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Rethinking post-Covid-19 school design in Brazil: adaptation strategies for public schools PEE-12 FNDE

Sinara Furlani [a] *| Grace Tibério Cardoso [a]

[a] Postgraduation Program of Architecture and Urbanism, School of Engineering and Applied Sciences, IMED, Passo Fundo, Brazil

* Corresponding author: sinarafurlani@gmail.com

ABSTRACT

In 2020, the World Health Organization (WHO) declared the disease COVID-19, whose causative virus is SARS-CoV-2, a pandemic. An important measure was the closure of schools in several countries to try to reduce the contagion levels, so that students were not exposed to risk, nor their families. The question that arises within this context is: In school architecture, what are the appropriate design methods to deal with challenges during and after a pandemic? In this scope, the article aimed to propose an adaptive design scenario in the post-pandemic moment for a standard school in Brazil. The methodology was built through a literature review and multidisciplinary research, to later present strategies based on the recommendations of competent bodies and studies focused on the school architecture, design patterns for 21st-century schools, technology and security. The focus was on design challenges in the education field in the post-pandemic moment, and on the adaptation of the school built spaces for the return of activities. The results can help the school community and public agencies in making decisions to face this challenge, recreating safer, user-centered schools.

Keywords: Covid-19, Design Patterns, Public School.

INTRODUCTION

In 2020, the World Health Organization (WHO) declared the disease COVID-19, caused by the SARS-CoV-2 virus, a pandemic. In order to limit the risk of contagion, an important measure was the closing of schools in several countries. This fact precipitated an educational crisis, further deepening social inequalities and weaknesses (UNESCO, 2020).

With the pandemic, Digital Information and Communication Technologies (TDICs) emerged as an opportunity for students to learn outside the classroom. However, a considerable portion has no structure or access to a quality internet network. According to Van Lancker & Parolin (2020), in Europe, 5% of children do not have a good place to do their homework, and 6.9% do not have access to the internet.

As social distancing measures are still imprecise, it is urgent to identify how countries can safely return students to education and parents to work (Viner et al., 2020). According to the authors, policymakers and researchers should look for less disturbing forms of social detachment in schools than the total closure of places, and can contribute substantially to maintaining control of the pandemic (Viner et al., 2020).

It is necessary to reflect about the quality of the traditional educational system, considering the critical role of the physical school environment in the quality of learning, in the well-being and social construction of the individual at present, as well as the flexibility and wholesomeness of educational spaces. In the design process, there is a fertile field for practices and strategies that directly impact the construction of quality schools. Thus, the question that arises is: in the current pandemic scenario, does the architectural design of schools offer a resilient and safe dimension for adaptations to the post-pandemic moment? How can architects and designers face the challenges of the new reality, and how can they adapt and reconfigure the school environment?

Thus, the objective of this article is to propose an adaptive design scenario for the the post-pandemic moment of the standard school called *Projeto Espaço Educativo 12 Salas*, from the National Fund for Education Development, in Brazil.

The methodology was built through a literature review based on the systematization and analysis of articles related to back-to-school security, school architecture, learning spaces suitable for the 21st Century, and technology. Figure 1 illustrates, in general, how the methodological process of data research was carried out for re-design of the case study.

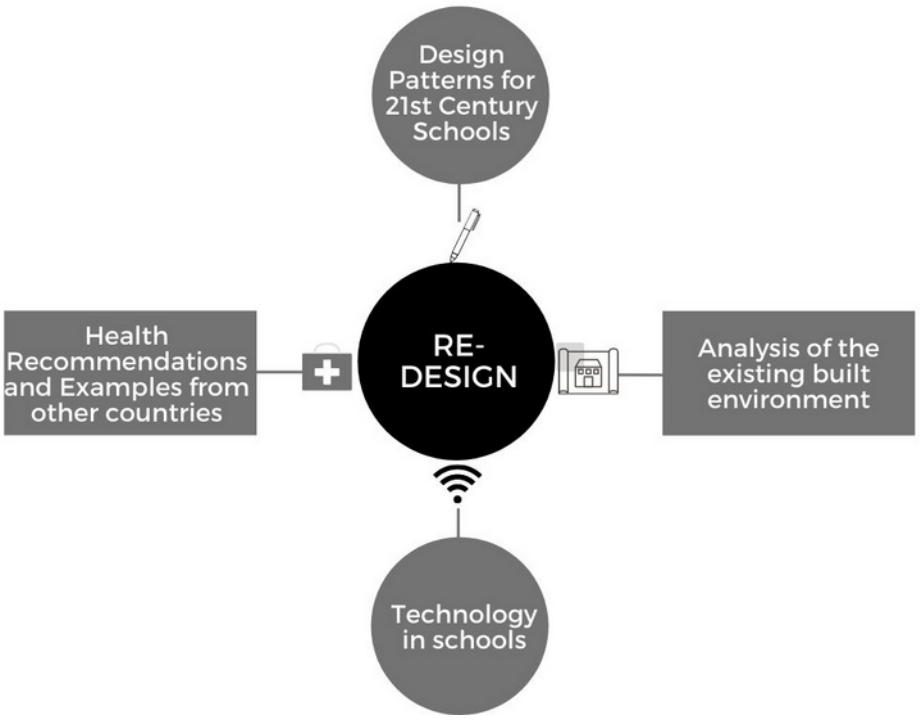

Figure 1. Research of data for school re-design.

In general, this research aims to foster reflection on the future of the school environment in face of the pandemic and other emerging situations, and to suggest a way of rethinking educational spaces, so that they are accessible and welcoming.

1. STRATEGIES FOR REOPENING SCHOOLS

The course of thought for now, despite many uncertainties in decision-making, is to reflect on how to proceed when public authorities allow schools to reopen for face-to-face education. In this process, it is essential to consider examples of success in other countries for possible implementation at national level, in addition to a constant reassessment of the benefits and limitations of this transition. The important thing, at this stage, is to ensure safe conditions for the health of the occupants.

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Sheikh et al. (2020) summarized four approaches that are being used internationally to enable a safe return to schools:

1. Keep schools closed until a vaccine can be administered to achieve immunity, or treatment is found.
2. Reopen schools completely when the sufficient number of reproduction (Rt) is well below 1. Despite the benefits of resuming face-to-face education, there is a risk of triggering additional peaks of infection.
3. Partially reopen schools, so that there are fewer students in the school.
4. The hybrid approach, in which face-to-face classes are transmitted live to those who need to be protected because of chronic illnesses or have the ability to study at home. However, this depends on high-speed Internet access and appropriate devices.

In Denmark, for example, children are taught outdoors and maintain a physical distance of 2 meters. In this case, a rearrangement of tables has been proposed in an attempt to reduce the transmission of droplets and contact (Sheikh et al., 2020).

For Fantini et al. (2020), safety measures for the reopening of schools may include the creation of small set groups of children, in order to maintain social distance, taking into account the available spaces and considering the implementation of different shifts to attend schools. Other strategies proposed by Fantini et al. (2020) are: avoid sharing materials, relocate rooms and common areas, ensure frequent access to hand washing, ensure ventilation and sanitize environments.

In summary, strategies that include returning to face-to-face classes at schools must be conducted according to each local, social and environmental context, with due care and strict control and inspection. Whatever strategy is adopted, carefully planned assessments are crucial to help develop a robust evidence base and guide the decision for this and future pandemics (Sheikh et al., 2020).

2. DESIGN FOR 21st CENTURY SCHOOLS

Campos (2020), in a research on resilience, education and architecture, highlights that by interacting with human emotion, the architectural composition of a school influences the mind of the student, and also points out that several studies have confirmed that environmental characteristics act on brain processes and learning.

Over the past decades, schools were constituted of classrooms as well-known physical and social structures, where the planned pedagogies were based on teacher-focused instruction and associated spatial arrangements. However, in recent years, there has been a growing appetite for allowing a wider range of pedagogical approaches than is possible in traditional classrooms (Young et al., 2019). Demirel (2009), stated that in the new teaching period of the 21st Century, the advance of skill level, self-education, self-development and the full use of individual skills would be in the foreground.

Campos (2020), further states that it is necessary to take into account the “educational” value of architecture in order to reinforce the proactive dimension of resilience. Schools with seriously considered architecture are safer schools, provide friendly environments and motivate students to learn.

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Thinking of establishing essential characteristics for a school project suitable for the 21st Century, Nair et al. (2013), delimited 29 project patterns, possible to work with according to each local context (Table 1).

Table 1: Design patterns by Nair, Fielding and Lackney (2013).

Item	Design Pattern
1	Classrooms, Learning Studios, Advisories and Small Learning Communities.
2	Welcoming Entry.
3	Student Display Space.
4	Home Base and Individual Storage.
5	Science Labs, Art Studios and Life Skill Areas.
6	Music and Performance.
7	Health and Physical Fitness.
8	Casual Eating Areas.
9	Transparency and Passive Supervision.
10	Interior and Exterior Views.
11	Dispersed Technology.
12	Indoor/Outdoor Connection.
13	Furniture: Soft Seating.
14	Flexibility, Adaptability and Variety.
15	Campfire Space: space to use with an expert who shares his knowledge with students.
16	Watering Hole Space: more informal learning spaces.
17	Cave Space: spaces for individual study.
18	Designing for Multiple Intelligences: each intelligence - linguistic, logical, musical, -corporal, spatial, naturalistic, interpersonal or intrapersonal, existential - only develops in spaces with specific characteristics.
19	Daylight and Solar Energy.
20	Natural Ventilation.
21	Learning, Lighting and Color.
22	Sustainable Elements and Building as 3D Textbook.
23	Local Signature: architectural language must express the pedagogical model and school values for the community.
24	Connected to the Community.
25	Home-like Bathrooms.
26	Teachers as Professionals: refers to environments that are suitable for teachers, from the meeting area to the rest spaces.
27	Shared Learning Resources.
28	Safety and Security.
29	Bringing It All Together.

Note: Adapted from Nair et al. (2013).

In a survey of Innovative Learning Environments (ILEs), Byers et al. (2018) assessed the impact of different classroom layouts on learning. While conventional classrooms have a rigid layout of lined up desks and teacher-centred didactics, rooms adapted to the ILE method remove these characteristics, allow spaces with a polycentric layout - with many focal points and greater use of digital technologies (Byers et al., 2018). In the study, students who stayed at ILEs identified a broader set of active learning experiences and collaborative learning modalities than their peers who remained in a traditional layout. Despite this, ILE, alone is not the agent of change, since other aspects are involved in the learning process (Byers et al., 2018).

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Based on this evidence, it is relevant to mention that with adequate and stimulating educational spaces, learning can be facilitated. Therefore, in the present-day field of education, it is essential to discuss how the school environment of the future can overcome barriers evidenced by the pandemic. It is necessary to transform the school structure into functional, stimulating, accessible and democratic spaces that provide well-being and are adapted to the needs of users in the 21st Century.

3. TECHNOLOGY IN SCHOOLS

According to Mayes et al. (2015), exposure to technologies generally meets student's expectations, improves productivity, contributes to successful careers, and complements lifelong learning skills. However, Barrett et al. (2019) point out that, despite the moderate use of computer in the classroom to assist in learning, there are some adverse effects of the intense use of this type of equipment, as it modifies the engagement in the teacher-student relationship. This requires efforts, improvement and discussion among those involved in this process.

Globally, changes in education were needed in 2020, so that many children could continue their studies online, during the COVID-19 pandemic, with the help of technology in their homes. However, it was not an enriching experience for all students, since a large number of families, especially low-income ones, do not have adequate equipment or quality Internet access.

In addition to the difficulties faced by students, the COVID-19 pandemic has highlighted the challenge of teachers in adapting to e-learning. Cani et al. (2020) pointed out that, for many teachers, the art of reinventing themselves, restructuring their didactics to the new practices has not been an easy task. However, they emphasize that one of the positive aspects is that schools will never be the same since the concept of educational space within walls has been replaced by the idea of flexible and technological spaces (Cani et al., 2020).

For Sarmento et al. (2020), blended learning, with broad access to information, brings a profound change in the roles played by teachers and students. The knowledge domain relations in the classroom are modified, and in the same way, the configuration of learning environments needs to be reviewed and updated (Sarmento et al., 2020).

In order to guarantee learning environments aligned with blended learning, Sarmento et al. (2020) presented some technical specifications for public schools, attending to student-centred education. Among them, some specifications of constructive elements and systems are highlighted in Table 2.

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Table 2: Technical specifications for school environments aligned with blended learning.

Item	Technical specifications
Floor and walls	Anti-reflective, anti-glare, anti-glare and sound absorber coating; Low reflectance floor; Sidewalls to the slate are not parallel, with a minimum slope of 8%, and medium reflectance.
Windows	Located on the back wall for good view of green areas, and also to view the corridor; Sturdy windows with adjustable opening; Blackouts for projection activities; Adequate solar orientation, to avoid direct sunlight; Brise-soleils, by solar orientation; Sills height up to 1 meter from the finished floor, allowing ventilation at users' body height.
Doors	Adequate to accessibility standards; Door material in wood, iron, aluminium or PVC; Handles of comfortable grip and adequate height; Translucent display; Position mismatched doors, avoiding sound propagation; Open outwards from the environment.
Acoustic lining	Internal thermal resistance; Ceiling height suitable for reverb control.
Layout	Free space between 1-meter tables and chairs; Storage space; Free area next to the blackboard for circulation of the teacher; Flexible layout that allows different organizations.
Color	Prioritize students' visual comfort, avoid eye fatigue.
Living spaces	Shaded spaces for relaxation and contemplation of nature, with comfortable and varied furniture.
Bathrooms	Close to classrooms and with domestic configuration; If there are internal cabins, doors and rooms must be from floor to ceiling; Partition between female and male bathrooms, and minimum sizing of 1 toilet and one washbasin for every 20 students.
Energy and lighting	Arrangement of sockets allowing the connection of cell phone and laptop chargers to student desks; Installation of a baseboard that allows electrical wiring to pass and open new energy points; Lighting that alternates with daylight, without glare; Specific lighting for blackboard; On work desks, provide lamps, use direct light, and lamps with good colour reproduction; Control system for lighting levels; Automatic activation of luminaires in rows (parallel to the windows) to be activated, as natural light decreases its intensity; Locate switches close to workstations, as well as close to doors; General key that controls the total lighting of the room.
Internet	Technological resources control room for technical support to equipment and management—high-capacity Wi-Fi.
Learning Management and Sharing	Wi-Fi connection between the physical environment and online classroom environment, for sharing educational content.

Note: Adapted from Sarmento et al. (2020).

In addition to these factors, Sarmento et al. (2020) mention others that involve environmental comfort, fine furniture and equipment for educational and personal use.

Based on this, it can be said that the world, increasingly globalized, will create new opportunities for designers and architects to design and adapt to the necessary technological changes in the field of education, as in several other areas of knowledge.

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4. THE STANDARD PROJECT FNDE EDUCATIONAL SPACE PROGRAM - PEE-12 IN BRAZIL: STRATEGIES FOR ADAPTING TO THE POST-PANDEMIC MOMENT

Projeto Espaço Educativo 12 Salas – PEE-12 is a standard public school architectural project for elementary school, and is part of the Plan of Articulated Actions - PAR, a policy of the Brazilian government to support physical structuring, together with the National Development Fund of Education. The program seeks to encourage the school's physical infrastructure, through funds to build schools or purchase equipment. This architectural typology aims to serve 780 students in elementary school, in two shifts (FNDE, 2020).

There are currently 216 schools completed in this architectural typology in the country since 2013, in addition to others in progress, paralyzed or not yet started (BRAZIL, 2020).

PEE-12 presents, in the architectural party, independent blocks that are interconnected by covered external circulations, obeying the proposed sectorization. The standard school has two technological blocks, one with laboratories and student council, and the other with a library, teachers' room and auditorium; an administrative block; three educational blocks with traditional classrooms and bathrooms; a block with a covered patio and a kitchen; an uncovered patio, functioning as a living square; an indoor court and changing rooms. Figure 2 illustrates the school overview.

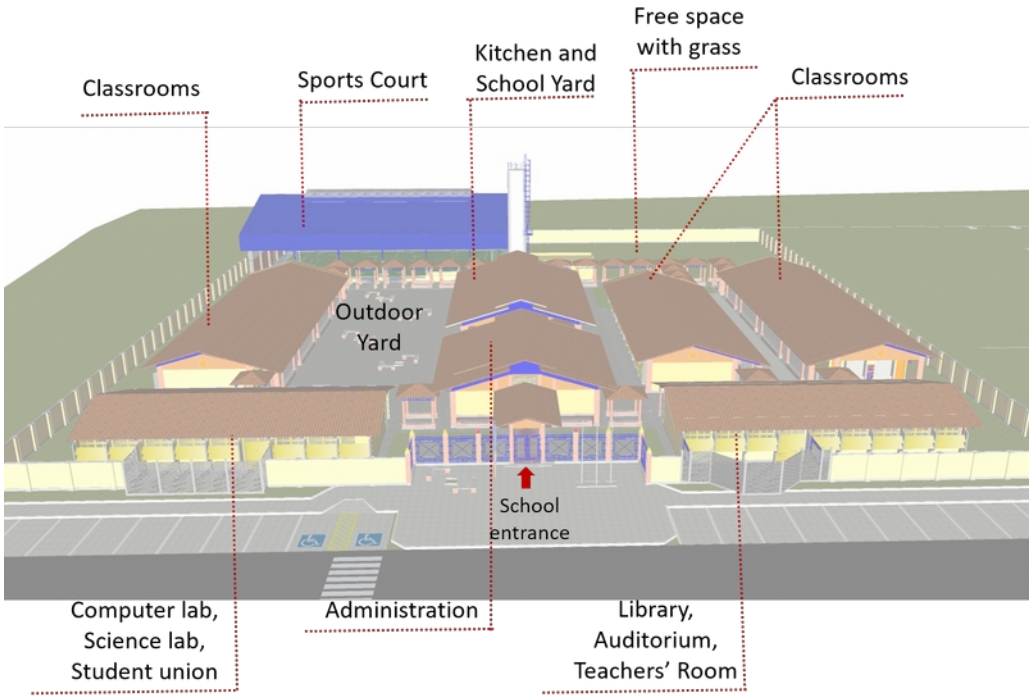

Figure 2. Layout of each block of the school's standard project (FNDE, 2020, adapted by authors).

As for the classrooms, all have the same architectural typology, with tall windows facing the internal circulation of the school, and larger windows facing the outside, in addition to two doors, also in the two walls of more significant extension, allowing cross ventilation (Figure 3).

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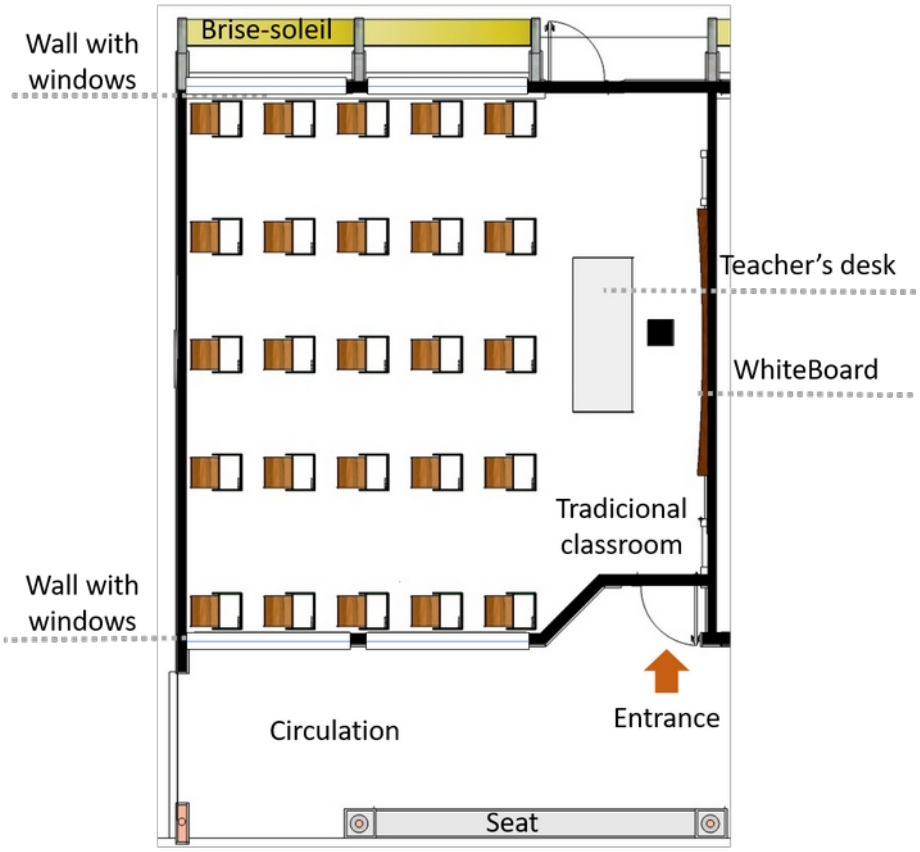

Figure 3. A floor plan of the classroom (FNDE, 2020, adapted by authors).

The standard typology of these schools is distributed in throughout most of Brazil, often disregarding the local, environmental and social context. In the current situation, with face-to-face classes paralyzed, it is essential to provide strategies for their return, with the necessary care to prevent the spread of the coronavirus and to promote safer school spaces.

Below, we systematize some short-term strategies for a safer adaptive architectural design in order to reinvent the school space in these primary education institutions.

4.1. Strategies for Adapting School Architectural Design

Considering the literature review presented in this article, some adaptation strategies have been proposed for resuming face-to-face classes in times of pandemic caused by Covid-19 for standard public education schools in Brazil, PEE-12 - FNDE. Intervention possibilities have been proposed within the limitations imposed by standard projects. It would not be feasible in this study to propose long term changes, because the objective here is to bring proposals for an urgent situation, returning to classes in face of the pandemic caused by the coronavirus.

These strategies are systematized in Table 3, based on some design patterns for 21st-century schools according to Nair et al. (2013), in Byers et al. (2018) research on innovative learning environments, in Sarmento et al. research (2020), with strategies aligned with blended learning, in the hybrid approach of Sheikh et al. (2020), and the strategies of Fantini et al. (2020).

As for the design parameters of Nair et al (2013), Table 1: # 1, # 4, # 8, # 11, # 12, # 13, # 17 and # 20 were selected. They are justified because the school under analysis offers some

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opportunities for adaptation, regarding the recommendations present in these parameters. Also, design patterns were selected that meet pandemic adaptation strategies.

Table 3: Strategies for the adaptive design of schools PEE-12 faced with the COVID-19 pandemic.

Item	Technical specifications
Class Format	• In-person and online, giving priority to hybrid teaching, and familiarizing students with this new teaching modality. • Access to content remotely through a digital platform and monitoring the student's progress. • Face-to-face classes should be broadcast live for those who have the opportunity to study at home, or for those who have a disease and are at risk. • Divide students into different shifts to reduce the number of people in the classroom. • Take advantage of open spaces for outdoor classes, in nature, within the possibilities of each region. Figure 4 illustrates some environments that can be used for these classes.
Classrooms, Learning Studios, Advisories and Small Learning Communities	• Independent study, during the pandemic. • Small groups of students, with reduced class density. • Learning based on mobile technology (laptops, smartphones). • Distance of 2 meters between chairs, mainly in the post-pandemic moment, to avoid contact, considering the available physical space, as shown in Figure 5. • The furniture must be accessible and flexible. • Classrooms with polycentric layout, combining the use of digital technologies, considering the available physical space.
Sanitation	• Guide students to avoid sharing materials; Information boards. • Ensure frequent access to hand washing, and if possible, relocate washbasins close to each classroom. • Provide hand sanitizer for cleaning in all classrooms, laboratories, library. • Ensure periodic cleaning in all school environments, including furniture. • Coatings that are difficult to clean and maintain must be changed. • Place sanitary mats for cleaning shoes when accessing the school. • Use of masks to prevent droplet transmission, until health agencies and public authorities consider it relevant.
Home Base and Individual Storage	• Ensure a larger and individualized space for each student to store their material, such as individual lockers, with a key.
Casual Eating Areas	• Provide snacks and meals in smaller “cafes”, for access to students during school hours. This parameter suggests more intimate locations than the cafeteria, and external areas can be used to place furniture, suitable for external conditions and comfortable.
Ventilation	• Classrooms must allow cross ventilation for cleaning, by opening the windows on the sidewalls of the blackboard.
Indoor/Outdoor Connection	• Allow more generous access to external areas and contact with nature. • Views from inside the rooms to green areas would be impressive. Direct physical connections.
Dispersed Technology	• High-speed internet access in all school environments, including hallways, yard and common areas, for students and teachers to use for educational content. The Wi-Fi network could even be accessible to students who do not have internet at home, in case of future pandemics, to access the school's educational content.
Furtinure: soft seating	• Provide comfortable and upholstered chairs in easy to clean material. • Enable diversity of furniture, with colours that avoid fatigue and stimulate concentration.
Cave Space	• Adapt individual spaces for reflection and study, with adequate furniture. Spaces outside the school in the middle of nature can be used.
Equipment	• Devices such as laptops, computers or tablets available to students. • Installation of projectors and digital whiteboard. • Blackouts or blinds on the windows, for activities that involve the use of a projector, avoiding reflection or glare. • Provide suitable quality printers and computers.
Electrical installations	• Installation of a more significant number of sockets, close to students' desks, the teacher's desk, and doors, allowing the charging of laptops, tablets or smartphones.
Teacher training	• Create public policies that offer training and courses to teachers, especially concerning e-learning and digital educational tools.
Technical support team	• Ensure adequate technical support for technological equipment and Wi-Fi network.

Figure 4 shows open spaces present in standard PEE-12 schools that can be used for outdoor classes, depending on the local context, climate and conditions that allow this teaching methodology.

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Figure 4. External spaces of the standard school for outdoor classes (FNDE, 2020, adapted by authors).

Figure 5 illustrates an adaptation of the PEE-12 school project classroom layout to the polycentric layout, with access to technology, digital whiteboard for activities with a projector, connection between indoor and outdoor, view of nature, ventilation, cabinets with keys, in addition to cleaning with hand sanitizer when accessing the classroom when it is not possible to install nearby washbasins.

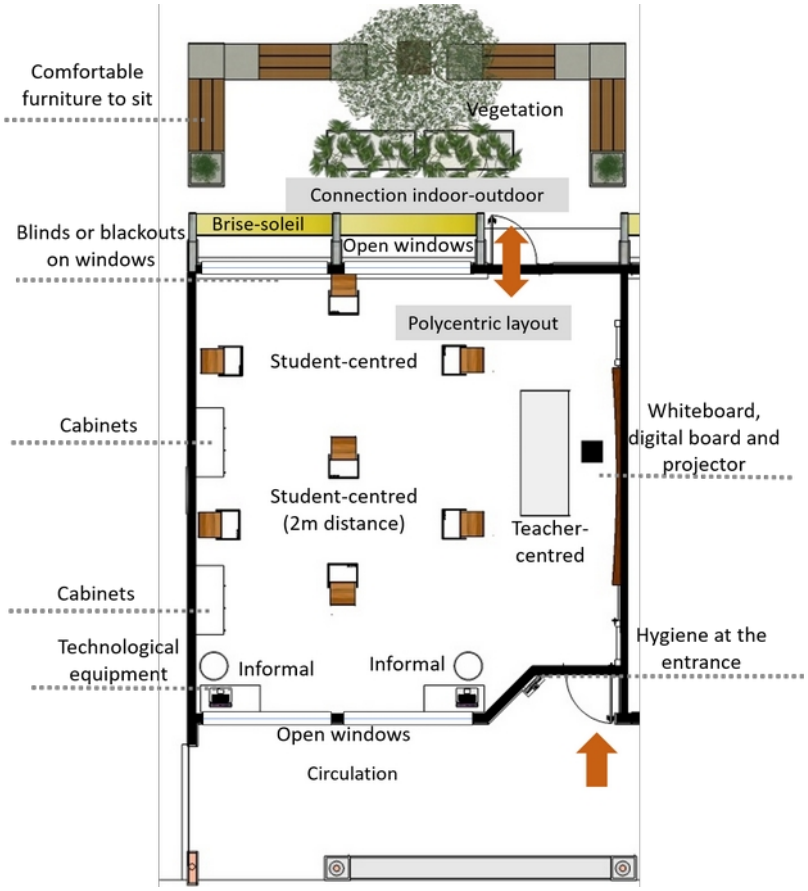

Figure 5. Adapted classroom layout (FNDE, 2020, adapted by authors).

Figure 6 shows design studies for “cave space”, using wood, vegetation, good lighting, available technology and comfortable furniture for study, and casual eating areas, with tables, chairs and sofas for students to use, proposing an environment that functions as an "outdoor cafe" at school.

Figure 6. Design studies for 21st-century schools (FNDE, 2020, adapted by authors).

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Adapting to the new post-pandemic reality is a significant challenge in all countries, especially for low-income populations, since many of the strategies mentioned involve economic factors, in addition to cultural and social aspects rooted in society. However, the discussion present in this study brings to light the need to remodel the design for education as a whole. In this context, architects, urban planners, designers, the community and policymakers must be attentive to the users' needs and desires, combining design in a creative, welcoming and safe way.

5. CONCLUSIONS

Currently, there are several debates about the reflection of the COVID-19 pandemic in education, and the answers are not yet concrete. In this context, the article sought to discuss the need to rethink the standard FNDE school projects, and propose new solutions to a social problem, through adaptive design strategies of the school environment for the post-pandemic moment. It is possible that the design parameters for 21st Century schools, combined with concepts such as innovative learning environments, hybrid teaching and the inclusion of technologies can enable healthier educational spaces that promote well-being.

Such adaptation strategies could be implemented when health authorities and agencies allow the resumption of face-to-face classes. However, they must, first of all, prioritize the health of the occupants.

It is remarkable how COVID-19 demonstrated the importance of the design response to the user's well-being, which ranges from simple tasks such as installing information signs to more complex changes. In the study of the school project in this article, among several other points, some possible strategies to be applied are: layouts that allow the focus on the student while maintaining social distance, adequate ventilation, quality internet access, individual study spaces, connection between interior and outside, technological equipment available to students and comfortable and diverse furniture.

It is difficult to say that with these re-design proposals applied, education responses to the pandemic will be resolved. However, the results of this article provide an opportunity for reflection and change. They can assist in the search for solutions to social, environmental, and public health problems within the school space, assisting public agencies, architects and designers.

Bearing in mind that design is inherent in the process of designing project systems, the design strategies of this research can be useful in planning future school architectural projects. It is necessary to adapt these traditionally built schools and recreate new schools aligned to the 21st Century that are resilient, safe and flexible.

Future research may include scenarios for other school buildings of different architectural types. Besides, the possibilities presented here could be applied in order to evaluate the results and their feasibility. Also, since the field of design comprises a multifaceted area, this research opens the way for ongoing studies related to school design adapted to social changes, for researchers from different areas of knowledge.

Finally, it is expected that this situation, in the field of education, caused by the Covid-19 pandemic, will become, in the future, an overall learning process. For now, it is necessary to build tools to face this challenge and reinvent the school space every day. Only then, and reassessing the decisions made now, can this situation be experienced in the future.

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