Designing a Green Teaching Factory on Vocational High Schools to Support a Sustainable Lifestyle

Yudha Prasetyawan[1,3], Ega Rizkiyah[1,4], Maria Anityasari[1,5], Mahendra Fauzan Budiono[1,6] Mariya Ernawati [2,7] Tri Setya Budi[2,8] Kasma Budi Rahayu[2,9]

[1]Department of Industrial and Systems Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, East Java, Indonesia
[2]State Vocational High School 2 Buduran, Sidoarjo, East Java, Indonesia

[3]prasetyawanyudha83@gmail.com, [4]ega.rizkiyah@its.ac.id,
[5]m_anityasari@yahoo.com.au, [6]mahen.budiono@gmail.com,
[7]ernawatimariya@gmail.com, [8]trisetyabudi2018@gmail.com,
[9]kasmabudirahayu@gmail.com

Abstract. Vocational High School is a vocational education institution that has an important role in improving the quality of human resources. In practice, students require a significant amount of electrical energy for items such as air conditioners and primarily use laptops or computers. The use of air conditioners and laptop computers will increase energy consumption. This study aims to increase the comfort and productivity of teaching factory residents with an ecological approach so that they can help improve environmental sustainability. Design thinking is a process used in this study, it consists of five iterative phases: empathize, define, idealize, prototype, and test. Design thinking help to define the exact problem so we can develop the right solution. The recommendations that can give for teaching factories in vocational high schools are layout adjustments to increase the comfort of building occupants without using air conditioning. As a result, it can improve air circulation in space and contribute to energy savings. In addition, added indoor plants to aid in air exchange. The aspects of reuse, reduction, and recycling are also considered for implementing the green teaching factory.
Keywords: teaching factory, sustainability lifestyle, layout design, and comfortability.

6. INTRODUCTION

The advancement of education in Indonesia is accelerating. This can be supported by the fact that Indonesia has made elementary and secondary education compulsory for 12 years. The vocational high school system is critical in preparing young people and adults for employment, decent work, entrepreneurship, and lifelong learning. Vocational High School (VHS) can provide youth with the skills they need to enter the workforce, including self-employment skill. VHS can also help companies and communities respond more quickly to changing skill demands, increase productivity, and raise wage levels. VHS can help to break down barriers that prevent people from entering the workforce [1]. The government, through its policy of improving the quality of vocational education, has launched the Teaching Factory Program. The directorate of Vocational High School (2016) explains that the teaching factory is the development of the production unit, which is the application of partner industry systems. The teaching factory is a learning model that is used in vocational high schools, with the form of the learning process referring to industry standards. In practice, the teaching factory has several objectives, including increasing the competency of VHS graduates', and increasing VHS graduates' entrepreneurial spirit [2]. The learning process in the teaching factory can be seen in Figure 1 [3].

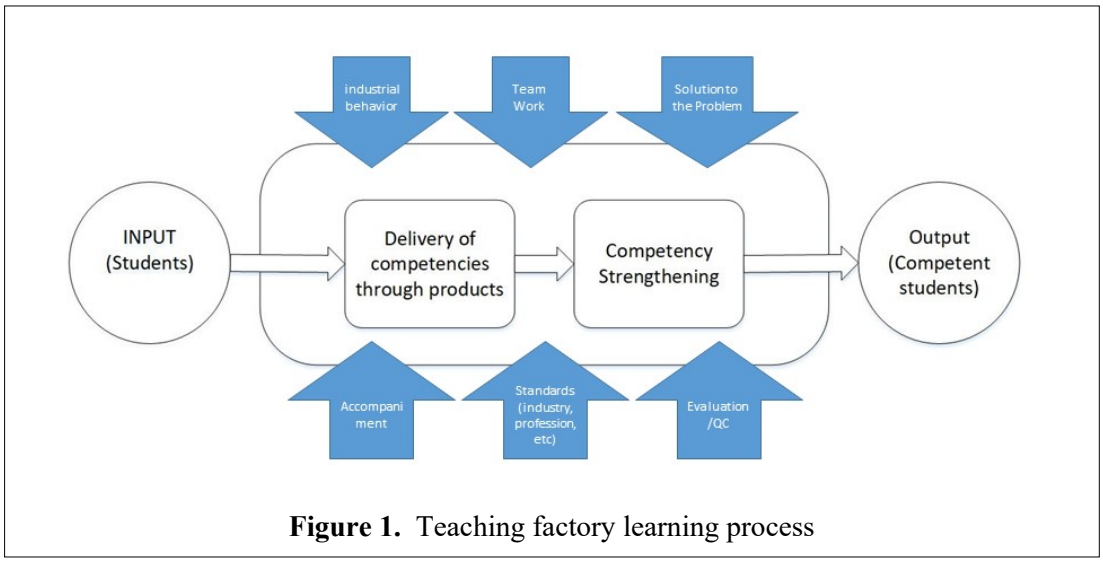

Figure 1. Teaching factory learning process

Since 2021, the Ministry of Education and Culture of the Republic of Indonesia has run the Teaching Factory program in Indonesia. There were 949 vocational high schools that received assistance, especially in the teaching factory program in Indonesia, which involved judges from industry, academia, and business practices with sources from professionals. In order for the school community to assume responsibility for future efforts to save sustainable development, it is important to provide favourable conditions for schools to serve as centers of learning and awareness. This is also supported by indicator is development of environmentally caring and culturally school policies. The process of pursuing knowledge and practises with the intention of becoming more environmentally friendly, enhancing decision-making and lifestyle in a more ecologically responsible manner, can lead to environmental protection and the sustainability of natural resources for current and future generations, according to UNESCO-UNEVOC. UNEVOC is a combination of UNESCO (United Nations Educational, Scientific, and Cultural Organization) and Vocational Education. Greening the campus, greening the curriculum and training, greening research, greening the community and workplace, and greening the institutional culture are whole-institutional approaches to implementing education for sustainable development (EDS) in technical and vocational education and training (TVET).

Human activities and workplace occupations must be carried out in an environmentally friendly and sustainable way. While indoor air quality comfort and safety are significantly influenced by HVAC systems [4]. The need for heating, ventilation, and air conditioning (HVAC) systems in various types of buildings is a result of factors such as population expansion, contemporary technologies, and changing lifestyles. The HVAC systems are responsible for 40–60% of the energy used in buildings [5]. Additionally, 15% of global energy consumption [6]. These findings highlight the significance of researchers, businesses, and policymakers taking HVAC sustainability development into consideration. Furthermore, to maintain healthy occupants while lowering energy consumption and expenses, HVAC system advancements and sustainability considerations are required [7].

The most effective approaches to save natural resources, protect the environment, and save money are to reduce and reuse [8]. The United States Environmental Protection Agency also explained that the benefits of reducing and reusing are to save energy, help sustain the environment for future generations, reduce greenhouse gas emissions that contribute to global climate change, and save money. According to the United Nations Environment Program, the world's population may exceed 10 billion people by 2050, and with more people comes more demand for food, fashion, travel, housing, and other related goals. In a world stretched thin for resources and under the threat of global biodiversity loss and climate change, human lifestyle decisions are putting the planet at risk.

Sustainable living means understanding how human lifestyle choices affect the world around us and creating solutions for everyone to live better [9]. The Sustainable Development Goals include the first

mention of sustainable living and lifestyles (4 Education and 12.8 Responsible Consumption). The UN has linked climate and the SDGs; nevertheless, official endorsement of integrating ecological boundaries and wellbeing by intergovernmental organizations and other global leaders is required to raise awareness and assist with global embedding [10]. At this point, it is evident that measures for lowering life-cycle energy use should begin by adding design considerations that considerably reduce building operational energy. Many activities that are associated with sustainable lifestyles, such as connecting with nature, participating in community activities, being active, learning, and sharing, are also strongly associated with higher levels of wellbeing, whereas the pursuit of a materialistic lifestyle is associated with lower levels of wellbeing [10]. The physical aspects of office environment design identified through the connections between certain physical aspects and worker motivation, well-being, and job satisfaction, and productivity [11].

The physical requirements of VHS, which require an organised, clean, well-maintained environment and several supporting components to make it easier for visitors to get information about the practises being carried out, must be considered in the implementation of the green teaching factory. So that is the current issue with VHS in Buduran has yet to implement the green factory concept. The following is an analysis of current conditions that can be carried out while taking environmental factors into account. In implementing the green teaching factory, it is necessary to pay attention to the physical requirements of VHS which are required to have an organized, clean, well-maintained environment, and have several supporting components to make it easier for visitors to get information about the practices being carried out. The following is an analysis of current conditions that can be carried out by considering environmental aspects:

- The extensive use of electronic devices related to Freon (Chlorofluorocarbons), such as refrigerators, freezers, and air conditioners (AC), turned on full-day.
- The air conditioner turned on full-day in the teaching factory room has not considered environmental aspects. The room only contains computers because this VHS only focuses on software engineering.
- There is no implementation of 3R (reuse, reduce, recycle) in teaching factories.

The use of electricity in teaching factories is critical for producing products that students will send to surrounding industries. In practise, students require a significant amount of electrical energy for items such as air conditioners and primarily use laptops or computers. The use of air conditioners and laptop computers will result in excessive energy consumption. This study aims to provide recommendations to increase the comfort and productivity of the teaching factory's occupants with an ecological approach so that it can help increase environmental sustainability. To achieve this goal, several things must be done in this study including:

1. Conduct in-depth interviews with vocational high school students. Participate in all vocational high school student activities in the teaching factory.
2. Evaluate the teaching factory room, including air circulation and lighting, then the facilities around the teaching factory.
3. Provide recommendations for comfortable workplaces and ways to improve environmental sustainability.

7. METHODS

Vocational high schools in Buduran have implemented a "teaching factory" in their learning by sending products, namely website development, to small industries in the surrounding environment by conducting assessments with large industries, such as electronics companies in Sidoarjo. The use of air conditioners that are turned on continuously during learning is then added to the use of computers, so that the average consumption of electrical energy is 10 hours per day. So to reduce the use of electricity, it is necessary to improve the teaching factory. The research was conducted during November 2022, with research locations at VHS in Buduran, Indonesia. In this study, the authors used two sources of data: primary data and secondary data. The primary data source is field data collected from software engineering majors. This study included 40 participants (two classes) who were software engineering students. Data collection was carried out by giving questions to students majoring in software

engineering through sampling. The questions asked relate to teaching factories in software engineering. where the teaching factory refers to environmental sustainability considerations.

A Design Thinking approach was used to ideate about potential solutions. Where the method begins with empathy by looking directly at the teaching factory in the vocational high school, then using data collection techniques directly in the teaching factory environment through in-depth interviews regarding the condition of the teaching factory room. As we can see in Figure 2. empathize, define, ideate, prototype, and test are the five iterative processes of design thinking. Design thinking is based on empathy for the user experience. This assists in defining the correct problem so that the appropriate solutions can be produced [12]. Design thinking combines an empathy mentality with an iterative human-centered design methodology. Overall, the goal is to stimulate innovation in industries that provide a product and/or service. Although many versions of the Design Thinking approach can be used in different contexts, they all share the common goal of creating human-centered solutions to improve the user experience. This paper will concentrate on the five-phase Design Thinking methodology utilized at Stanford's Hasso Plattner Institute of Design. Individual ideas are communicated through a depth interview in this model, and each participant is encouraged to generate as many ideas as possible. The five design thinking phases can be seen in figure 2 [12].

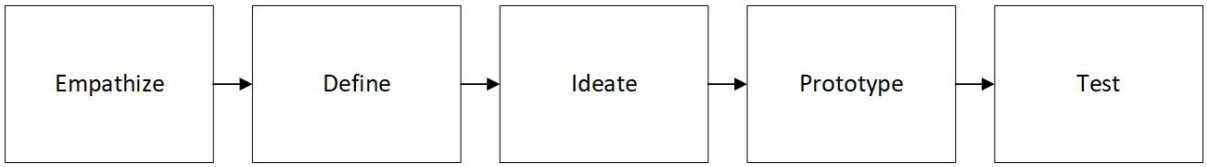

Figure 2. Design Thinking: 5-phase process

8. RESULTS AND DISCUSSION

There is a solution to one of the several problems faced by Software Engineering in Buduran, namely the implementation of a new SOP on the green teaching factory, one of which is the application of an SOP emphasising the standardisation of electricity use. By standardising the use of electricity, the VHS environment in Buduran will be better maintained and the use of electricity will be reduced, which will have many benefits, such as reducing the risk of short circuits, making electronic goods more durable, and reducing expenses [13]. The teaching factory programme itself still has several deficiencies that need to be addressed. One of them is by implementing the 3R programme (reuse, reduce, recycle), which can help students be more effective, efficient, and efficient in the use of energy or materials. 3R also helps the teaching factory programme to maintain the environment; in this case, for example, it is the segregation of waste and waste generated from the implementation of the teaching factory program. Students can use materials they have previously used to create their next project, such as removable electrical components. There needs to be a movement from the VHS in Buduran, especially in saving electrical energy because it is directly related to the department. A small example of these movements is:

1. There are regulations on the use of air conditioning (starting at 10 a.m. As a result, from 7 a.m. to 10 a.m., this course does not use air conditioning and instead relies on the wind from the surrounding environment. This also influences the shape and design of the room, as it requires more windows or doors for airflow so that a healthy air cycle is formed in the classroom or laboratory.
2. There are limits to the use of electricity to charge batteries on devices such as cell-phones and laptops. These limitations include such things as duration limitations or even limits on the number of times one student charges the battery. These two examples might be said to be small movements that can be done continuously. In fact, although movements like this seem like

"small movements," movements like this greatly affect the footprint of energy use within a school environment.

3. Another action that can be taken by students is planting trees.

As mentioned before a Design Thinking approach was used to ideate about potential solutions, The description of each step is as follows:

1. Empathize: Occupants of the building said that the teaching factory always uses air conditioning, there is no heat source from certain machines. But the computer is the only source of heat. Therefore, the computer in the teaching factory room must also be supported to reduce the heat.
2. Define: The use of electricity in the teaching factory is very high, due to the use of air conditioners throughout the day. Apart from air conditioning, laptop use also affects energy consumption.
3. Ideate: Students from Vocational High School shared their ideas for upgrading the teaching factory area, which included changed the layout of the teaching factory room, created a teaching factory space in order to improve air circulation in the room, and added indoor plants to aid in air exchange. Furthermore, indoor vegetation has a variety of effects on people's thermal comfort. Plants can serve as figurative cues, reminding building occupants of outdoor environments and, as a result, expanding their thermal comfort range as if they were outside [14]. This is supported by recommendations to improve thermal comfort by adding vegetation to the room and it must be considered in addition to adding landscape vegetation [15].
4. Prototype

The propose improvements created an approach based on results of design thinking approached can be seen in figure 3.

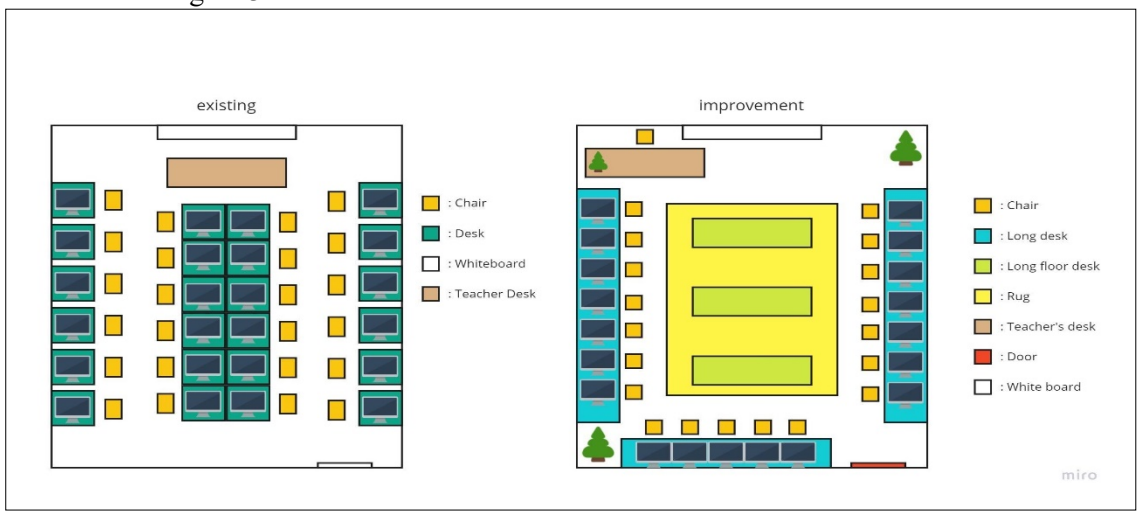

Figure 3. Layout improvement

In the existing conditions, the layout of the tables and chairs limited the space for students to move. Therefore, a teaching factory layout is needed by placing a long table on the edge of the classroom, which is also a place for computers, and then in the middle of the class there is a long floor table for students who use laptops. To reduce barriers, building changes and costs over time, improve communication, and increase flexibility, there is a need to consider whether creating an open space to share the same space with other teams is preferable to being separated by building walls.

The class in software engineering is a class that is not allowed to use footwear. So the addition of carpet is needed to make students more comfortable while doing the assignments that have been given. People, the environment, and profit are all taken into account in the improvements that have been made. For the people element, add carpets and floor tables so that students are comfortable and can maximise their work. For the planet, add plants in the classroom so that air

circulation is good and also limit the use of air conditioning in the classroom. For the profit aspect, increased comfort and space for students to move is an investment in future health conditions so that students can achieve their goals.

In addition, the aspects of reuse, reduction, and recycling are also considered, which are important aspects in implementing the Green Teaching Factory. Students can do reuse activities by reusing the software for the next project. In the reduced aspect, students are expected to be able to reduce the use of equipment that can have an impact on the accumulation of waste or carbon footprint, for example, excess electricity. Students are expected to recycle their needs in learning and implementing the Green Teaching Factory in addition to recycling. Classrooms of different capacities will be allocated in support of academic areas in proportion to the numbers of people on the floor/in the department as indicated in table 1 based on UCL Standard [16].

Table 1. Meeting Space Guidelines

Room Space	Area Per Person (M^2)	Space Per Person
2-4 person	1,5-2	1:50
4-8 person	1,5-2	1:75
8-12 person	1,5-2	1:100
12-20 person	1,5-2	1:100
20+ person	1,5-2	1:200

5. Test

This is the phase where there is an opportunity to see if the problem is properly framed. When conducting testing, the user will ultimately use the prototype. Where the initial problem is the layout of the room, there are arrangement items that do not fit the lighting that goes into the room and are blocked. In addition, the size of the windows and ventilation do not match the size of the room, so light and air enter the room less smoothly. Inside the room, ornamental plants are also centralised in one location, reducing the spread of fresh air throughout the space. The implementation of the green teaching factory helps fix the problems faced by VHS.

9. CONCLUSION

Based on the research, teaching factory rooms in vocational high schools can be given recommendations for layout adjustments to increase the comfort of building occupants without the use of air conditioning. As a result, it can improve air circulation in the space and contribute to energy savings. created a "teaching factory" space in order to improve air circulation in the room and added indoor plants to aid in air exchange. Furthermore, indoor vegetation has a variety of effects on people's thermal comfort. This research was only conducted in software engineering, so it must be applied in other fields of study, where the application of green teaching factories is personalised to the conditions of each teaching factory. The green teaching factory is a new and evolving concept with an infinite timeframe. We recommend that institutions engage in a formal greening process until they are confident that the concepts have been embedded, the actions have been mainstreamed into daily functions, and they are covered by routine monitoring measures. Since vocational high school institutions diverge from small rural handicraft centres to highly advanced technical schools, the general advice provided here must be tailored to the specific learning situation.

REFERENCES

[1] Majumdar, S. (2017). *Greening Technical and Vocational Education and Training: A practical guide for institutions.* Paris: United Nations Educational, Scientific, and Cultural Organization.

[2] Herminanto , S. (2011). Optimalisasi pembelajaran berbasis kompetensi pada pendidikan kejuruan. *Jurnal Pendidikan Vokasi*, 113-128.

[3] Fitrihana, N. (2018). Rancangan Pembelajaran Teaching Factory di SMK Tata Busana. *Home Economics Journal Vol 2, No. 2. October*, 56-64.

[4] Asim, N., Badiei, M., Mohammad, M., Razali, H., Rajabi , A., Haw, L. C., & Ghazali, M. J. (2022). Sustainability of Heating, Ventilation, and Air-Conditioning (HVAC) Systems in Buildings-An Overview. *International Journal of Environmental Research and Public Health*, 1-16.

[5] Pérez-Lombard, L., Ortiz, J., & Pout, C. (2008). A review on buildings energy consumption information. *Energy and Buildings Volume 40, Issue 3,* , 394-398.

[6] Rafique, M. M., & Rehman, S. (2018). Renewable and Sustainable Air Conditioning. *Sustainable Air Conditioning Systems; Books on*.

[7] Ma, Z., Ren, H., & Lin, W. (2019). A review of heating, ventilation and air conditioning technologies and innovations used in solar-powered net zero energy Solar Decathlon houses. *Journal of Cleaner Production, Volume 240*, 118-158.

[8] EPA. (2022, March 25). *Reducing and Reusing Basics*. Retrieved from United States Environmental Protection: https://www.epa.gov/recycle/reducing-and-reusing-basics#:~:text=Benefits%20of%20Reducing%20and%20Reusing,-Reduces%20greenhouse%20gas&text=Saves%20energy.,sent%20to%20landfills%20and%20incinerators.

[9] UNEP. (2022, May 9). *Enabling Sustainable Lifestyles in a Climate Change*. Retrieved from UN Environment Programme: https://www.unep.org/resources/policy-and-strategy/enabling-sustainable-lifestyles-climate-emergency

[10] Gilby, S., Mao, C., Koide, R., Watabe, A., Akenji, L., & Timmer, V. (2019). Sustainable Lifestyles Policy and Practice: Challenges and Way Forward. *Institute for Global Environmental Strategies*, 1-45.

[11] Elmahadi, M. A., Tahir, A. A., Surat, M., Tawil, N. M., & Usman, I. S. (2011). Effective Office Environment Architecture: Finding Ingenious Ideas in a Home to Stimulate the Office Environment. *Procedia Engineering*, 380-388.

[12] Deitte, L. A., & Omary, R. A. (2019). The Power of Design Thinking in Medical Education. *Academic Radiology Volume 26, Issue 10*, 1417-1420.

[13] Hidayanti, N. N., Nuruddin, M., & Hidayat, H. (2021). Perancangan Standard Operating Procedure (SOP) proses produksi pada TEFA (Teaching Factory) (Studi Kasus: Smk Manbaul Ulum). *JUSTI (Jurnal Sistem dan Teknik Industri)*, 301-306.

[14] Mangone, G., Kurvers, S., & Luscuere, P. (2014). Constructing thermal comfort: Investigating the effect of vegetation on indoor thermal comfort through a four season thermal comfort quasi-experiment. *Building and Environment*, 410-426.

[15] Purwaningsih, R., Prastawa, H., Susanto, N., Saptadi, S., & Pirogo, B. (2019). Assessment of green building score based on greenship rating of the green building council of Indonesia. *AIP Conference Proceedings*, 1-10.

[16] UCL . (2018). *Space Standards Guidelines: UCL Estate Space & Feasibility.* London: London's Global University .