Classroom concept as a response to the COVID-19 pandemic: An antivirus built-environment approach

F X T B Samodra*, B P N Harahap
Department of Architecture, Institut Teknologi Sepuluh Nopember, Kampus ITS, Sukolilo, Surabaya, 60111, Indonesia

*Email: fxteddybs@arch.its.ac.id

Abstract. This discussion is based on the COVID-19 pandemic, which causes children to be vulnerable to infection due to their still-developing organs and immune system. The nature of the virus to thrive in the environment encourages the existence of variants of the virus, making vaccines the only way to stop the virus from spreading internally. Based on the latest research by WHO, a new virus variant has been found with the potential for transmission and effects that are more severe than the previous virus. The COVID-19 pandemic has had an impact on changing educational activities to distance through the use of technology. Children are at a golden phase to learn and get to know something that tends to be through direct interaction. However, this is less effective because of children who need to be supervised and tend to be given natural environment and the children's homes' different psychological conditions and conditions. This study aims to analyze the concept of an excellent class to minimize the risk of spreading COVID-19 and other virus variants in the future so that it is safe for the health of users, namely children. It conducts a concept-based framework with an antivirus built-environment approach supported with simulation, literature and precedent review. In the discussion, the concept of an antivirus built-environment class is supported by an understanding of biophilic built-environment, especially biomimetics and direct use of nature, as well as the existence of spatial shift standards due to the risk of spread, government regulations on learning systems, healthy space and climate conditions in Indonesia. Biomimetics translates the character and work system of viruses biologically with the help of antivirus software tools because of the similarities in their properties. Antivirus built-environment on the class concept is realized in the form of scanning incoming users with the help of technology and room protection. The application of this concept, when discovered, is expected to prevent the accumulation of users from minimizing interactions that are at risk of spreading the virus, nourish users with the help of nature, and provide a place for children's learning activities.

1. Introduction
Corona Virus Disease 2019 (COVID-19) is one of the acute respiratory infections (ARI) caused by SARS-CoV-2 and declared a pandemic in early 2020. Though the pandemic will not last forever, the virus will be in nature for a long time due to the dynamic nature of the virus to survive in the wilderness therefore virus mutations will occur continuously if the potential for transmission is available [1]. Until June 2021, three new variants have been discovered by the World Health Organization (WHO) and circulated in Indonesia, which are alpha (B.1.17), beta (B.1.351), and delta (B.1617.2). The new variants have faster infectious properties causing clusters in a short time, allowing them to escape diagnostics,
causing more severe clinical symptoms and lead to more rapid death [2]. Based on COVID-19 distribution data in Indonesia as of June 17, 2021, there has been a significant increase in cases in several regions and children.

The COVID-19 vaccine, which was discovered in early 2021, is still considered effective against existing mutations and will continue to be developed to respond to mutation developments [3]. The vaccine is currently in the deployment stage for adults and the elderly. At the same time, children are expected to be found at the end of the year due to differences in the anatomy organs of children and adult so that different drug compositions are needed [3]. The current viral mutation has receptors that cause children to be as vulnerable as adults. Although it has not been officially proven, preliminary analyzes of how and where the new variant spreads have a higher tendency to infect children [4]. Children's organs that are still in the developmental stage make children prone to coinfection, which is when the body is infected by more than one disease simultaneously [5]. This risk has an impact on the inhibition of teaching and learning activities for early childhood in the classroom, where at that age, children learn the world and develop skills with direct interaction and communication through sensory and motor activities with peers and adults [6]. This study evaluates children's movements tend to be influenced by objects, living things, and natural surroundings. The abilities and experiences of children who the environment and people around them influence cause direct physical interaction and contact, which sometimes without adult supervision makes children unknowingly infected and transmit the virus by and to their peers [6]. With new virus variants and vaccines being developed, it is unlikely for people to return to completely normal life. Therefore, health protocols and the new normal system will continue to be implemented.

2. Methods

The Concept-based framework is used to describe the flow of thinking with several other methods towards the design concept [7]. The design hypothesis was motivated by the COVID-19 pandemic in Indonesia and the future risk of different viral variants that threaten children. Concept-based methods in a top-down manner provide freedom in determining the concepts used. Figure 1 shows the flow of design concept thinking based on a concept-based framework.

![Concept-based framework as a design methodology adapted from Plowright (2014).](image)

In this design, antivirus built-environment is applied as an approach and design concept. According to Ahlefedt and Novakovic, antivirus built-environment has four approaches, which are urban,
architectural, digital transformation, and construction structures. In this design, an architectural approach is used to focus on refocusing green spaces. These points talk about how built-environment can be greener and more sustainable. From this point, biophilic design was chosen because its purpose is to promote the physical and psychological health of the user. From fourteen descriptions of biophilic design, biomimetic and visual connection with nature are used in designing the classroom concept. In this design, biomimetic utilizes biological viruses which has similar properties with antivirus software as a reference in designing to be translated into the built-environment. In the application of the biomimetic method into the design, antivirus software is used as a tool.

On the designing process, the causes and effects of COVID-19 transmissions and its impact on built-environment are understood through precedent and literature review. The literature review used are about the pandemic and its architectural responses, antivirus software which will be translated into built-environment, government policies in education, the context of regulation of space standards before and after the pandemic, and healthy area provisions to determine design’s decisions. In addition, data distribution of COVID-19 in the Indonesian context makes the tropical climate an element of consideration in the design.

The precedents selection for precedent review is those that discuss related to social and physical distancing. Based on consideration virus transmission through the air, changes in space and layout, integration of outdoor and indoor spaces to encourage natural ventilation, touchless technologies and antimicrobial materials, and transitional area for user's movements for safety and security.

3. Results and discussion

3.1. Rethinking built-environment due to pandemic

Social and physical distancing policy by the government due to minimizing the virus transmission prompts people to realize that the current built-environment is neither designed nor built to effectively respond to the pandemic's causation. Although a pandemic will not last forever, predicting when a pandemic will end is difficult, as it is filled with constantly changing variables. Judging from the experience of previous pandemics, the duration of the pandemic is inconsistent so that the human response to learn from experience will form a better-built-environment in the future. Therefore the built-environment is expected to act as resilience to help humans adapt to existing situations and conditions to continue human existence.

| Approach            | Attribute                                                                 |
|---------------------|---------------------------------------------------------------------------|
| Urban               | Develop an area horizontally to avoid overcrowding, encourage urban farming and more urban facilities. |
| Built-environment   | Green and sustainable concepts, the use of environmental components for human and building needs. |
| Construction strategy | The use of modular construction and lightweight materials to speed the construction process encourages adaptive reuse to respond to human needs and hygienic materials. |
| Digital transformation | The use of technology to maintain human safety in buildings and facilitate technology for remote activities. |

The design concept focuses on the architectural aspect, especially green and sustainable, with the help of biophilic design. Biophilic design has 14 points which are described in Table 2. Of the fourteen points, biomimetics are blend with visual connection with nature. Biomimetics is a term to study the
best ideas and processes in nature and imitate the design of these ideas and strategies to solve human problems. In this case, biomimetics utilizes nature as a reference by imitating aspects of organisms or living things in nature and applying them to design a building.

Table 2. Categories of experiencing nature in the built-environment.

| Categories                  | Attribute                                                                 |
|-----------------------------|---------------------------------------------------------------------------|
| Direct experience of nature | Light, air, water, plants, animals, natural landscapes and ecosystems,    |
|                             | weather, fire                                                             |
| Indirect experience of      | Images of nature, natural materials, natural colors, simulating natural   |
| nature                      | light and air, naturalistic shapes and forms, evoking nature, information  |
|                             | richness age, change and patina of time, natural geometries, biomimicry   |
| Experience of space         | Prospect and refuge, organized complexity, integration of parts to the     |
| and place                   | whole, transitional spaces, mobility and wayfinding, cultural and          |
|                             | ecological attachment to place                                            |

3.2. Application of biomimetic method: translation of antivirus software to built-environment

Antivirus built-environment adopts the word 'antivirus' on computers to protect users in the built-environment. The computer antivirus itself is a term inspired by biological viruses in humans which encourage antivirals or antibiotics because of the identical principle, character, and properties [9]. Subsequently, the concept is adopted into the built-environment to control unwanted aspects from the outside (the environment) to the inside (built-environment) to maintain user safety. The translation of antivirus software into the architectural domain is shown in Figure 2.

Figure 2. Antivirus software's principle translated to built-environment.

3.3. Precedent review

The following is a collection of precedents responding to the aftermath of the pandemic shown in Table 2. Unlike the initial study related to the changing environment adaptation [10], the pandemic idea encourages the physical distancing and technological integration investigation.

Table 3. Precedent review regarding the pandemic.

| Precedent          | Attribute                                                                 |
|--------------------|---------------------------------------------------------------------------|
| CLTH (2020)        | Lightweight material,                                                     |
| Rios (2020)        | Refocusing green spaces, better air quality, integrating                  |
| AIA Architect. (2020)| Arrangement of layout and                                                 |
expanding horizontally, layout, cleaning area | outdoor and indoor spaces | transition space for testing and cleaning area

| Touchless Technologies and Antimicrobial material | Mobile built-environment, self-sufficient and modular construction | Layered protection before entering activity area |

3.4. Classroom design concept

3.4.1. Classroom and site layout. The classroom concept begins from a basic form, where experiments are carried out on depth and connectivity in several masses with depth map shown in Figure 3. In addition to the space syntax and environmental aspect approaches to previous findings [11], the square and rectangular shapes are selected based on typical classroom layouts in general, while circular and hexagonal shapes are chosen based on the shape of the virus head biologically. The bluer the area shown, the lower the connectivity and density in the mass, while the redder means the higher it is. Based on these experiments, the hexagonal shapes are areas with low connectivity to minimize interaction and density in the room. In addition to connectivity, the effectiveness of people's movement and shape structuring was tested to see if the shape was appropriate (Figure 4). Measurement of space effectiveness is done by making a circle with a radius of 1 meter and arranged consistently on the mass. The radius of 1 meter is used to respond to the provisions of physical distancing and social distancing set by WHO.

![Connectivity simulation with depth map on several masses.](image)

![Effectivity simulation with sketch up on several masses.](image)

Classroom arrangement is constructed through depth map simulation with a square shape for experimentation (Figure 5). Based on the simulation, the alternating space arrangement has the lowest connectivity. This arrangement will form an irregular shape that can respond to the wind spreading in all directions for natural ventilation and increase the opportunity for sunlight to enter to improve the
user's immune system. In addition, the open space as a result of the arrangement can be used to create visual connection points with nature by planting vegetation.

![Figure 5. Classroom arrangement with depth map simulation.](image)

3.4.2. Classroom circulation. The circulation of the human movement into space is adjusted by the antivirus software system when entering an object shown in Figure 6. At the entrance area; the subject will be intercepted for a body temperature check. If the temperature doesn't meet the standard, the subject will be asked to leave the room and directed to the health area. There should be two doors in the room to distinguish the entrance and exit. One door is facing the indoor area while the other is in the outdoor space. The updating system of the software means using UV light when the classroom is finished. Other than that, updating the system is presented through the use of modular or non-fixed structures and constructions to allow for changes in the area in the future. The concept of free learning, the risk of spreading the virus, and the unlimited teaching and learning activities for children, can encourage screen board facilities for remote online meetings for those who cannot attend in person or are sick but still want to learn. An overview of the arrangement of the classroom on-site and circulation is depicted in Figure 7.

![Figure 6. Classroom's circulation stage](image)

3.4.3. Classroom details. Details in the Classroom are based on the idea of a healthy room on how architectural infection prevention and control can be carried out as stipulated in the Regulation of the Minister of Health of the Republic of Indonesia Number 27 of 2017 concerning Guidelines for Infection Prevention and Control in Health Care Facilities in chapter 2 Number 4 on environmental control and based on learning policies in Indonesia due to the pandemic, namely an emergent curriculum that encourages more flexible learning concepts in terms of space, assessment and teaching methods. The concept of learning encourages more relaxed teaching and learning activities both inside and outside the Classroom. Virus transmission through water and air droplets enables a spatial shift in spaces that are used communally. Each room will be given an additional area as a transition area before entering the activity room. Suppose the standard of space circulation is 30%. In this case, there will be an additional
45% of classroom space due to static movement in the room and the provision of a courtyard area to integrate indoor and outdoor learning activities. In addition, to reduce the interaction and accumulation of students in the room, the government set a policy to reduce the number of students in one class from 40 to 20 students.

Designs on sites with tropical climates can be used for user health. The sun has excellent benefits for increasing immunity. The presence of a garden between classrooms can encourage the integration of indoor and outdoor activities in the morning so users can sunbathe with large windows to let light and breeze in and let sunlight into the room to kill viruses. In this case, the louver window or sloping window is an attractive window to respond to sunlight in the morning and evening. Changes in temperature and humidity at any time in a tropical climate make ventilation one of the primary considerations to minimize the risk of spreading the virus and multiplying the virus in the room. Based on the previously mentioned healthy room regulations, classrooms utilize hybrid ventilation, a combination of plasmacluster AC with a purifier to filter air pollutants that enter the room, a humidifier to humidify the air, and natural ventilation for dynamic airflow. The entrance to the Classroom is equipped with a testing area in the form of thermal, people counting, and mask detection CCTV, while the cleaning area is equipped with a hand washing area or hand sanitizer, distribution of changing masks, and a disinfectant room. The updating or cleaning stage after class is used to take advantage of UV light technology to kill viruses in the room and use gypsum material for the walls between the two rooms to make it flexible when a larger space is needed in the room future. For the surface layer, the walls can use antimicrobial paint with pastel or natural colors to create a calming impression during the use of vinyl for flooring. This is where the corner of the wall and floor is curved for easy cleaning. Items such as doors, windows, and light switches can be facilitated with hands-free handles to avoid the indirect spread of the virus. The classroom structure utilizes a hexagonal column-beam modular structure with a column in the middle of the room. This column can be used to place a recording camera for students who cannot participate in live learning activities to support an empty area on the wall that is used as a screen for the remote. The Classroom's detailed concept overview is shown in Figure 8, whereas the UV light for cleaning and gypsum board material for the classroom’s wall as a part of updating the implementation is shown in Figure 9.

![Figure 8. Classroom’s concept.](image)
4. Conclusions
The concept of classrooms for children will change in the future as an anticipatory response to COVID-19 transmissions and the risk of other viral variants even though the vaccine has been given. Although distance learning activities can be carried out, face-to-face activities still need to be carried out if you see the character of education and child development at an early age. The concept of the learning area is described with a concept-based framework, making the antivirus built-environment an approach and concept. Antivirus built-environment is focused in terms of architecture, especially green and sustainable design, with biophilic as the main key. Biomimetic adopt viruses biologically with antivirus software as a tool. The first stage focused on health and protection scanning with technology, while the protection stage focuses on the shape responding to light and wind, the use of technology to respond to local climatic conditions, and for cleanliness and spatial shift due to changes in existing standards. The visual connection with nature is presented to protect the user from the outside, such as filtering air and light and providing a psychological effect with the presence of nature in the middle of the built-environment. Thus, this paper can be more comprehensive so that it can be applied in the future. The entrance to the classroom is equipped with a testing area in the form of thermal, people counting, and mask detection CCTV. In contrast, the cleaning area is fitted with a handwashing area or hand sanitizer, distribution of changing masks, and a disinfectant room.

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