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# Designing a Science and Technology Education Center with a Smart Building Approach in Pekanbaru

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A B S T R A C T

Science and technology are the main pillars of the country's progress. The development of science and technology is the key to achieving the vision of Advanced Indonesia 2045. Challenges such as the digital divide, data protection, cybersecurity, and technological innovation are still key challenges. The Riau Science Center in Pekanbaru is not yet able to be a technological representation of inadequate buildings and inadequate facilities. Therefore, innovative facilities such as the Science and Technology Education Center designed using a smart building approach are needed. This approach leverages advanced technology for energy efficiency, comfort, and building function. This study applies case study methods and combined strategies. The facility will be equipped with props, exhibits, and science-technology displays to create a progressive learning experience. The design of this building adopts the concept of "Science-Tech Evolution" which combines theory, experiments, and applications in a balanced triangular design.

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## INTRODUCTION

Science and technology are two things that cannot be separated. In practice, science automatically produces what is known as technology. Science is theoretical and intangible, while technology is practical and tangible. In essence, science is studied to develop and strengthen human existence on earth. Technology was created to alleviate and free humans from various difficulties in life. Science and technology are two fields of study that must be understood to achieve quality human energy sources. A country needs science and technology to be able to compete with other countries because research and development in the field of science and technology can be the key for a country to grow into a developed country. One of the pillars of Indonesia's 2045 vision is to become a developed country, namely carrying out human development and mastery of science and technology (Astuti & Rahindra, 2022).

Indonesia's technology issues bring unique challenges as well as opportunities for significant growth. With a soaring population and a rapidly growing economy, Indonesia is faced with complex issues, such as the digital divide, data privacy protection, cybersecurity, technological innovation, technology education, and the government's digital transformation. In facing these challenges, efforts to strengthen technology infrastructure, improve digital literacy, and support the startup ecosystem are very important. Active participation from various sectors, including government, the private sector, academic institutions, and society, is indispensable to address these technological challenges. By making the right investments and establishing solid cooperation among all relevant parties, Indonesia has enormous potential to emerge as a competitive developed country in the ever-growing digital era.

In achieving the state's goals in the science and technology development sector, each region in Indonesia has a government forum that is tasked with formulating local government policies in the field of research and development in the region (BALITBANG), one of which is Riau Province. To realize this task, the Riau Provincial Research and Development Agency has a strategy designed to realize this task, including: Increasing the application of Science and Technology (IPTEK) in development, electronic media exhibitions, and print media. Improving the quality of research and development of science and technology in the fields of Natural Resource Economics and socio-cultural and strategic issues. One of the implementations of the strategy adopted by the Riau Province Research and Development Agency (BALITBANG) is the establishment of the Riau Province Science Techno Park (STP) (Amriani & Prihatin, 2019).

Pekanbaru as the capital of Riau Province is required to have similar services through the Riau Science Center contained in the regulations of the Riau Governor Regulation Number 21 of 2020. The Riau Science Center functions as a learning facility that aims to increase the understanding of the public, especially the younger generation, about the significance of science and technology. However, the Riau Science Center is still located on the first floor of the Riau Information Communication and Statistics Office building. The facilities available are still minimal, inadequate, and obsolete in the era of

modern technology. Meanwhile, suboptimal space zoning shows a lack of attention to effective interior design. Limited space also poses obstacles to providing an adequate experience for visitors. In addition, the suboptimal air circulation and lighting system also reduce the comfort and functional value of the building. With these conditions, the Riau Science Center has not reached the standard of being a modern science center and does not reflect the ideal smart building concept in the use of technology.

In Pekanbaru, several activities have been held with the theme of science and technology which aims to increase public understanding and appreciation of science and technology. Some of them include the National Technology Awakening Exhibition (National Technology Awakening Day) which was held in 2018 at the Riau Province governor's complex, the Sumatra STEAM Cup event as a robotics competition event that took place in 2022 at the Pekanbaru Exchange Building, and the Science Olympiad Expo competition held at FKIP University of Riau, where this activity is held once a year. However, although these activities are a positive first step in educating the public about science and technology, there is no sustainable or comprehensively integrated program to develop public interest and understanding of science and technology. There needs to be further efforts to create sustainable programs to improve science and technology literacy among the people of Pekanbaru and have a greater impact in encouraging progress in the field of science and technology in the area.

Based on the problems described above, it can be concluded that Riau Province needs a forum to learn or develop one's potential for science and technology, namely the Science and Technology Education Center which pays attention to the level of comfort and well-organized spatial arrangement. Providing adequate facilities, optimizing space zoning, and improving the air circulation and lighting system, without reducing the attractiveness of the building. The Science and Technology Education Center is a non-formal educational facility that functions as an educational forum and educational tourist destination that focuses on Science and Technology and is filled with various Science and Technology props. It also has a replica exhibition of science discoveries, workshops to gain knowledge by encouraging direct involvement, collaboration, and skill development, a photography gallery with Science and Technology Information, a café with a Science and Technology theme, and a retailer that sells Science and Technology accessories. This place is interesting for visitors of all ages to visit because it is entertaining and informative. Visitors can also add insights from various Science and Technology demonstrations so that visitors' perception of Science and Technology becomes more positive.

To realize this, an approach is needed that can be in line with the demands of the increasingly advanced development of Science and Technology, and also an approach that can express Science and Technology that leads to the development of the future era that can be felt through the understanding of science and its application in daily life. So the right design approach is assumed to be a smart building approach. Casey (2013) describes building strategies to achieve substantial energy savings by utilizing advantages in the development

of materials and technologies in various aspects such as structures, equipment, electrical systems, plumbing, heating, ventilation, air conditioning, and cooling systems. Smart Building itself has several principles, namely efficiency, effectiveness, convenience, and the application of new technology (Mannan & Muchlis, 2012). These principles were chosen as the design solution for the Science and Technology Education Center.

## THEORETICAL REVIEW

Education centers are education and training centers that aim to provide new knowledge, events, and experiences that can be used to develop one's abilities and potential. Science centers have an important role in providing scientific understanding to visitors through exhibitions and interactive activities (Friedman, 2000). Multimedia performances, innovative exhibitions, and practical experiments, science centers create opportunities for individuals to develop their creativity and understand the role of science in innovation (Bevan, 2011). The main goal of the Science and Technology Education Center is to provide a variety of learning resources that meet the needs of individuals and communities in the city of Pekanbaru and its surroundings.

One of the main functions of this building is displays, workshops, auditoriums, and classrooms. According to Junaedi & Cholisana (2021), a display is a tool to provide information to operators or humans at work to create an environment where an operator can understand information and convey it by seeing and can also facilitate his work. So that there is a realization of information that develops in the company so that regulation or information is created in the form of a display. This display is an environment that communicates its state to humans (Sutalaksana et al., 2006). An auditorium is a large space that can be used for various activities, including public meetings and performances (Medeastika, 2005). The main focus of this teaching room is on the aspects of the phenomenon described by the props, with more emphasis on direct experience than on their historical value.

Supporting functions in this building include a library, cafeteria, retail, playground, and management room. Tunardi (2018) said that libraries are defined as information warehouses, education centers, research places, preservation of the nation's cultural wealth, and healthy, affordable, and useful tourist destinations. Marsum (2005) argues that a café is defined as a place that serves fast food with a relaxed or informal atmosphere. Children's play facilities need to provide what children need because play is a social experience where they learn to understand the consequences of their behavior. Neufert (2000) said that the requirements of children's play facilities are safe from traffic, no pollution, sufficient sunlight, easy to reach, and the water level is not too high.

A smart building is a structure that adopts an automated process in managing building operations, including heating, ventilation, and other systems that support various activities in it. Remote control systems, computer-based, and microcontrollers can automatically control various equipment within the building, creating an intelligent and responsive environment. Smart building is an effort to create energy-efficient buildings. The main focus is on

the use of energy for various activities in the building, including HVAC (Heating, ventilation, and Air Conditioning) systems, to reduce energy consumption in the building.

According to (Mannan & Muchlis, 2012) the basic principles of Smart Building are:

a. Efficiency
   One of the benchmarks for success in implementing a smart building approach is if the building is efficient in its management.
b. Effective
   The effective principle in smart building means the application of appropriate technology, where the tools or materials chosen are following what is needed. Philosophically, this means the accuracy of the answers given to the problems at hand.
c. Easy
   Ease in this case means easy to operate, easy to maintain, and existing systems are easy to replicate and develop elsewhere.
d. The application of the latest technology
   The application of this principle is in the search for useful technological innovations in building into an integrated basar system. Hardcastle (2013), teknologi bangunan pintar dapat meningkatkan efisiensi operasional, menghemat air dan energi, serta mengurangi emisi gas rumah kaca (CO2).

Wong and Wang (2005) argue that a building with the concept of smart building must meet three main requirements, including:

1. The building must have the latest automation system to monitor various kinds of facilities needed by the building, such as air conditioning, ventilation, lighting, fire safety, and so on, to create a comfortable and safe environment for users.
2. The building must have a good network infrastructure between the floors of the building so that the data flow can be streamed smoothly.
3. The building must provide adequate telecommunication facilities.

Based on the above requirements, several characteristics of the application of the smart building concept in buildings appear as follows (Handri et al., 2021):

1. Access control system This system plays an important role in building security. The basic form is the use of an ID card to enter a room or building that can be used in areas where access is restricted, such as parking gates and elevators.
2. Video surveillance system (Video Surveillance System).
3. Video surveillance system is more often called CCTV (Closed Circuit Television) system. This system is part of the security and safety planning of a building, security and safety planning includes physical and operational aspects.

4. Electrical System
   Electrical systems are sensors used to facilitate building performance for the convenience of building users and the use of wireless network systems.
5. Transportation System
6. The transportation system in smart buildings is the allocation of elevators that are not far from the top to the basement, but there is a division with certain distances to streamline elevator work and waiting time. As well as the use of sensors on escalators when no one is using them will slow down and reduce electricity use.
7. Communication Systems Communication systems in smart buildings use alarms that ring in emergencies, information through speakers throughout the building, and the use of wireless internet networks that connect to each user in the building.
8. Security and fire systems
   Security and fire systems in smart buildings include heat and smoke sensors caused by fire for anticipated fire extinguishing the spread of fires with sprinklers throughout the interior building.

## METHODOLOGY

The Design Method at the Science and Technology Education Center with a Smart Building approach uses Case Studies and Combine Strategies methods. Case Studies are research for designing through the deepening of certain cases or complex events in a real context. This method involves collecting detailed data from various sources to understand, analyze, and provide an in-depth interpretation of the case being studied to gain a more comprehensive understanding of the phenomenon being studied. (Tashakkori, A., & Teddlie, C. Eds.. 2010). This method is a design method that is part of the qualitative research method which begins by identifying problems followed by analyzing according to the facts and theme of the design.

## RESULTS AND DISCUSSION

### *Design Project Location*

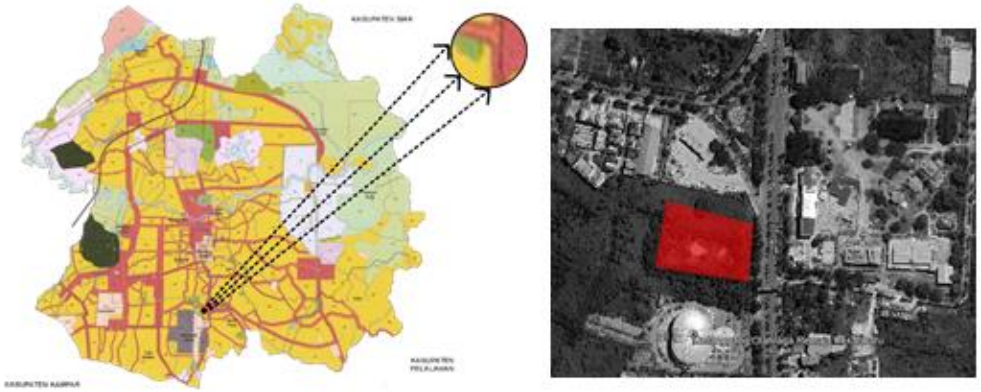

Figure 1. Site Design Project Location

The location of the design site is on Jl. Jenderal Sudirman, East Sidomulyo Village, Marpoyan Damai District, Pekanbaru City, Riau Province. The design location of the Science and Technology Education Center is located in the southern part of Pekanbaru City, with a distance of 5.6 km or 9 minutes from the city center. Based on land use, the location of the chosen site is in an area with the functions of a trade and service area, office, and education. Where the location of the site is located in the office zone which is marked with a red zone.

***Project Design Analysis***

The analysis of sunlight on the site gets good sunlight because the area is still minimal in tall buildings and on compact land. The existing buildings around the area are located to the north and south which are mostly residents' houses, so that sunlight will not be blocked from entering the site. Based on the analysis of the sun on the site, the orientation of the building facing the arterial road or east of the site is used to optimize natural lighting in the morning while minimizing excessive heat during the day.

The use of glass technology such as low emissivity and energy-saving E-glass allows control of incoming light and heat, creating a bright and comfortable environment. With the abundant potential of sunlight, it is utilized to the maximum through the installation of solar panels with photovoltaic cells as a sustainable source of renewable energy. Skylights with photovoltaic glass materials are strategically placed in public areas to support natural lighting while affirming the commitment to energy efficiency and sustainability. On the side of the building that is susceptible to heat radiation, the use of double facades with kinetic façade technology is designed to maintain a balance between natural lighting and protection from the sun's heat.

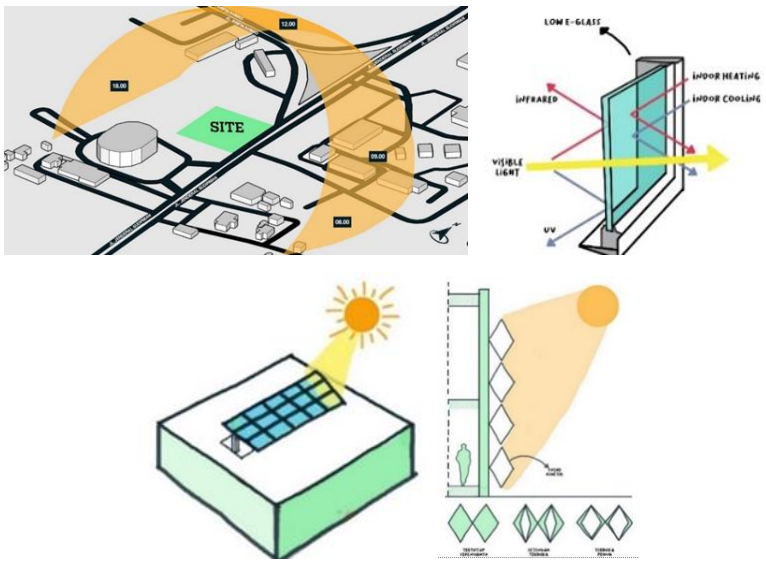


Figure 2. Building Lighting Analysis and Plan

The site is located in an area with heavy traffic, the air entering the site from the south tends to be contaminated by pollution and dust. To overcome

this problem, the Smart Building approach will be applied by presenting effective solutions. One solution is to install pollution and dust filtering systems on the south and east sides of the site. The system is equipped with vegetation that can filter dirty air before entering the site or building. In addition, an artificial pond will be added to increase the efficiency of dust and pollution filtration to the maximum. The movement of the wind in the design area is evenly distributed, allowing for optimal air circulation. To make the most of it, openings in the direction of the incoming and outgoing wind will be maximized with a cross-ventilation system, while voids will be prepared in public areas within the building to facilitate airflow between floors of the building.

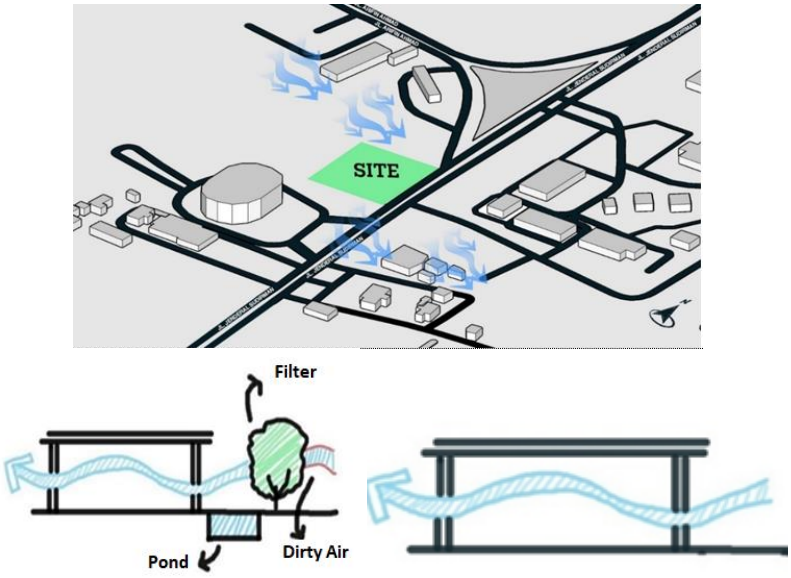


Figure 3. Building Air Circulation Analysis and Plan

Functional analysis discusses the functional needs of the design, activities, users, space programs, standards of needs, and zoning arrangements in the Science and Technology Educational Center.

Table 1. Space Needs Analysis

| No | Space Group | Area ($M^2$) |
|---|---|---|
| 1. | Reception and information facilities | 1.408,4 |
| 2. | Main facilities | 8.187 |
| 3. | Supporting facilities | 2.670,332 |
| 4. | Facilities manager | 642,72 |
| 5. | Service facilities | 707 |
| Total Building Area | | 13.615,452 |
| Outdoor Space (KDB Calculation Results 50%) | | 5.000 |

Natural lighting is an important element in building design, especially when the source is sunlight. The design of the Science and Technology Educational Center will maximize the use of natural lighting by considering the potential for temperature increase in the room as a result of sun exposure. To address this problem, various strategies will be implemented, including the use of kinetic façade technology and the use of high-quality glass with optimal heat insulation (Low E-Glass), as well as the use of skylights in public areas. Artificial lighting is an important key in situations where natural lighting cannot function optimally, such as at night or when the weather is cloudy.

In the design of the Science and Technology Educational Center, the need for artificial lighting is the main support in creating a bright and comfortable environment for building users. In this planning, the artificial lighting that will be used is LED lights that are environmentally friendly and supported by an Optical Sensor system. For types of artificial lighting, use the types of Spot Light, Accent Light, and General Light according to the function of the room. Artificial lighting also utilizes an optical sensor system to optimize energy efficiency.

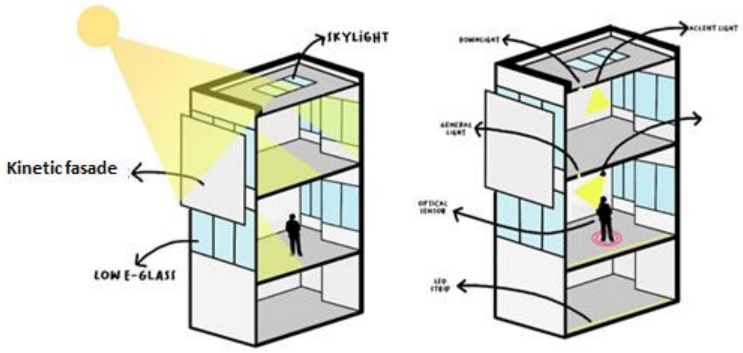


Figure 4. Building Air Circulation Analysis and Plan

In the design of the Science and Technology Educational Center, air conditioning systems are divided into two main types: natural and artificial. Natural ventilation maximizes air circulation, while artificial ventilation is used in unfavorable weather conditions or to maintain air quality. The natural ventilation system will utilize airflow as its main source and will implement a cross ventilation system in the openings supported by Automatic Window which will allow the flow of fresh air through the glass façade into the room. In addition, natural ventilation will also be strengthened through the use of natural elements such as reservoir ponds and vegetation. This helps reduce air pollution from the outdoors while providing optimal airflow inside the building and optimizing energy efficiency.

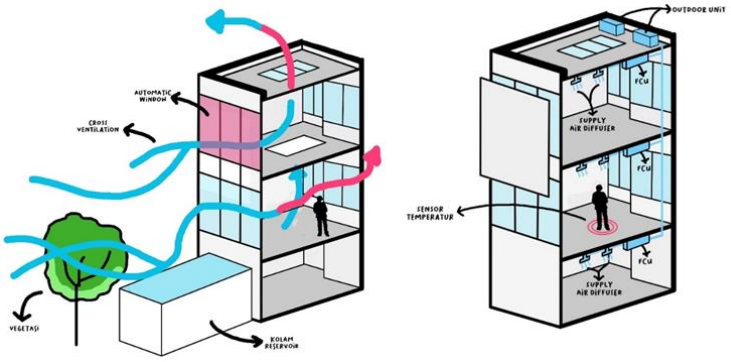


Figure 5. Building Air Conditioning Analysis

An artificial air conditioning system is a system that relies on machines and technology to regulate room cooling. It uses a VRV (Variable Refrigerant Volume) AC system that is automatically regulated by a temperature sensor. VRV air conditioners have high energy efficiency and flexibility. When the room is not in use, the air conditioner will turn off. The VRV air conditioning system is equipped with a temperature sensor to adjust the pressure according to comfort standards. One outdoor unit of a VRV air conditioner can connect several indoor units of different types, which can be set up via mobile device.

***Design Concept***

The building will be taken from the concept of "Science-Tech Evolution" which continues to evolve with various stages of scientific evolution, as well as integrating dynamic and innovative architectural elements. The building will be designed to reflect the philosophy of "Science-Tech Evolution" in every aspect, from the structure, physicality, and zoning of the space, to the technology applied in it. Its design will depict the progress and transformation of scientific evolution that continues to create an inspiring and enabling environment. This Science Evolution will describe the process of sustainability of scientific evolution from the Theory, Experiment, and Application levels in the learning approach and use of technology. Where in the design, three mass buildings were adopted from the stage of "Scientific Evolution" (Theory, Experiment, Application) which were then integrated into a mass unit. The first building mass will be placed as a level 1 evolution building with a theoretical science education function, this building mass focuses on presenting learning to users and visitors in detail. The second building mass will be placed as the building mass of the 2nd stage evolution, this zone acts as a container that houses activities in the form of experimental experiments from the elaboration of the results of the theory that has been put forward previously.

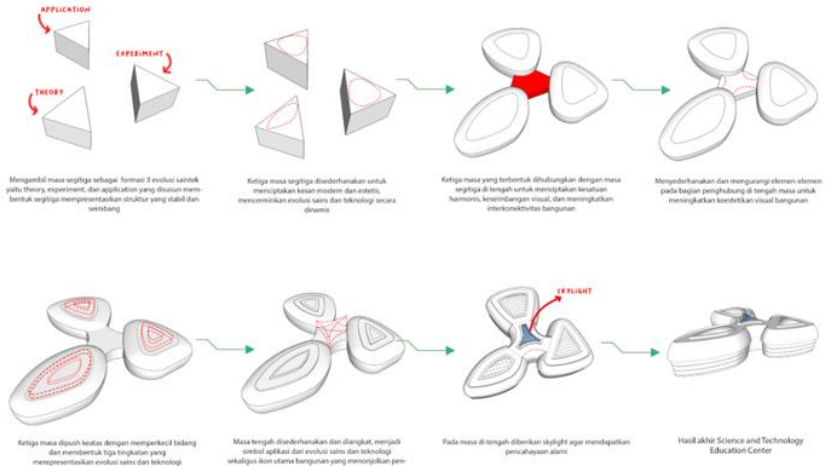


Figure 6. Building Shape Transformation

The mass of the third building will be the last stage of the elaboration of scientific evolution, in this mass it functions as an application space to provide learning activities as well as experiences and application of theories that have been experimented before. It aims to create adaptive and responsive learning spaces, which can adapt to changes in educational and technological needs, and facilitate collaboration, experimentation, and innovation among diverse educational and technological communities. Thus, the building not only becomes a physical symbol of the concept of "Science-Tech Evolution", but also becomes a real container where evolution continues, making a positive contribution to the future development of education and technology.

The façade concept at the Science and Technology Education Center is based on the latest updates in technology, reflecting a commitment to leveraging the latest advancements in supporting educational and learning goals. In its design, the Fasad Science and Technology Education Center combines kinetic facades and LED lighting to represent technological innovation. The kinetic façade is responsive to the environment, improving aesthetics as well as energy efficiency through the arrangement of natural lighting and ventilation. Meanwhile, the LED façade features flexible lighting that reflects the themes of education and technology. This combination creates a façade that is symbolic, functional, and sustainable. The façade of the Science and Technology Education Center combines kinetic facades and LED lighting to represent technological innovation. The kinetic façade is responsive to the environment, improving aesthetics as well as energy efficiency through the arrangement of natural lighting and ventilation. Meanwhile, the LED façade features flexible lighting that reflects the themes of education and technology.

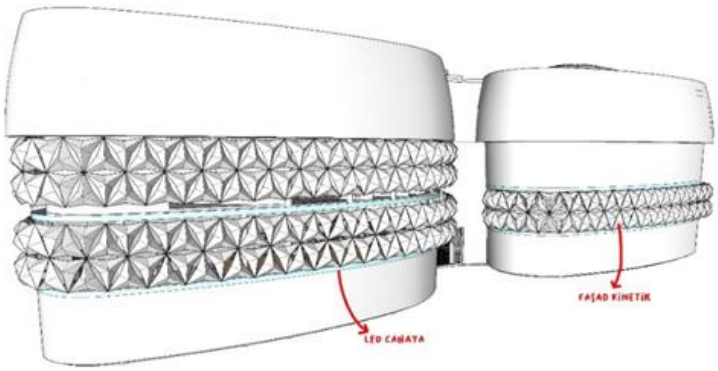


Figure 7. Kinetic Facade Shape of a Building

***Application of Smart Building in Building Design***

*Efficiency*

One of the benchmarks for success in implementing the smart building approach is if the building is efficient in its management. In its application in the form of alternative energy solar photovoltaic, which provides diversification and increases the potential of renewable energy in buildings and also uses energy-saving Low-E Glass materials.

Figure 8. Photovoltaic in Building System

The effective principle in smart building means the application of appropriate technology, where the tools or materials chosen are following what is needed. Philosophically, this means the accuracy of the answers given to the problems at hand. Automatic door, temperature sensor, and optical sensor.

*Effective*

Exposed is meant in this principle to display one of the buildings such as structures, wall materials, glass, and others. The application that will be applied based on this principle is that the building will be dominated by the exposure of glass materials and building structures. What is meant is to highlight the collection of an architectural building, and distinguish between private space, circulation, and service sections. This coloring helps to explain the function of the components or zoning in the space in the building. The application that will be applied based on this principle is the play of indoor colors according to their function.

Figure 9. Glass Opening on Building Exposure Concept

The application of this principle focuses on useful technological innovations in buildings by developing an integrated system that is adaptive and efficient. Kinetic facades are applied to respond dynamically to solar heat radiation according to environmental conditions, improving energy efficiency. Virtual Reality (VR) and Augmented Reality (AR) technologies are used on the props, providing an interactive and immersive experience for visitors. In addition, artificial intelligence (AI) is leveraged to optimize building performance by studying usage patterns and environmental conditions, such as temperature regulation, lighting, safety, and comfort, while robotics supports maintenance and operational tasks. This approach creates buildings that are technologically advanced, interactive, adaptive, and sustainable. The application of this principle focuses on useful technological innovations in buildings by developing an integrated system that is adaptive and efficient.

Figure 10. Adaptive Building Facades

Kinetic facades are applied to respond dynamically to solar heat radiation according to environmental conditions, improving energy efficiency. Virtual Reality (VR) and Augmented Reality (AR) technologies are used on the props, providing an interactive and immersive experience for visitors. In addition, artificial intelligence (AI) is leveraged to optimize building performance by studying usage patterns and environmental conditions, such as temperature regulation, lighting, safety, and comfort, while robotics supports maintenance and operational tasks. This approach creates buildings that are technologically advanced, interactive, adaptive, and sustainable.

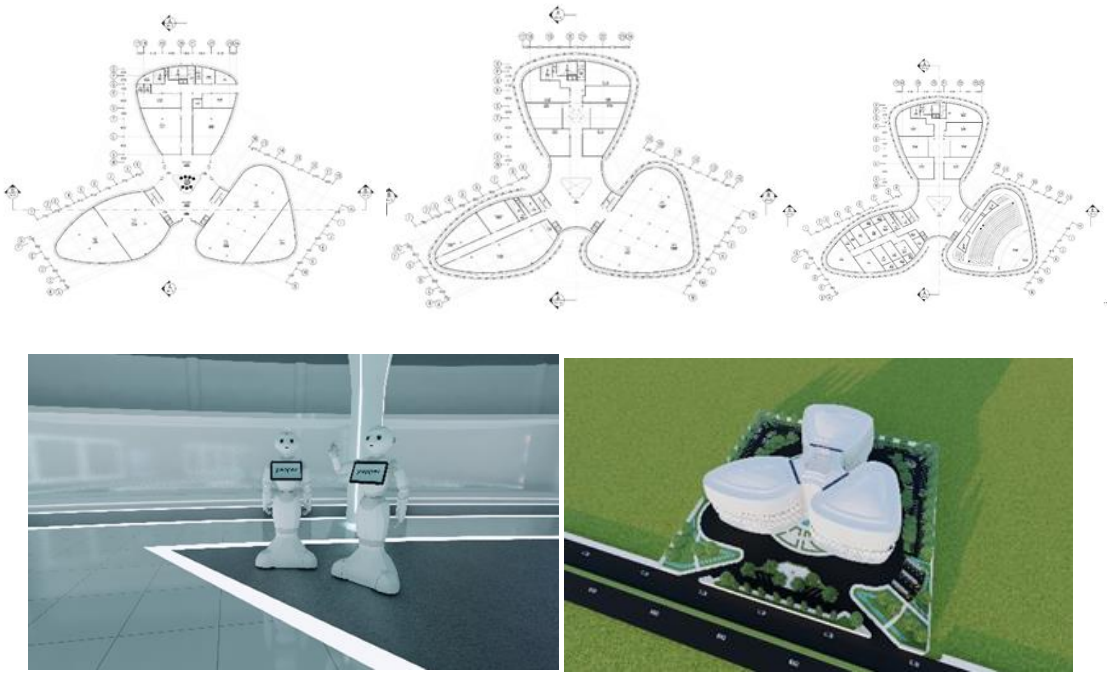

Figure 11. Building Design Results

## CONCLUSIONS AND RECOMMENDATIONS

The Science and Technology Education Center with a Smart Building Approach in Pekanbaru is an educational and recreational institution that offers facilities for learning while playing, by conducting live demonstrations using props for its visitors. The Science and Technology Education Center with a Smart Building Approach in Pekanbaru in its design creates an efficient environment, is responsive to technological developments, and provides an interesting interactive experience for visitors. This approach combines artificial intelligence, automation, and information technology to improve the comfort, security, and efficiency of resource use within buildings. Thus, this center becomes an educational space that is not only informative but also competitive in the era of modern technology. The design concept of the Science Educational Center in Pekanbaru is named "Science-Tech Evolution". The concept was created to describe an approach focused on continuous evolution in science and technology education, in line with the rapid developments in the existing fields of science and technology.

## FURTHER STUDY

This research is a research based on design exploration so it urgently needs input in maximizing model simulation and concept deepening. The development of forms will be maximized with more time so that the application of smart buildings can be further developed in all aspects of the building. Building shapes can be explored using various modeling applications so that they will produce a comparison of shapes that are also diverse and better.

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