-19 proposes two directions for improvement. One that is about improvement of existing learning spaces to be safer and more technologically friendly. The other is about a change in the concepts of designing for educational spaces to fit the needs of new pedagogies rather than limiting the teaching pedagogies within the walls of the classrooms and ask children and teachers to adjust accordingly.

First direction: improvement of exiting learning spaces (Classrooms)

Classrooms before Covid-19

As clarified in the figure below, the typical classroom in Egyptian schools is as follows.

Windows for cross ventilation, desks that are of durable material that are not necessarily flexible, Desks are arranged as close as possible for holding maximum capacity, and classroom setup fits mostly lecturing style of teaching.

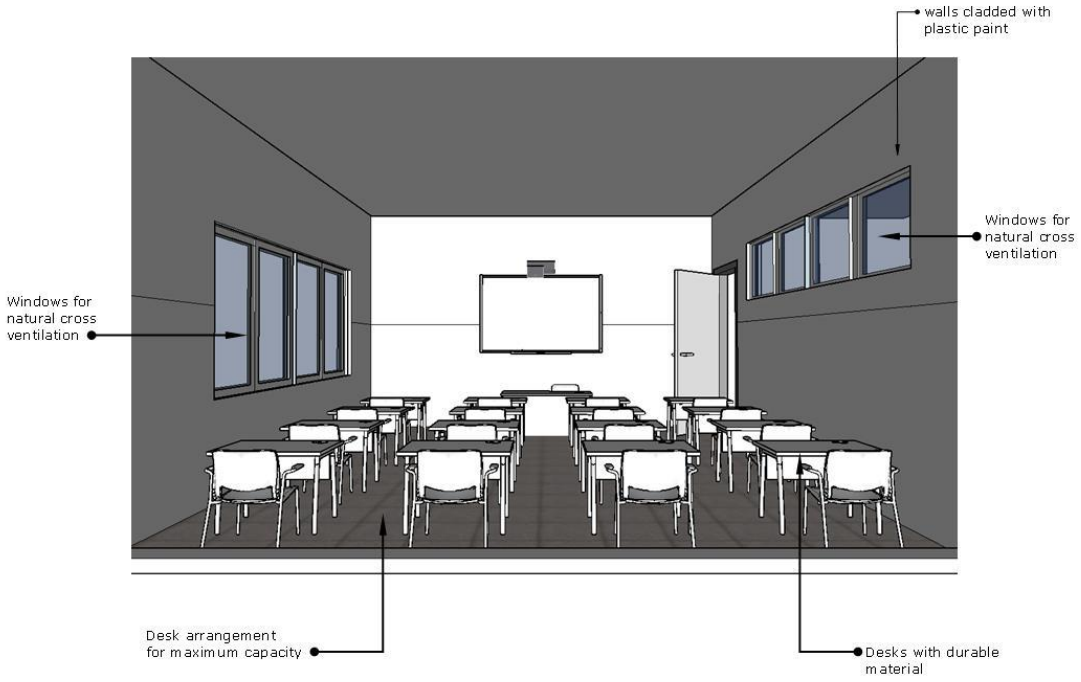


Figure 42 Classroom prototype before Covid-19. Source: Author

Classrooms after Covid-19

New design considerations for classrooms in the post Covid-19 that prioritize health and application of new pedagogies. First, ensure that ventilation achieves appropriate rate change even if including more methods either naturally or mechanically is needed depending on each site on its own. If mechanical methods were to be applied, placement of vents is to be considered and placed as shown in the figure below. Also, if fans were to be applied, it is recommended that it is placed in center and spins the air upwards rather than spreading it over the place. Second, furniture is to provide physical distancing through application of barriers. Also, the materials used should be washable and safe for constant sanitizing as well as it being light in weight to be flexible to provide different classroom settings. Third, Walls are to be cladded with washable finishing since Covid-19 particles are accumulated over them. Finally, inclusion of technology and access of internet inside each classroom is a must in order to implement blended learning and provide constant online coverage of the classrooms for children quarantining at home.

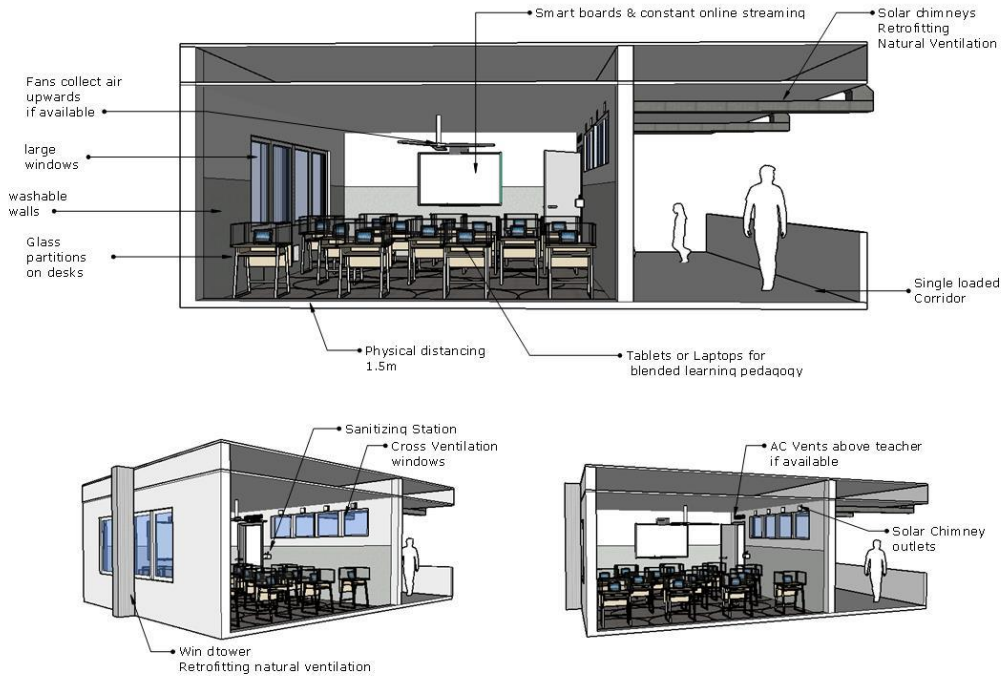


Figure 43 Classroom design considerations after Covid-19. Source: Author

Second direction: Developing design considerations of educational spaces

After envisioning the new elements of the classroom post Covid-19, this research proposes that a change of the vision of the strategy of designing for learning spaces may revolutionize the educative experience in Egypt while providing safe learning spaces in the time Covid-19.

As comprehended from the interviews with the authorities, the pillars of designing for learning spaces were not inclusive of neither the learning pedagogy nor the health factor. Meaning, the way we teach is not considered in the design of the architecture of our buildings. And that the architectural standards are not considerate of providing healthy buildings with sick building syndromes in mind. The standards however are dependent on other factors related to other constrictions like budgets, land area, population, resources … etc. It is also not inclusive of health considerations as well and this concept is newly introduced with Covid-19.

The challenge Covid-19 had put on in front of us could be an opportunity rather than a limitation if we choose to think beyond the situation. As Covid-19 circumstances require new additions to our spaces, we can re-shuffle the thinking process to serve first the quality of offered education and manage to have it be a safe environment in the time of covid-19.

It is recommended to consider implementation of learning strategies that enhance the student's wellbeing and the quality of education into being more interactive, inclusive, and practical to produce more creative thinkers for the future.

From the learning strategies that can be adopted fit such purpose and can be of a significant contribution to provide safe spaces in the time of covid-19 are the blended learning and outdoor learning strategies.

The following is a diagram of the recommended aspects to consider when designing for learning spaces for the future in the post Covid-19 era where the red color indicates additions, and the black color indicates existing aspects. The diagram calls for a shift in mindset of designing for learning spaces to be more integrated and inclusive of a variety of considerations that provide a wholistic approach for design.

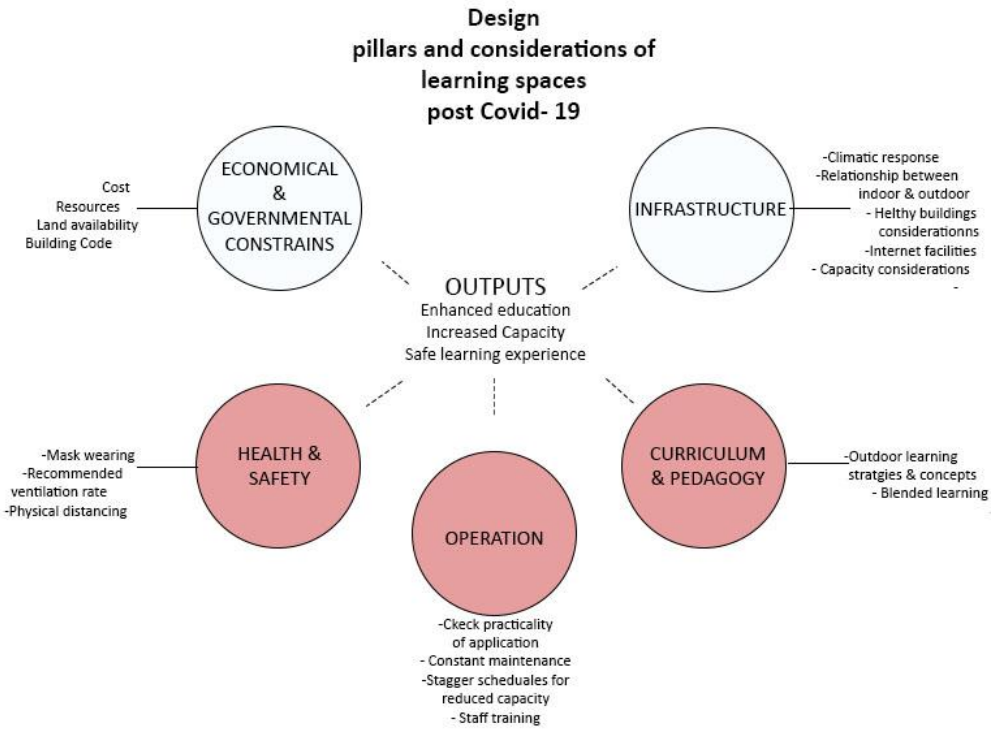


Figure 44 Design Pillars & Considerations of learning spaces post Covid-19. Source: Author

As demonstrated in figure 44, in order to provide enhanced education, increase the capacity of hosted students and at the same time offer a safe learning experience we cannot keep adopting the same design strategy from before Covid-19. Three more variables should be added into the equation of designing of learning spaces to reach the expected outcome. The first pillar is the health and safety, we can no longer ignore the fact that buildings designs play a huge role in risk management of disease spreading. Therefore, the general authority of educational buildings needs to collaborate with the ministry of health to readjust the design of the building code to respect the

new needs for indoor spaces to be safe which require new constrains for ventilation rates, thermal comfort, placing of vents and carbon dioxide rates.

The second pillar is the adopted learning pedagogy and the offered curriculum. For so long the architecture of the learning spaces has not been responsive to what is being taught and often the classrooms are limited in providing potential for learning in other ways that lecturing like experiential learning per say. Since one of the solutions to mitigate the challenges of Covid-19 on educational buildings is adopting the blended learning and the outdoor learning strategies, this could be a great opportunity for general authority for educational buildings to collaborate with the ministry of education to rethink the design of learning spaces that match on going development of the design of curriculums. Luckily, the pedagogies recommended for mitigating Covid-19 challenges are in line with the 2030 vision for education in Egypt that opts for inclusion of technology, integration of activities and experiential learning like international curriculums. Therefore, rethinking the design of classrooms and outdoor areas to be more responsive to the offered pedagogy shall benefit both the quality of education and new health considerations for the buildings in the post Covid-19 era.

The third and final pillar is the operation, as concluded from the interviews and field work, the ignorance of including the practicality in operation may cause conflict in achieving the design intent. The space is often designed with certain expectations that are based on carefully calculated standards but not practicality, external factors (i.e., climate, noise, neighboring zones … etc.) and human behavior which leads do malfunction of the design. Therefore, any design proposal for educational spaces need to consider the practicality and acceptability of the application to the target user and design a maintenance strategy and a follow up plan to ensure the continuation of achievement of the design target in the long run that includes solutions for different expected scenarios in application.

Chapter 5: Conclusion

Covid-19 had a negative impact on the education sector resulting in school closure for months not only in Egypt but worldwide. The reason for the school's closure was to stop the disease from spreading and constrain it as much as possible. However, the issue of how to get schools to open again in the time of the pandemic was differently addressed from one country and one school to another.

As this research explored the architectural changes that need to be done to provide safer learning spaces for students in the future, it had turned out that the challenges that need to be addressed were not only exclusive to the architecture nor are they exclusive to Covid-19.

After analyzing the effect of Covid-19 on schools in Egypt then relating them to the challenges other schools had faced from other countries and relating them to the proposed mitigations that shall offer safe learning spaces in the time of Covid-19, it became obvious that situation is rather complex and need to be addressed from different angles. Some of which lead to the root of issues in the educational sector in Egypt as an entity rather than just the space design itself.

The concluded mitigations were divided into three categories: operational, pedagogical, and architectural. Each of which is responsible for the same thing which is decreasing the spread of the virus. Each category simply addresses an aspect. The operations are responsible for ensuring safety measures, pedagogy is to be redesigned to decrease capacity of students inside the classroom and the architecture is to provide better ventilated learning spaces.

The challenges faced on the other side were more entangled and interlaced. First, regarding the operational measures, it had been observed that in practice it is not efficiently applied since it goes against the normal behavior of humans to always wear suffocating masks and to maintain a physical distance at all times, especially when dealing with children. Therefore, it is almost impossible to completely depend on trusting the proper implementation of the safety measures at all times. This leads us to the need to depend on other mitigations. The pedagogical mitigations proposed to decrease the capacity were remote learning, blended learning, and outdoor learning. Luckily, the government in Egypt had already started implementing technology in education a couple of years ago but it also came with limitations of its own especially for early primary stage students. But as for the outdoor learning pedagogy, unfortunately it is not yet a very common concept and that the majority school's playground are mostly covered with asphalt and offer only sports courts and no learning setting. Finally, regarding the ventilation, the design of the natural cross ventilation in our schools does not provide the proper rate of air exchange per hour needed in the post Covid era in its most efficient state. Nevertheless, the natural ventilation system is ignorant of external factors like noise, climate, dust … etc. which result into an often closure of doors and windows or the need to provide mechanical ventilation which is not an option that is feasible for all schools.

This research worked on understanding the relations between the challenges and tested the practicality of the mitigations. Consequently, proposed a different mentality for designing learning spaces in the post covid era in Egypt. A mentality that adds new pillars to design considerations,
ıce education beyond the walls of the classroom,
:lassroom time as efficiently as possible. And finally,
these new considerations in the education sector
the provision of safer learning spaces with lower risks

References

A.Moneim, D. (2020). 75% of Egyptian students sit in overcrowded classrooms : AUC policy paper . *Ahram Onlie*.

Allianz. (2021, May 22). *Schools in Egypt*. Retrieved from Allianz care: https://www.allianzcare.com/en/support/health-and-wellness/my-expat-life/school-guides/schools-in-egypt.html

Andrea Faber Taylor, F. E. (2011). *Could Exposure to Everyday Green SpacesHelp Treat ADHD? Evidence fromChildren's Play Settings*. University of Illinois at Urbana-Champaign APPLIED PSYCHOLOGY: HEALTH AND WELL-BEING.

BBC News. (2020, October 19). *Coronavirus: Germany improves ventilation to chase away Covid*. Retrieved from BBS News: https://www.bbc.com/news/world-europe-54599593

BLU_. (2021). Retrieved from Blended Learning Universe: https://www.blendedlearning.org/models/#stat

Bodor, K. J. (2020). *Guide to Advocating for Outdoor Classrooms in Coronavirus-Era School Reopening*. Mississippi State : North American Association for Environmental Education and National Wildlife Federation.

Bosch, R. (2020). *Learning Spaces Need to Enable and Motivate Every Learner*. Retrieved from Rosan Bosch: https://rosanbosch.com/en/approach/learning-spaces-need-enable-and-motivate-every-learner

Boston university. (2020). *Outdoor classroom user guide*.

Cathy Li, F. L. (2020). The COVID-19 pandemic has changed education forever. This is how. *World Economic Forum*.

Chawla, L. (2006). Learning to love the natural world enough to protect it. *Research gate*.

Christoph Mall, G. L. (2017). Effects of Regular Classes in Outdoor Education Settings: A Systematic Review on Students' Learning, Social and Health Dimensions. *International journal of environmental research and public health*.

COLLIERS INTERNATIONAL. (2020). *Egypt K12 Education Sector Market Overview Greater Cairo: Unlimited Opportunities*.

Dhawan, S. (2020). Online Learning: A Panacea in the Time. *Journal of Educational Technology Systems*.

Dugdale, S. (2009). *Space Strategies for the New Learning Landscape*. EDUCAUSE.

ECES . (2020). Views on the Crisis The Impact of COVID-19 on Egypt's Pre-University Education System. *Views on News*, Issue 5.

Edeh Michael Onyema, D. N. (2020). Impact of Coronavirus Pandemic on Education . *Journal of Education and Practice*.

Fisk, W. J. (2017). *The Ventilation Problem in Schools:*. Energy Analysis and Environmental Impacts Division.

Galloway, H. (2020). *A room, a bar and a classroom: how the coronavirus is spread through the air*. Retrieved from El Pais Newspaper : https://english.elpais.com/society/2020-10-28/a-room-a-bar-and-a-class-how-the-coronavirus-is-spread-through-the-air.html

Global Education Coalition. (2020). *COVID-19 response – hybrid learning Hybrid learning as a key element in ensuring continued learning* . UNESCO.

Green school yards America. (2020). *Outdoor infrastructure planning strategies for taking learning outside as schools reopen*. USA: Green school yards america.

Hachem, H. (2019). Overcrowding in Schools: Why is it a Huge Issue? .

HARVARD. (2020). *Risk Reduction Strategies for schools*. Healthy buildings for health.

Hurst, B. (2013, September). The Impact of Social Interaction on Student Learning. *Reading Horizons*.

IBE-UNESCO. (2021). Retrieved from http://www.ibe.unesco.org/en/glossary-curriculum-terminology/b/blended-learning

Indranil Chakraborty, P. M. (2020). *COVID-19 outbreak: Migration, effects on society, global environment and prevention*. Science of The Total Environment.

Jimenez, J.-L. (2020). *COVID-19 Airborne Transmission Tool Available* . Colorado: CIRES.

Johnson, D. (2018). Egypt's Long Road to Education Reform. *The Tahrir Institute for Middle East Policy*.

Kaveh Asanati, L. V. (2021). Healthier schools during the COVID-19 pandemic: ventilation, testing and vaccination. *Royal society in medicine*, Vol 114, issue 14.

KRASULIA, A. V. (2017). *Blended Learning Advantages and Disadvantages in the Classroom*. UKRAINE: SUMY STATE UNIVERSITY.

Learning Landscapes. (2013). *Geen ountain elementary schoolyard master plan*. University of Colorado .

Leila, R. (2019, March 15). *Technology at Egyptian schools*. Retrieved from Ahram online: https://english.ahram.org.eg/NewsContent/1/64/328288/Egypt/Politics-/Technology-at-Egyptian-schools.aspx

Luis Espino-Díaz *, G. F.-C.-M.-L.-G.-L.-C. (2020). Analyzing the Impact of COVID-19 on Education Professionals. Toward a Paradigm Shift: ICT and Neuroeducation as a Binomial of Action . *MDPI*, Sustainability.

Malgorzata Stopikowska, Y. M.-D. (2012). The education system of Egypt: Contexts, frames & structures. *Problems of education in the 21st centuary*.

Ministry of Education. (2020). Retrieved from https://moe.gov.eg/

Ministry of education of Egypt. (2014). *The Strategic Plan of Pre-University Education 2014 -2030*. Ministry of education of Egypt.

Ministry Of Health. (2020). Retrieved from https://www.care.gov.eg/EgyptCare/Index.aspx

Nasseir, D. (2020). The Benefits Of Online Learning In A COVID-19 World And Beyond. *Small Bussiness sense*.

New, K. C. (2016). *Bringing the Classroom Outdoors: An Analysis of Toronto Educator Perceptions and Challenges*. Toronto: Department of Curriculum, Teaching and Learning Ontario Institute for Studies in Education of the University of Toronto.

OECD. (2020). *Education and COVID-19: Focusing on the long-term impact of school closures*. OECD ORG.

OECD. (2020). *Education and COVID-19: Focusing on the long-term impact of school closures* .

OREGON. (2021). *Supplemental Guidance for Learning Outside*. Oregon department of education.

Oyedotun, T. D. (2020). Sudden change of pedagogy in education driven by COVID-19: Perspectives and evaluation from a developing country. *ElSeveir*.

R Pombal, H. I. (2020). *Risk of COVID-19 during air travel*. JAMA.

Shouib Nouh Ma'dbeh, A. A.-z. (2020). Simulation study for natural ventilation retrofitting techniques in educational classrooms. *Cell Press*.

Silcott, K. (2020). *TRANSCOM/AMC Commercial Aircraft Cabin Aerosol Dispersion Tests*.

Siyao Shao, D. Z. (2020). *Risk assessment of airborne transmission of COVID-19 by asymptomatic individuals under different practical settings*. Minnesota : Department of Mechanical Engineering Of Minnesota University.

Steelcase Education. (2020). *Navigating what's next post-COVID learning spaces*. Steelcase Inc.

U.N.D.P. (2021). COVID-19 pandemic Humanity needs leadership and. *United Nations Development Programme*.

UMWELT & GESUNDHEIT. (2008). *GUIDELINES FOR INDOOR AIR HYGIENE IN SCHOOL BUILDINGS*. Berlin: German Federal Environment.

UNESCO. (2020). *Adverse consequences of school closures*.

UNESCO. (2020). *Education: From disruption to recovery*. WWW.UNESCO.ORG.

UNICEF. (2020, September 09). Classroom precautions during COVID-19.

World Health Organization. (2020). *Checklist to support schools re-opening and preparation for COVID-19 resurgences or similar public health crises*.

World Health Organization. (2021). *Covid-19 Dashboard Egypt*. Retrieved from https://covid19.who.int/region/emro/country/eg

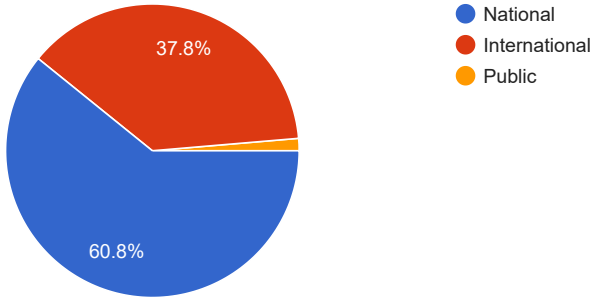
Students' Survey

74 responses

Publish analytics

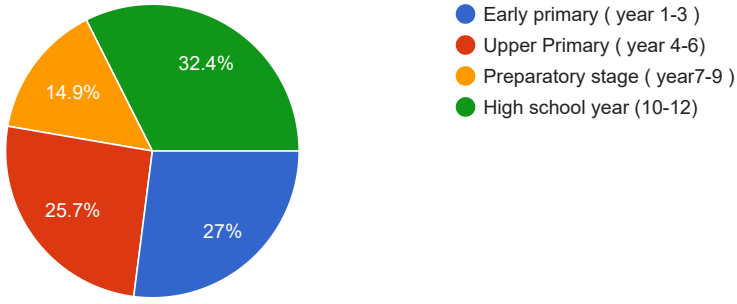
What type of school do you attend ?

74 responses



Which grade are you at ?

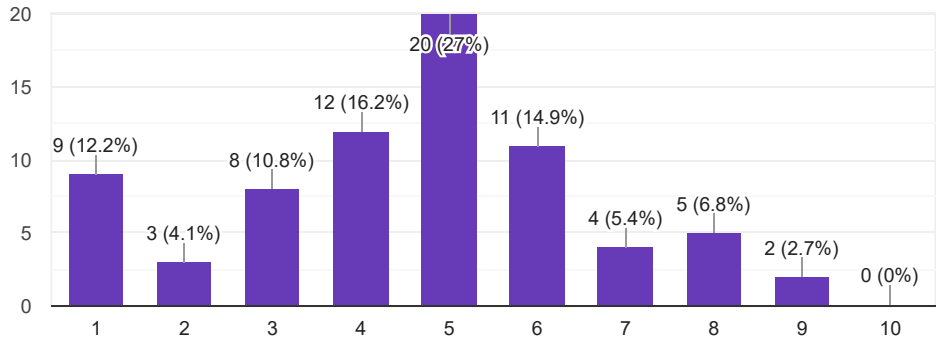
74 responses



Challenges from online learning during the pandemic

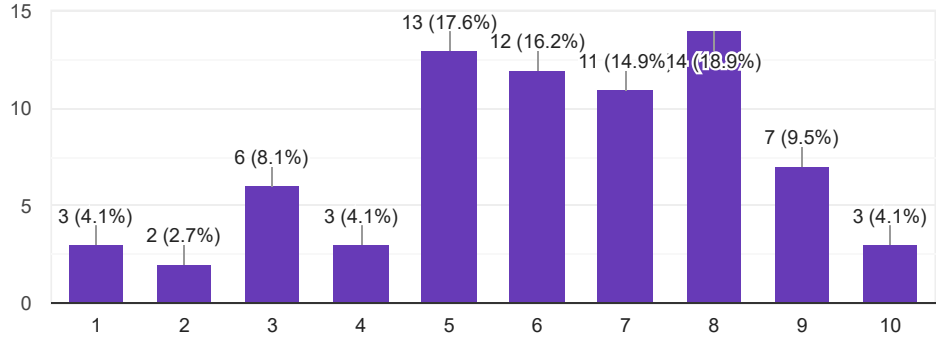
In your opinion, How successful is online learning in delivering the course contents?

74 responses



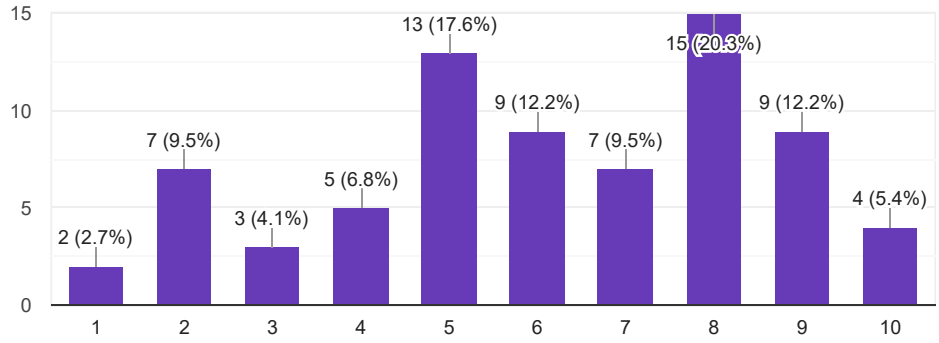
How well do you think teachers are able to teach online ?

74 responses



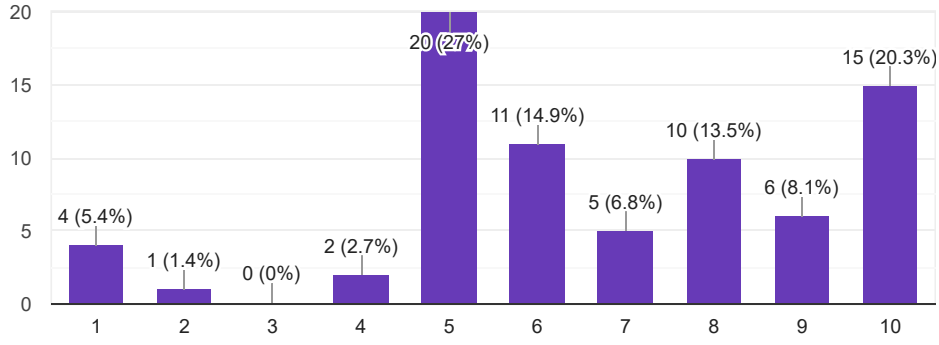
How well can your teacher give one-to-one connection with you on the online platforms ?

74 responses



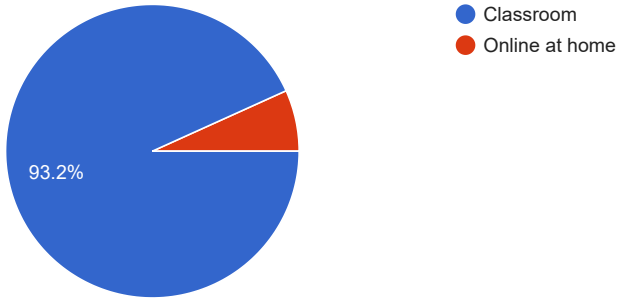
What do you think of online learning as a substitute for in-person learning ?

74 responses



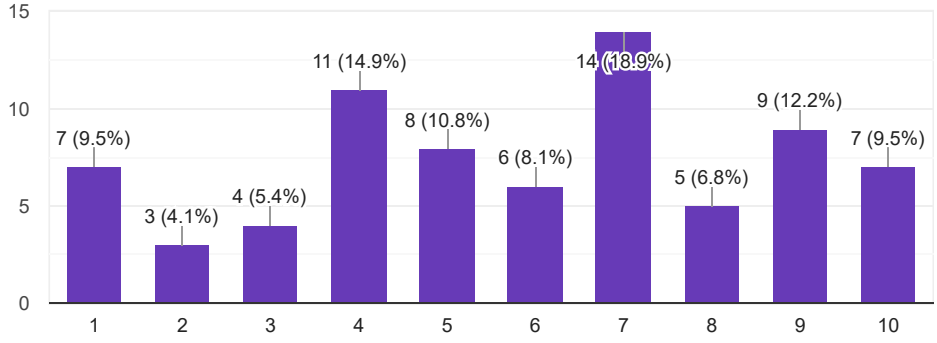
Where do you focus better ?

74 responses



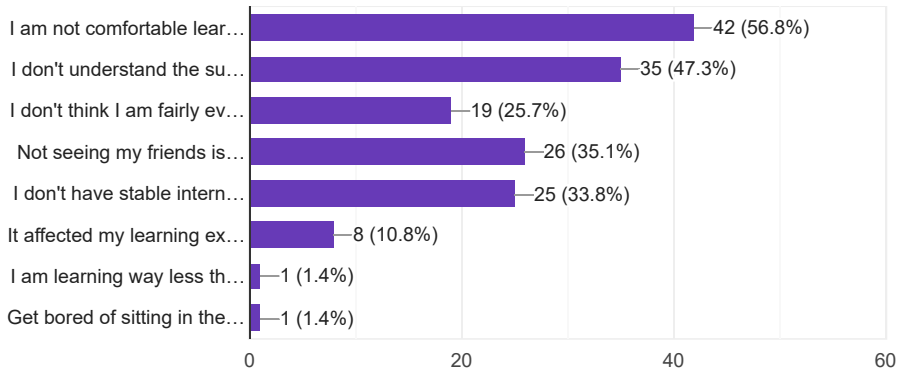
How well can you use the online learning methods ?

74 responses



How did the Learn from home experience affect your overall learning experience ?

74 responses



What is the biggest challenge you faced learning from home during the pandemic ?

74 responses

The teacher can't answer my question

Internet connection caused late submission of my exams

Na

Teacher's always lag

Not focusing that much

Concentration

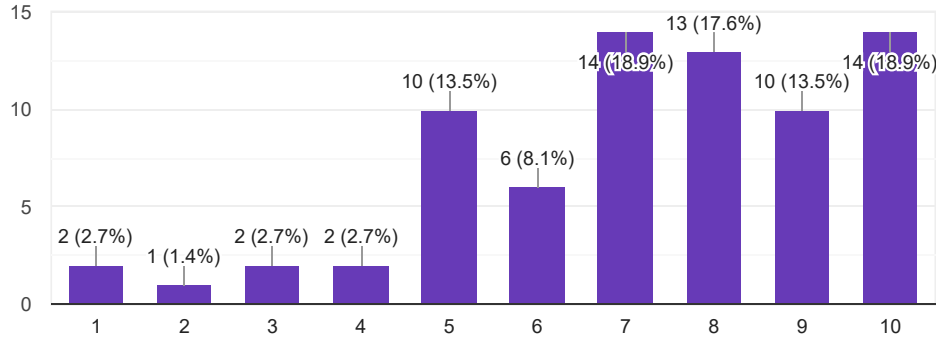
New experience

Monitoring more than one child at the same time during Zoom sessions and following up with my children all the amount of assignments required to be done on time.

Reading books

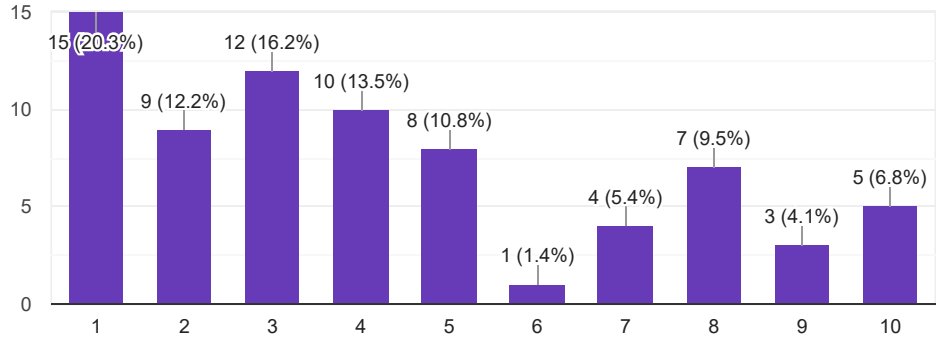
Is the lack of social connection and staying at home negatively affecting you ?

74 responses



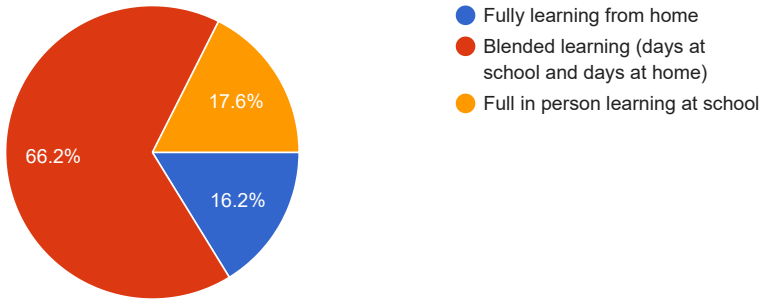
What do you think of going to school 3 days and learning from home the other 2?

74 responses



Which of the following do you think provides the best education quality and safe experience in the time of COVID-19

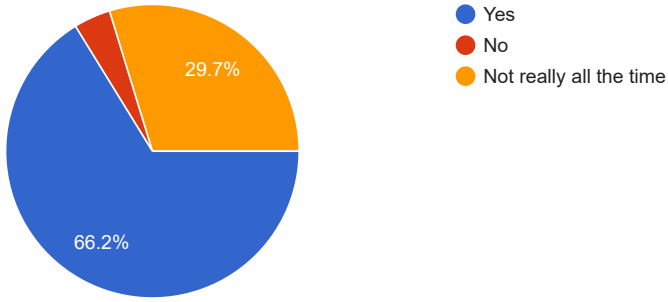
74 responses



Safety measures inside the classroom post COVID-19

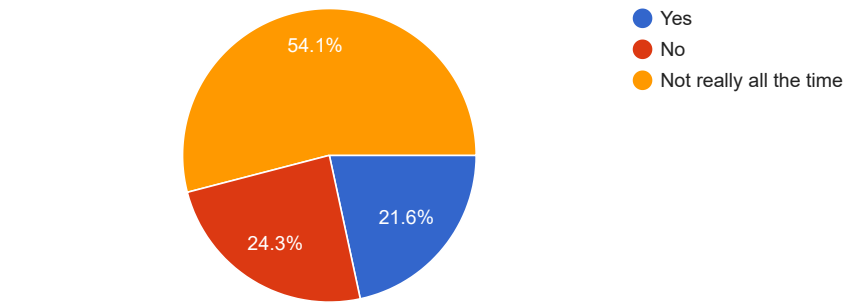
Do you wear your mask inside the classroom ?

74 responses



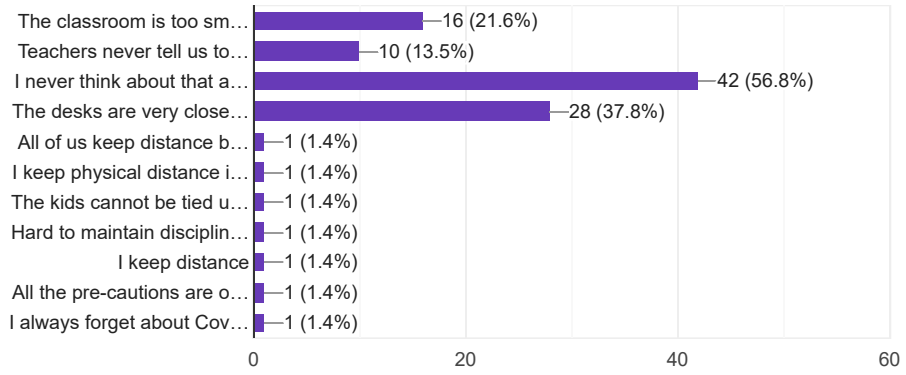
Are you able to always maintain physical distancing (1-2 meter distance) inside the classroom ?

74 responses



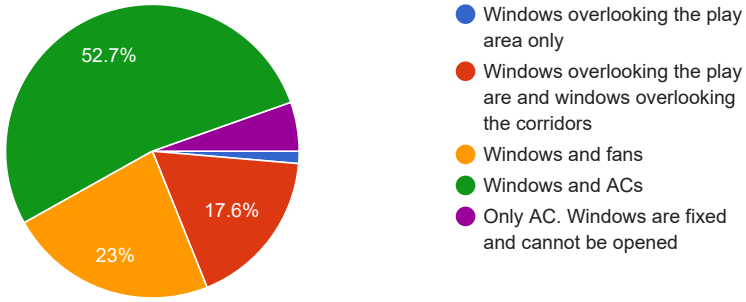
Why don't you keep physical distancing inside the classroom ?

74 responses



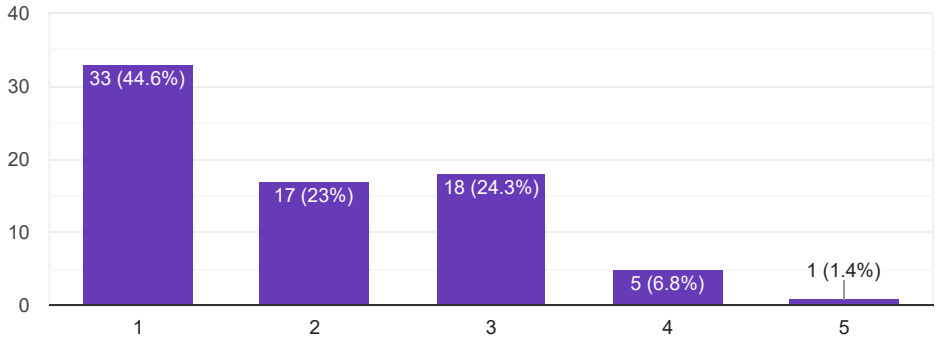
How is the classroom at your school ventilated ?

74 responses



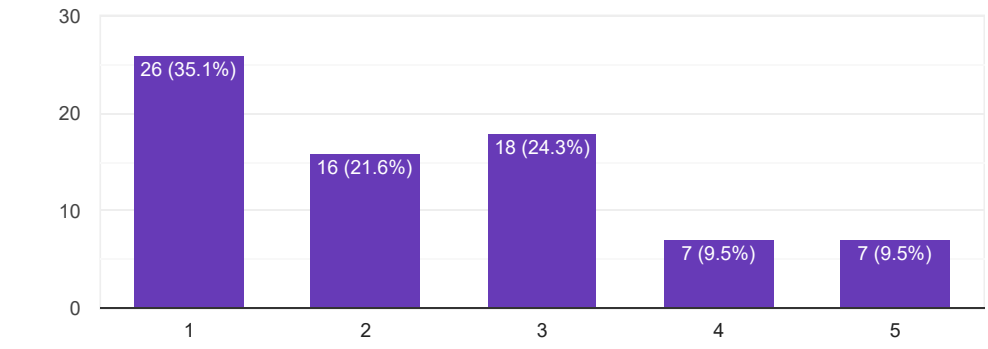
How often does the teacher open windows for ventilation?

74 responses



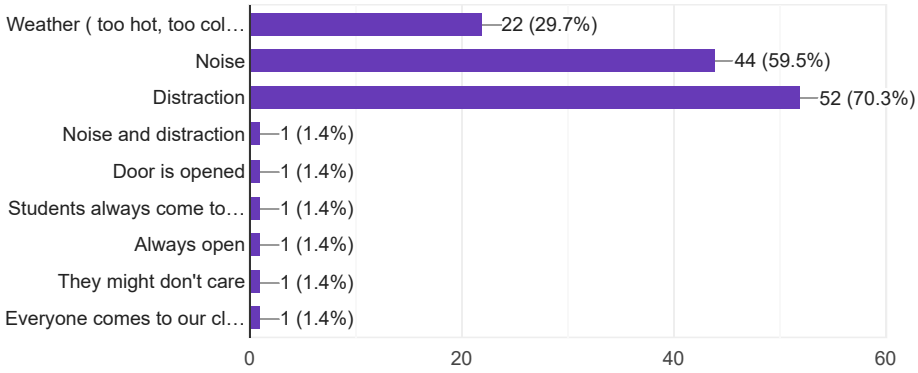
How often do you open doors for ventilation ?

74 responses



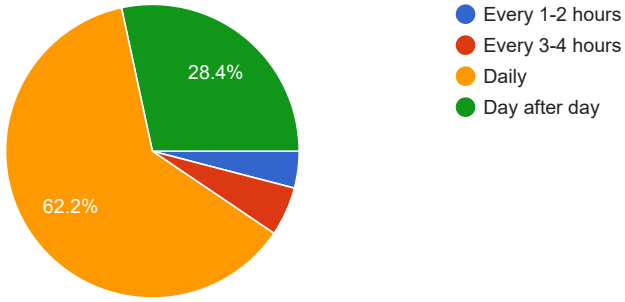
Why do you think the teacher does not open doors or windows for ventilation ?

74 responses



How often are the classrooms cleaned and sanitized ?

74 responses



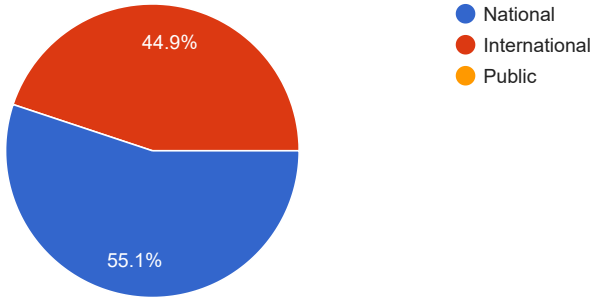
Teachers' Survey

49 responses

Publish analytics

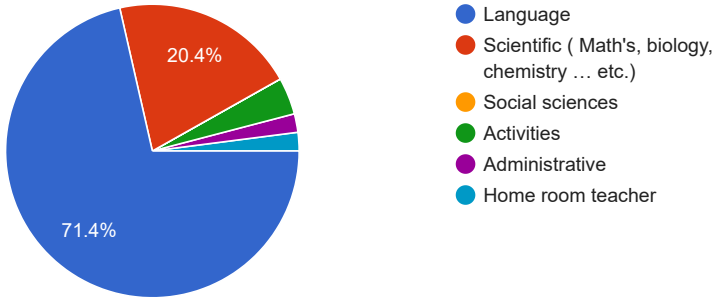
What type of school do you teach at ?

49 responses



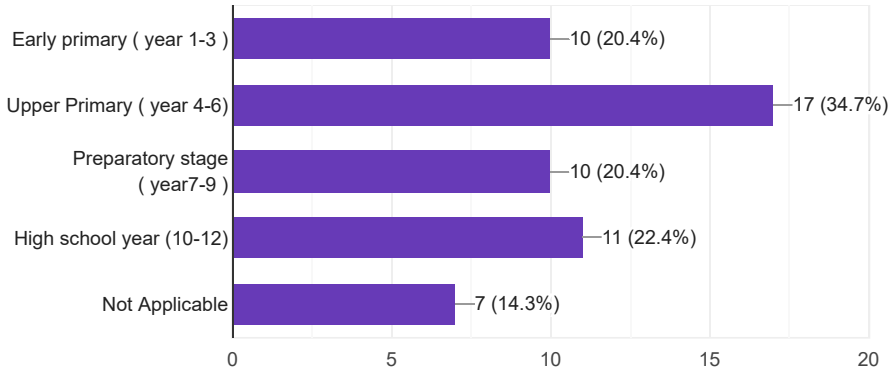
What type of subject do you teach ?

49 responses



Which grade do you teach ?

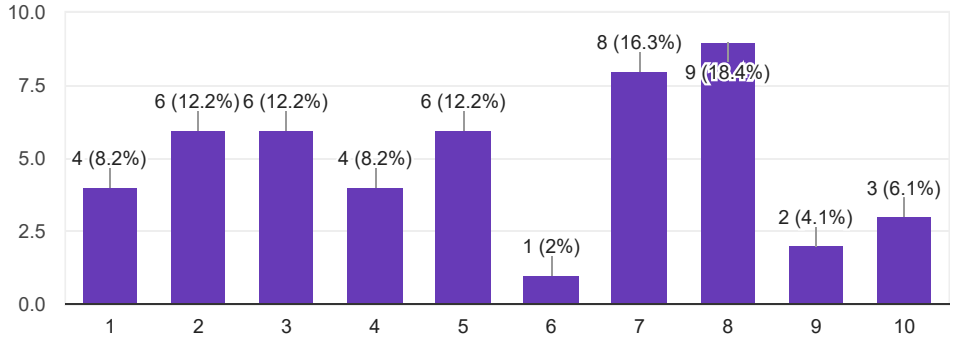
49 responses



Challenges from online learning during the pandemic

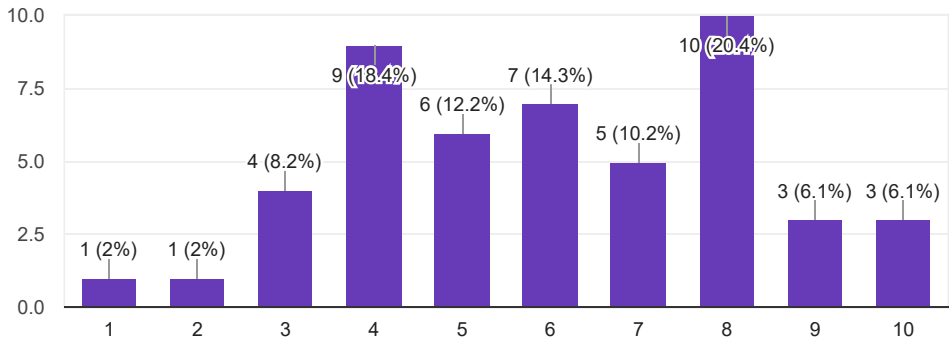
How well was your school equipped to switch to online learning with the appearance of the pandemic ?

49 responses



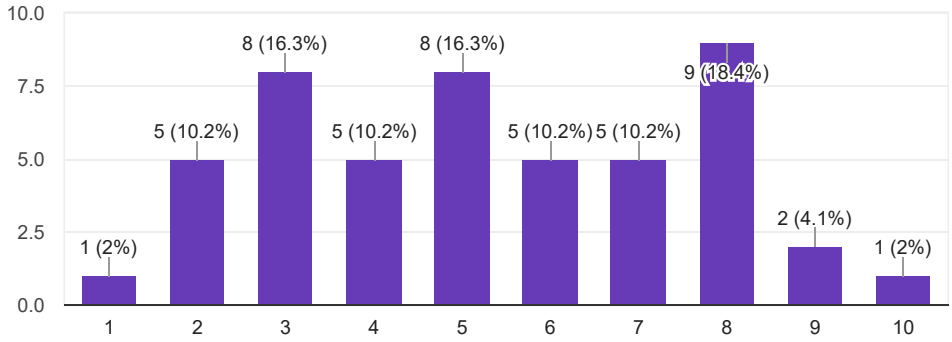
How flexible do you think online learning is in delivering the course contents ?

49 responses



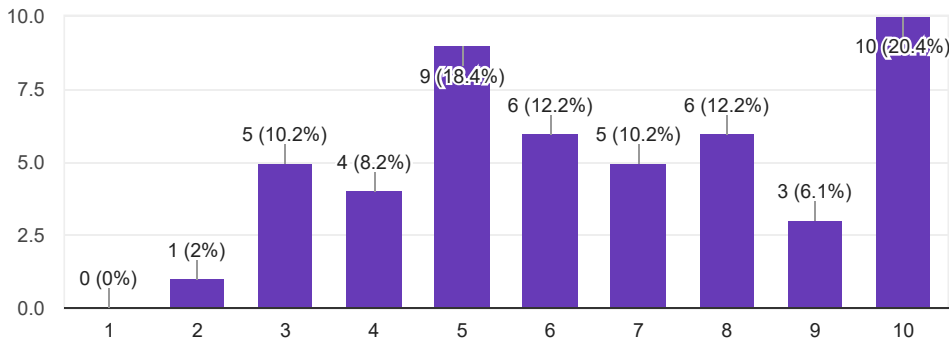
How well can you personally connect / bond with students through online learning?

49 responses



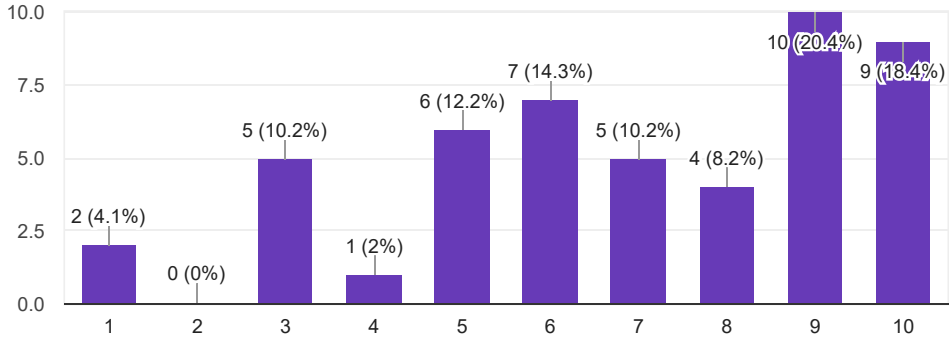
What do you think of online learning as a substitute for in-person learning ?

49 responses



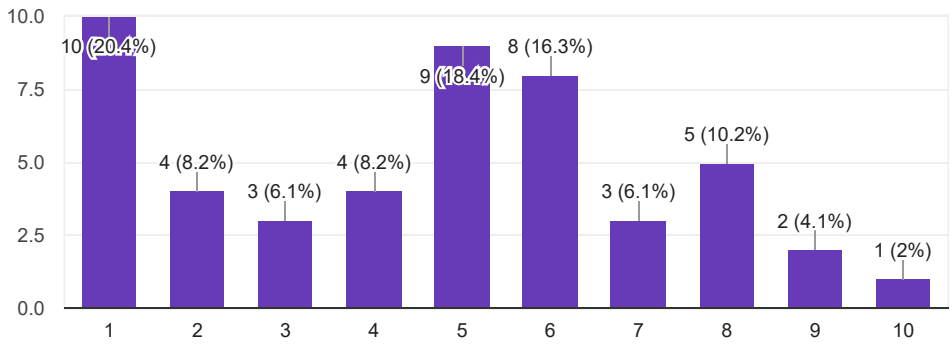
How fair are online methods for evaluating the child by the end of the year ?

49 responses



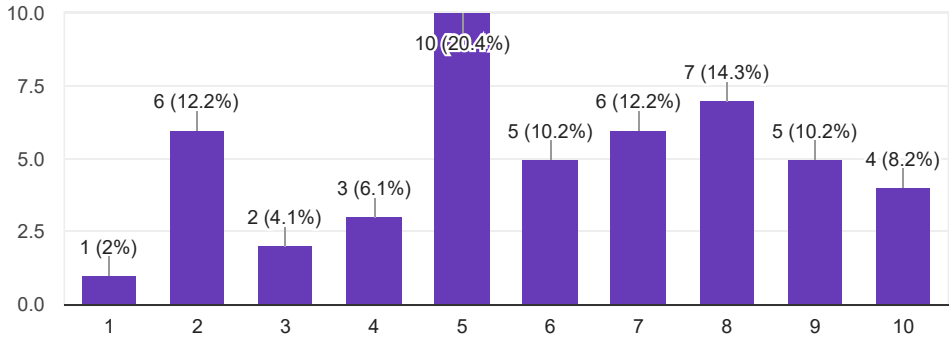
As a teacher, How good do you think you are with online teaching ?

49 responses



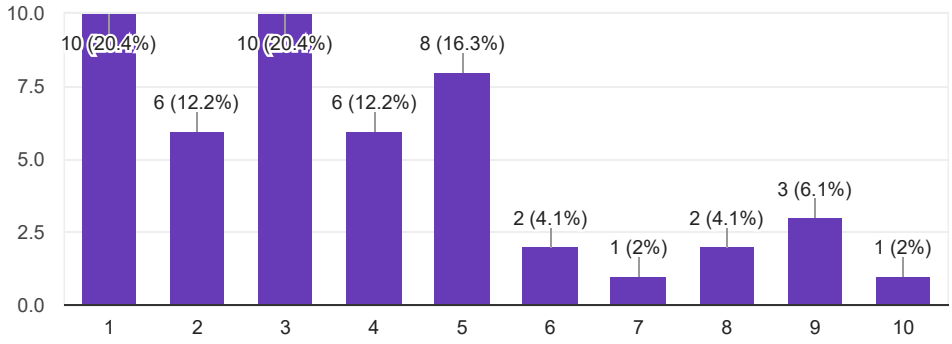
How well do you think the curriculum fits into the online modal delivery?

49 responses



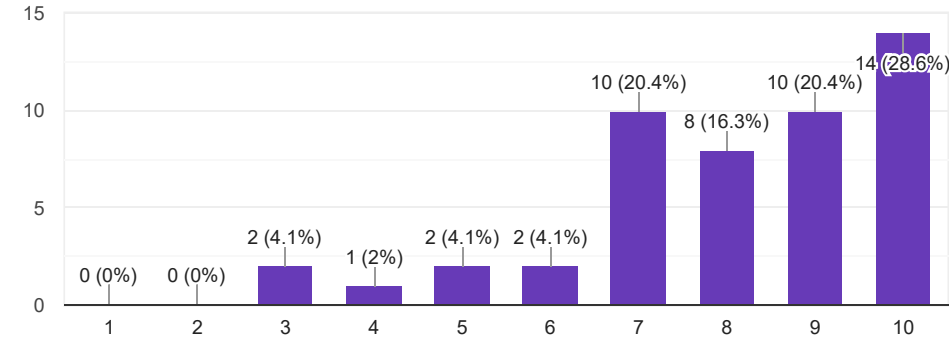
How do you think the lack of social connections is affecting the students learning experience ?

49 responses



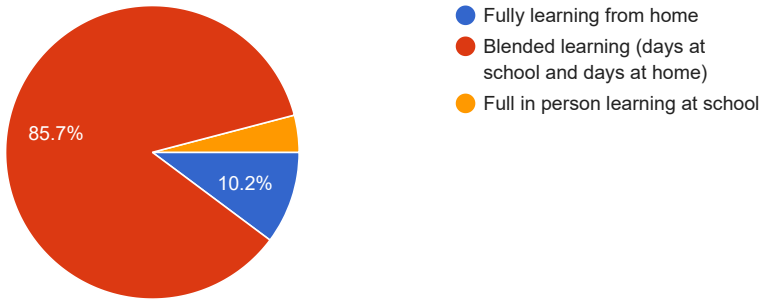
What do you think of mixing online learning with in class learning to decrease attendance during the week but still assure social interaction for students ?

49 responses



Which of the following do you think provides the best education quality and safe experience in the time of COVID-19

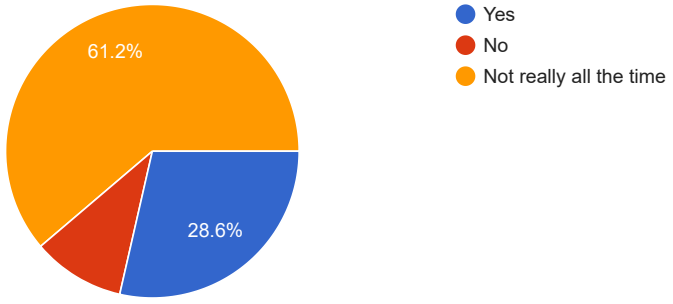
49 responses



Safety measures inside the classroom post COVID-19

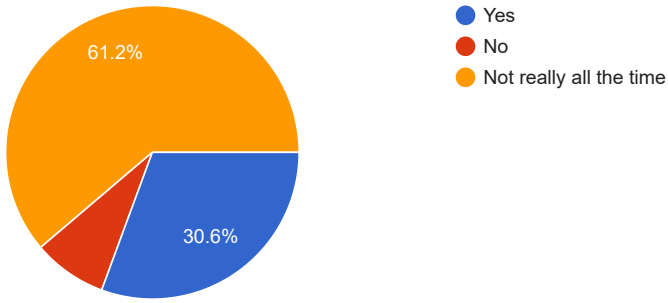
Are students wearing masks at all times ?

49 responses



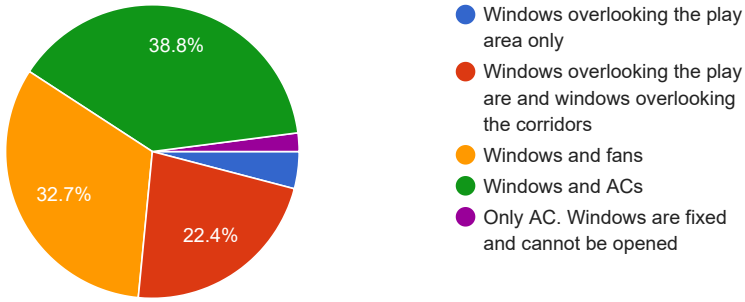
Are physical distancing measures maintained inside the classroom at all times?

49 responses



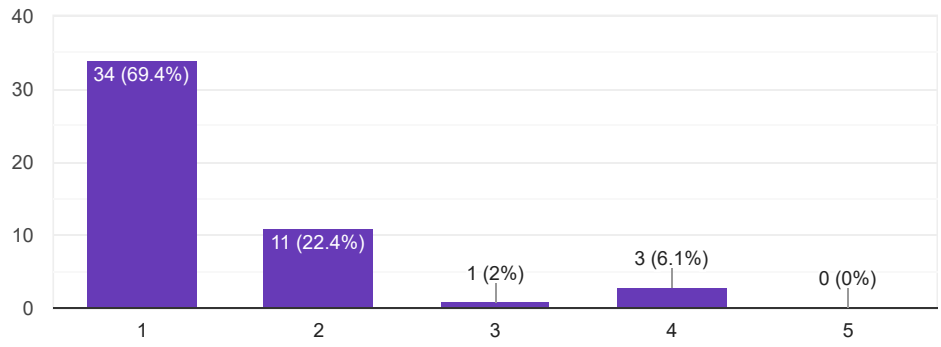
How is the classroom at your school ventilated ?

49 responses



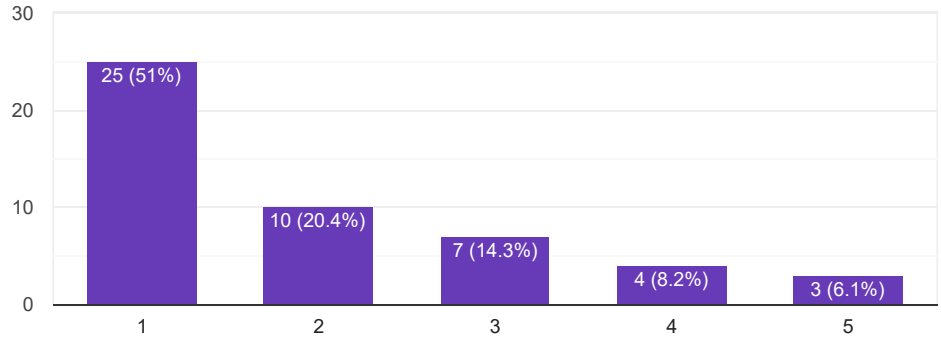
How often do you open windows for ventilation?

49 responses



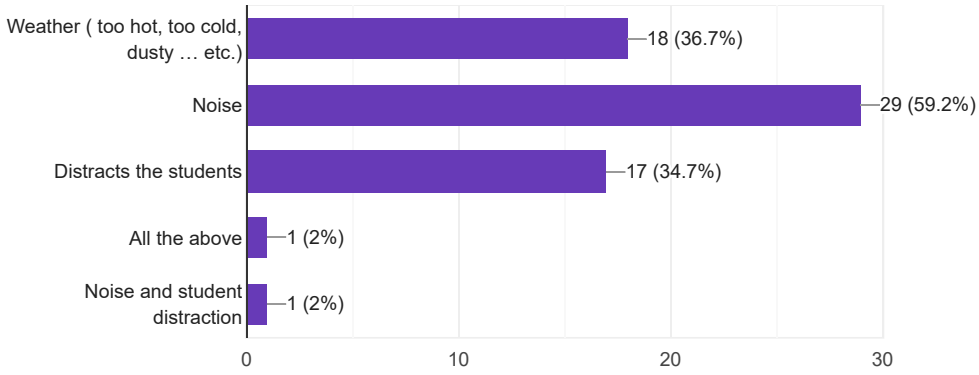
How often do you open doors for ventilation ?

49 responses



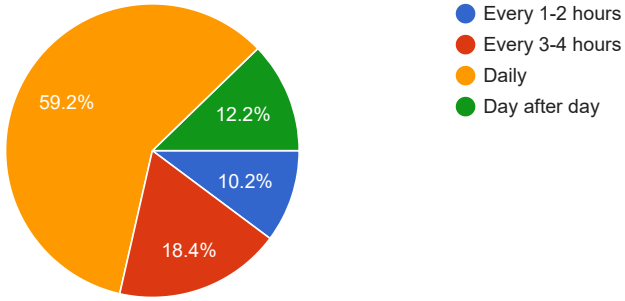
What would make you not open doors or windows for ventilation ?

49 responses



How often are the classrooms cleaned and sanitized ?

49 responses



نبذة مختصرة

بسبب جائحة فيروس كورنا المستجد تم إجراء العديد من الدراسات العلمية بهدف تطوير المعايير المعمارية الخاصة بالمنشئات التعليمية ، وأنواع أخري من المباني لتلبية التدابير الاحترازية المطلوبة لمجابهة إنتشار الفيروس .. كما يدرس الباحثون إمكانات جديدة لأساليب التعليم من خلال إعداد تصميمات معمارية مناسبة تتوافق مع تلك التدابير الاحترازية.

أثار فيروس كورونا المستجد العديد من التحديات بأوساط النظام التعليمي مما أدى إلى إغلاق ما يقرب من 85٪ من المدارس بجميع أنحاء العالم في غضون شهرين فقط بعد ظهوره حيث ترك لنا مسؤولية إيجاد سُبل لتطوير الهندسة المعمارية بمدارسنا لتكون أكثر أماناً ومرونةً تجاه العقبات التي شكلها الفيروس مع مواكبة التطور المستمر لأساليب التعليم.

يهدف البحث المشار إليه إلى رسم خريطة التحديات التي نتجت عن جائحة فيروس كورنا المستجد وأثرت على التعليم في مصر .. وذلك للمساهمة في تلبية الإحتياجات الجديدة الخاصة بنظامنا التعليمي وكيف يمكن للهندسة المعمارية أن تستجيب لتلك التحديات من أجل توفير بيئة تعليمية مُطورة وأكثر أماناً من خلال إتخاذ مدارس نفرتاري الدولية كنموذج لدراسة الحالة التي تمثل البيئة المعمارية للمدارس في مصر .. كما يهدف ذلك البحث إلى التحقيق في التحديات التي واجها الطلاب والمعلمون خلال فترة إغلاق المدارس في ضوء إنتشار الجائحة كذا التحديات التي سببها الفيروس بعد إفتتاح المدارس مجدداً بالإضافة إلي القيام بدراسة البيئة المعمارية للمنشئات لتحليل المشاكل المتعلقة بالمباني التعليمية الحالية مقارنةً بالإحتياجات والتحديات الجديدة التي نتجت عن تلك الجائحة.

الكلمات المفتاحية : فيروس كورنا المستجد ، تصميم المباني التعليمية ، المباني الصحية

إقرار

هذه الرسالة مقدمة في جامعة عين شمس وجامعة شوتجارت للحصول على درجة العمران المتكامل والتصميم المستدام. إن العمل الذي تحويه هذه الرسالة قد تم إنجازه بمعرفة الباحث سنة ...

هذا ويقر الباحث أن العمل المقدم هو خلاصة بحثه الشخصي وأنه قد اتبع الإسلوب العلمي السليم في الإشارة إلى المواد المؤخوذه من المراجع العلمية كلٌ في مكانه في مختلف أجزاء الرسالة..

وهذا إقرار مني بذلك،،،

التوقيع:

الباحث: مريم حمدي

التاريخ:يولو2021/

إعادة التفكير في تصميم
مساحات التعلم بعد COVID-19

مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

أعداد: مريم حمدي

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لجنة الحكم

أ.د. .....الممتحن الخارجي
أستاذ.....
جامعة .....

أ.د.....
أستاذ.....
جامعة .....

أ.د.....
أستاذ.....
جامعة .....

التوقيع

تاريخ المناقشة:.....

الدراسات العليا

ختم الإجازة

موافقة مجلس الكلية .../.../...

أجيزت الرسالة بتاريخ:.....

موافقة مجلس الجامعة .../.../...

MM/DD/YYYY

جامعة عين شـــــمس

جامعة عين شـــــمس

إعادة التفكير في تصميم مساحات التعلم بعد COVID-19

رسالة مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

إعداد

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يوليو 2021