

INVESTIGATION ON THE SUSTAINABILITY OF AN INNOVATIVE PHYSICAL LEARNING ENVIRONMENT IN PUTRA FUTURE CLASSROOM, UNIVERSITI PUTRA MALAYSIA

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ARTICLE INFO

*Education 4.0
future classroom
future learning
innovative learning space
learning experience
sustainability.*

ABSTRACT

The aim of this paper is to study the sustainability of future physical learning environments and their adaptability to the changes in the learning and teaching methods in the 21st century. This paper analyses several theories on the sustainability of the physical design of learning spaces in order to collect the main variables for data analysis. The methodology in this study consists of a visual observation that is conducted in Putra Future Classroom (PFC) in Universiti Putra Malaysia (UPM) in order to make a comparison between the variables and the existing physical design elements in PFC. This paper is based on an ongoing study that aims to assess the physical design of PFC and its role in improving the learning experience of the students and indirectly increases the quality of higher education in UPM. The findings of this paper could lead to create guidelines for improving the sustainability of the physical learning environment in UPM and other public universities in Malaysia which can help to improve the quality of higher education in Malaysian universities.

1. INTRODUCTION

In the beginning of 2011, a revolutionary development of multiple sectors such as industry, education, business, and others came along with the increasing use of internet and digitalization in these sectors. This growth was referred to as the Industrial Revolution 4.0 or IR4.0 which can be defined as the transformation of the traditional methods in industry, business, management, transportation and education using smart digital systems, online communication and the revolutionary use of the internet (Shahroom & Hussin, 2018).

IR4.0 brought a large number of innovations in different fields such as cloud computing, system integration, additive manufacturing, simulation, big data and many others. But perhaps the biggest innovation of IR4.0 is the 'internet of things' or IOT. According to Shahroom & Hussin (2018), IOT is a network of devices or objects that has the ability to connect to the internet and can be controlled remotely.

IR4.0 and IOT both had a huge impact on every aspect of our everyday life, including our education. With these latest innovations came huge changes in the way we learn, teach and interact to make education more personalized and sustainable. This new model is referred to as Education 4.0. The new learning methods in Education

4.0 are designed to enhance the students' willingness and motivation for learning through innovative learning process that is relevant and reflective to their interests, which is one of the main concepts of sustainable education (Keser & Semerci, 2019).

The revolutionary development in the educational process and the teaching and learning styles created a gap between the need of the learning activities in these learning styles and what the traditional learning space can support. And while previous researches have already been made on the need to create a more flexible and adaptive design of physical learning environment to enhance the sustainability of the space, none of these researches were made for public universities in Malaysia. Along with the initiatives of University Putra Malaysia to create a sustainable future classroom (Putra Future Classroom (PFC)), this research has been conducted to analyse PFC and to give recommendations on how to improve its sustainability and adaptability.

The findings and final recommendations of this research can enhance the sustainability of the space, improve the learning experience of the students and reflect the **Sustainable Development Goal 4 (SDG #4) which is to ensure inclusive and equitable quality education and promoting a lifelong learning opportunity for all.**

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<https://doi.org/10.47836/AC.15.1.Chapter04>

2. SUSTAINABILITY IN EDUCATION 4.0

Sustainable education can be defined as the educational process that aims to create a sustainable development through participatory and engaging learning methods (Wagner & Wallner, 2016). These new learning methods that shape Education 4.0 aim to enhance the students' critical thinking and collaborative decision making that allows today's students to prepare for any future scenario, and therefore, increase the sustainability of education.

With the wide effects of IR4.0 and IOT on education, many innovations were used in the process to make learning more convenient, enjoyable, and personalized. According to Keser & Semerci (2019), the revolutionary use of the internet and technology has increased the need for innovative learning that can respond to the growth in the constantly developing professionally oriented jobs. This requires the students to have a wide set of social, critical thinking and problem-solving skills which traditional learning cannot develop. This is where new learning models were needed to create a more sustainable education that can extend beyond the classroom walls and equip the students with the skills they need to become self-sufficient and life-long learners.

According to Altbach et al (2018), Education 4.0 can be defined as the revolutionary use of technology and the fourth industrial revolution innovations in education in order to create a more personalized, collaborative and skill building educational process. The use of the internet has also increased the awareness of the importance of higher education, which led to a higher diversity of students' backgrounds who came with different needs and requirements of the learning process and spaces. Wagner and Wallner (2016), explained that several learning methods were developed to respond to those aims.

The development in the teaching and learning methods has brought a large number of requirements that a traditional physical learning space cannot support. Therefore, several studies on the sustainability of learning spaces were conducted to address the new design requirements through flexibility, adaptability and personalization to support all current and future learning models (Altbach et al, 2018). In this article, several theories on the sustainability of physical learning spaces are studied and analyzed. These theories were selected to connect to Education 4.0 from different approaches and through studying different effects, such as the use of technology in education, the changing in students' background number, the learning types in Education 4.0 and the adaptability and flexibility of the space. However, all the theories are selected with the same concept of educational sustainability, which is to enhance the students' willingness and motivation for learning.

3. LEARNING MODELS FOR SUSTAINABLE EDUCATION

Most of the new learning models in Education 4.0 were not only created to improve and develop the social and real-world skills of the students and to prepare them to be adaptive to the changing career demands. But they were also created to create flexibility and freedom to address the different needs of these students (Glasby, 2015). Redecker et al. (2016) stated that successful future learning

models focus on three main features which are informalization, personalization and collaboration (Figure 1). Focusing on these features helps the students to address and overcome their issues, support their needs and enhance their real-world skills.

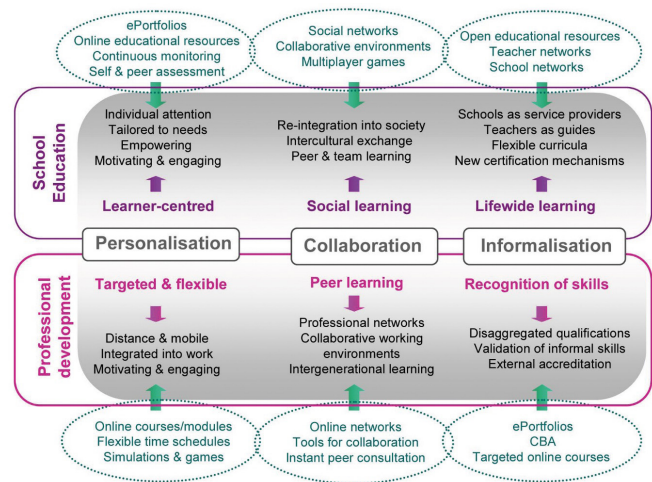


Figure 1: Learning of the future (Redecker et al., 2016) overcome the current economic crisis and grasp new opportunities. The strategic framework for European cooperation in education and training ('ET 2020').

Some of the most common teaching and learning models in Education 4.0 include collaborative learning or group learning, this method has the ability to develop the students' communication and social skills, allows them to learn from different perspectives and share knowledge effectively with others (Boruvkova & Emanovsky, 2016). Experiential learning, also called project-based learning focuses on enhancing the knowledge, the participation and the joy in learning through tasks, assignments and experiences (Andresen et al, 2016). Holt et al., (2016) also explained that the most popular learning model in Education 4.0 is Computer-Assisted learning which integrates multiple technologies and display options in order to enrich content delivery. Online learning has also been increasingly popular lately due to the opportunities it gives for the students to participate in the learning process from anywhere in the world (Stern, 2018). And finally, enhancing learning with simulation, virtual realities or any kind of learning through virtual environment experience is called Immersive Learning which gives students the ability to integrate multiple senses instead of relying on their imagination (Li Shang Ly et al, 2015).

Each one of these learning models comes with different requirements of the learning space. While some might require screens, tables and chairs, others might require a large open space, or even movable furniture that can be rearranged to support both individuals and groups. These requirements can no longer be supported in a traditional classroom or lecture room. Therefore, sustainable learning spaces should be flexible and adaptive to any existing or future learning models that might still be created with the constant development of technologies and innovations.

4. PHYSICAL LEARNING ENVIRONMENT SUSTAINABILITY IN EDUCATION 4.0

Space sustainability is often understood as the low impact of space elements, structure and materials on the environment. However, space sustainability also means the ability of the space to support current and future needs (Brown, 2018). Learning space sustainability often refers to the flexibility and adaptability of the space with any learning activity and the capability of supporting future learning models (McDaniel, 2014). In order to know the characteristics of a sustainable learning space, several theories have been analysed and compared. While these theories all focussed on the sustainability and flexibility of the learning space, each of the authors with different educational background analyses the issue from a different perspective.

The first theory by Duvivier (2019) concentrates on the ability of the space to support informal learning activities which are increasingly popular with the use of the internet and online learning in education. The second theory by McDaniel (2012) studies the learning space ability to support the changing needs of students with different backgrounds as a result of the increasing rates of higher education and the variety of the students. The third theory by Kim (2019) focuses on the sustainability of the classroom that can enhance the spaces support of different learning models and increases the comfort and participation of the students. And the final theory by Niemi, (2018) discusses the adaptability of the learning space design with the changing technologies.

4.1 Theory 1 by Duvivier (2019)

Duvivier (2019) stated that the increasing role of the internet on every aspect of our lives comes with the rapid growth in informal learning as it has allowed learning to happen from anywhere, anytime. Informal learning offered comfort to the learners as it can be practiced and merged with daily living activities such as food, beverages, naps. Informal learning has changed the way students learn and their requirements of a comfortable learning space to give them freedom and control. Food, beverages and a good internet connection are now the main part of a comfortable learning and working space which is why modern cafes are now considered preferable spots for studying and group meetings (Brown, 2018). According to Duvivier (2019), a sustainable physical design of learning spaces should provide comfort for the students and support informal learning which is getting increasingly popular. This requires the space to merge the students' daily activities into the learning process by providing spaces for food, drinks and relaxing areas for short breaks.

Brown (2018) also stated that this can be achieved by designing multi-purpose areas in the space that are equipped with a good internet connection, learning technologies, a variety of furniture sets and different services that enhances the comfort of all students.

4.2 Theory 2 by McDaniel (2014)

The use of the internet, social media and the higher demand for professionally oriented jobs has increased the awareness for higher

education which also led to increasing the number of students and the variety of their educational and cultural backgrounds. With this variety comes new needs for these students which cannot all be supported in the same space setting, learning models or assessment methods. Therefore, in order to respond to these needs, a wide range of formal and informal learning models should be provided to offer a flexibility in learning. These models should also be supported by sustainable and flexible formal and informal learning spaces that can support any learning activity (McDaniel, 2014). Successful current and future learning models rely on active collaborative learning rather than teacher-led learning (Shah, 2013), that is why learning spaces should be redesigned in response to these changes by offering a flexible, adaptive and personalized experience (Brown, 2018).

According to McDaniel (2014), in order to design a sustainable and supportive learning space, different types and sets of furniture should be used. Sofas, chairs and tables of different sizes and a food service or pantry area can contribute in enhancing the students' comfort. Shah (2013) also explained that students tend to spend more time in spaces where they have a sense of control. Spaces with flexible furniture and adaptive layout can enhance this feeling.

Reducing the students' level of stress can be achieved by providing break areas such as lounge areas and informal spaces such as courtyards that have direct connection with the learning space. Both formal and informal learning spaces should offer a number a technology such as display surfaces and computers, internet connection and a sufficient number of electrical ports. Movable chairs, round tables and screens also enhance collaboration and group work. Storage areas and space dividers are also essential to support different learning activities (McDaniel, 2014).

4.3 Theory 3 by Kim (2019)

Kim (2019) explained his theory on the Flipped Classroom as a sustainable active and personalized learning space that supports both individual and group work through a variety of flexible furniture sets and different types and sizes of tables and chairs. The flexible cluster arrangement of the Flipped Classroom also supports the movement of the instructor between the tables to enhance their interaction with the students. A lounge corner is designed to allow the students to relax and change position, while natural indoor elements and large openings also have the ability to enhance the students' critical thinking.

Flipped Classroom (Figure 2) provides a variety of screens and other movable display options which makes it easier for collaborative discussion and group work (Jamilah et al. 2018).

This classroom by Kim (2019) was designed to support the Flipped classroom in the instructional strategy, which focuses on the pedagogy method of moving direct teaching from group learning to individual learning, which is then transformed into group discussions. Flipped classroom by (2019) focuses on the physical design of the learning space that can support flipped learning by providing both individual corners and group discussion spaces.



Figure 2: Flipped classroom by Kim (2019).

4.4 Theory 4 by Niemi (2018)

The rapid change in technology constantly alters our education and learning models. A fixed traditional design of the learning space can no longer support the learning models of Education 4.0 and the many more models to come in the future. Therefore, sustainable learning spaces should be designed to be flexible and multi-purpose, providing multi-use technologies, furniture and other physical settings. The overall layout of the space should support both collaborative and group discussion and individual learning (Niemi, 2018).

Large open spaces can be designed to provide different levels. Steps can be used as sitting areas while it can divide the space into multiple areas for different activities. A strong internet connection is essential along with flexible furniture, a variety of display options and learning technologies with electrical power ports as well as providing rest areas and food service corners can all participate in enhancing the comfort and joy in the learning process (Niemi, 2018).

5. METHOD

This research uses qualitative data collection through a visual observation. According to Creswell (2012), an observation can be conducted in order to analyse a phenomenal, place or a concept. In this case, a non-participant observation has been conducted in PFC during class time in order to collect more accurate data. Creswell (2012) explained that non-participant observation can prevent the presence of the researcher from influencing the participants' actions, which leads to more accurate results. The variables of the observation are collected through a comparison between the previous four theories through listing down all the characteristics from the four theories in a table, then considering only the elements that were shared by two or more researchers to create the final checklist for the visual observation.

5.1 Comparison of theories

The previous theories are analysed and compared in order to create a list of characteristics of a sustainable physical learning space. This method provides a list of variables that is agreed upon by several authors with different educational background and different perspectives.

This study is based on an ongoing study. The full study uses a mixed methodology through a visual observation, a questionnaire survey for the students of PFC in order to investigate their opinions and satisfaction. Finally, an interview that is conducted with the designers

and lecturers of PFC, and the management staff in order to fill the gaps in the data and further understand the philosophies behind the design of the space. However, this article only uses qualitative approach through a visual observation to make a comparison between the variables from the theories and the existing physical design elements in PFC.

The three methods in the research are used to achieve the main objective of the research which is to give recommendations on designing future learning facilities that can improve higher education quality in UPM. The findings of the original research can also be used to create guidelines for creating an innovative future learning space in public universities in Malaysia.

The characteristics of a sustainable learning space in the four theories (theory 1 by Duvivier (2019), theory 2 by McDaniel (2014), theory 3 by Kim, (2019) and theory 4 Niemi, (2018)) were compared, and only the characteristics that were shared between two theories were considered in the study. And while other characteristics that were only mentioned once are not less important, considering the shared characteristics allows to create a more accurate list that is agreed upon by different researchers from different backgrounds. (Table 1).

Table 1: Comparison of theories

Variables	Theory 1 Duvivier (2019)	Theory 2 McDaniel (2014)	Theory 3 Kim (2019)	Theory 4 Niemi (2018)
Sufficient network connection 24/7	x	x	x	x
Merging living activities with learning	x	x	x	
Multi-useability of the space			x	x
Working surfaces (Chalkboards, white board)		x	x	
Learning technologies (screens, interactive and display options)	x		x	x
Sufficient number of electric ports		x	x	x
Connection between formal and informal learning spaces		x	x	x
Flexible furniture and physical settings		x	x	x
Pantry area		x	x	x

Variables	Theory 1 Duvivier (2019)	Theory 2 McDaniel (2014)	Theory 3 Kim (2019)	Theory 4 Niemi (2018)
Movable space dividers		x	x	x
private individual corners		x	x	x
Spaces for group work	x	x	x	x
Various sizes of movable round tables and chairs	x	x	x	x
Multi-level spaces				x
Soft floor carpet and acoustic ceiling to create a good acoustic environment.				x

Table 1 shows that all the four theories focus on the importance of providing a strong network connection with proper coverage that is available for the students at all times. While only three theories (Duvivier, McDaniel and Kim) suggest merging the daily living activities in the learning process to enhance the students' comfort. Space multi-usability was only covered by Kim and Niemi to allow the space to be flexible and support different learning activities. Traditional working surfaces such as white boards and chalk boards are still advised by McDaniel and Kim. However, smart technologies and interactive surfaces are explained to be very important by Duvivier, Kim and Niemi.

Theories 2 by McDaniel, 3 by Kim and 4 by Niemi all agreed that a sustainable and supportive future classroom must have enough electric ports, provides a proper connection with outdoor and informal learning spaces to allow the students to destress and relax, provides flexible furniture and physical settings, provides a pantry or food preparing area and provides space dividers and spaces for individual work. All the theories, however, focused on the importance of providing proper settings for group work such as proper spaces and corners and Various sizes of movable round tables and chairs, while only Niemi explained the need to provide multi-level spaces and soft floor carpet and acoustic ceiling to create a good acoustic environment.

Table 1 contains all the 15 characteristics stated in the four theories. However, after taking only the shared characteristics between two or more researchers, this number is reduced to 13 for the final list of comparison.

The comparison of the characteristics forms the final checklist for the visual observation which is defined as:

- ☐ Sufficient network connection 24/7
- ☐ Merging living activities with learning
- ☐ Multi-useability of the space

- ☐ Working surfaces (Chalkboards, white board)
- ☐ Learning technologies (screens, interactive and display options)
- ☐ Sufficient number of electric ports
- ☐ Connection between formal and informal learning spaces
- ☐ Flexible furniture and physical settings
- ☐ Pantry area
- ☐ Movable space dividers
- ☐ private individual corners
- ☐ Spaces for group work
- ☐ Various sizes of movable round tables and chairs

5.2 Visual Observation in Putra Future Classroom (PFC)

A non-participative visual observation was conducted in PFC. The aim of the visual observation was to compare the final checklist of variables with the design elements in PFC, finding the strengths and weaknesses in the design and giving recommendations on further enhancing the sustainability of the space.

The observation was conducted during class time for a period of two hours. The author selected a point of observation at the back of the classroom by the entrance in order not to cause any disturbances for the students or the learning process. The author finished the checklist through visual observation of the physical elements and with the help of classroom assistance who clarified the rules and the accessibility measures in the classroom. The strengths and weaknesses of the space were identified through the comparison the classroom elements and the final checklist.

6. RESULTS

After comparing the physical design elements of PFC with the list of the required characteristics, several issues and strengths were found in PFC that were later addressed in the discussion (Table 2).

Table 2: Internet access evaluation list

CHECK LIST		SCALE OF MEASUREMENT		
Internet access	1. speed	<6.0 mbps/s	8.0 mbps/s	>12.0 mbps/s
	2. Spaces of availability	40% > (of faculty spaces)	60% > (of faculty spaces)	80% > (of faculty spaces)
	3. Connection process speed	3 min >	1 min <	30 sec <
	4. Login requirements	Required / limited	Required / unlimited	Not required
	5. Availability	8>h/day	12<h/day	24 h/day

Table 2 shows the scale of measurement for part of the elements in the checklist (internet speed, internet accessibility which is divided to Spaces of availability, Connection process speed and Login

requirements, and finally internet availability) the internet speed, coverage, login requirements and availability values on the scale of measurement are according to Husniyah (2019) on the appropriate internet speed for education.

In the observation it was found that the internet speed in PFC is considered slow (650-1500 kbps/s) which was measured online through www.speedtest.net. and while PFC is completely covered, the network only covers around 60% of the informal surrounding spaces (courtyard and lobby). The internet coverage in these spaces was measured due to their direct connection to PFC, which means they can be used for informal learning activities by the students. The connection process was easy and convenient as it requires no password or login. Few food services and sales tables are provided during break time in the lobby near PFC which also provides a vending machine for beverages outside PFC (Figure 3). However, a pantry area is not provided, and food is not allowed inside the classroom.



Figure 3: Vending machine outside of PFC.

The observation also shows that PFC provides good physical settings as it contains a lounge corner with a sofa, an armchair and a bean bag. The sofa and the armchair both provide back, neck and arm support with pillows (Figure 4). The tables provided have a modular design which allows them to be assembled into one larger table for group discussions or dissembled for individual use, while the chairs provide cushions, back and arm support but no neck support (Figure 5). Storage areas, storage cabinets for the students and also space dividers are unavailable which means that individual corners and private discussion areas are unavailable.



Figure 4: Resting corner in PFC.



Figure 5: Modular tables in PFC.

The central cooling system in PFC is controlled by IOT. This improved the overall environment that ensures a stable classroom temperature but it prevents the students from controlling the temperature or the power to their preference. Also, the limited accessibility to the classroom prevents students from spending time in the space as it is only accessible on class time.

The space provides a large variety of display options, such as large screens around the classroom, a movable interactive screen and a projector. A sufficient number of electric ports (1 port per 2 students) is also provided (Figure 6). Tempered glass boards are available for discussion and group work (Table 3). PFC also provides a direct connection with an outdoor area that contains simple tables and chairs for breaks and stress reduction (Figure 7).

Table 3: Learning technologies evaluation list

CHECK LIST poor		SCALE OF MEASUREMENT		
		average	good	
Learning technologies	1. screens	unavailable	Available / limited access	<u>Available / unlimited access</u>
	2. Interactive surfaces	unavailable	Available / limited access	<u>Available / unlimited access</u>
	3. projectors	unavailable	<u>Available / limited access</u>	Available / unlimited access
	4. Electric ports	1 Port per > 10 students	1 Port per > 5 students	<u>1 Port per < 2 students</u>

Table 3 shows the scale of measurement for the elements in the learning technologies (screens, interactive surfaces, projectors and electric ports) the elements are measured based on their availability and accessibility (staff only for limited access, staff and students for unlimited access).

Figure 6 shows the technologies in PFC which include screens on the side of the classroom, a large interactive screen in the front and projectors of the ceiling.

**Figure 6:** Technologies in PFC.**Figure 7:** PFC's connection with outdoor resting areas.

7. DISCUSSION

The findings of the visual observation show that PFC provides excellent physical settings through movable and flexible furniture, which according to McDaniel (2014), Kim (2019) and Niemi (2018) allows the space to have an adaptive configuration that can be changed according to the learning activity or students' needs. However, the area of the classroom is considered small. According to McDaniel (2014), providing a large area for the learning space enhances its sustainability as it allows it to support any learning activity or several activities at the same time. The furniture used in the informal lounge corner provides all the comfort feature such as back, neck and arm support. McDaniel (2014), Kim (2019) and Niemi (2018) explained that this can help the students to take breaks from the chairs and change posture during long classes. However, the chairs used provide back and arm support but no neck support which according to Maradei, et al (2017) can cause neck and shoulder pain and health issues for the students. The modular tables provided in PFC offer an excellent support for both individual and group use and can be adapted to any required configuration according to Duvivier (2019), McDaniel (2014), Kim (2019) and Niemi (2018).

PFC is equipped with a large variety of technologies that can enrich the learning experience and improve content delivery. The number of large screens on all walls allow students to have a clear vision from anywhere in the classroom and supports group discussion (Duvivier, 2019. Kim, 2019. and Niemi, 2018). The interactive 60" touch screen also creates an easier and more effective content delivery. The easy network connection allows students easy access to online materials and resources which according to Duvivier (2019), McDaniel (2014), Kim (2019) and Niemi (2018) helps expand their knowledge while the number of electrical power ports provided makes PFC a BYOD (bring-your-own-device) friendly space. However, the network speed is considered poor which according to Husniyah (2019) is not sufficient for many learning activities that require access to large online resources, download large files or make online calls or video streaming.

The connection between PFC and the outdoor courtyard and lobby with tables for eating or food and vending machines provides the students with the opportunity to take breaks, relax and reduce their

stress levels during long classes according to McDaniel (2014), Kim (2019) and Niemi (2018).

On the other hand, a large set of characteristics are missing in PFC as merging the living activities of the students with the learning process is considered poor. The restricted access of the students to the classroom limits the time they spend there which according to McDaniel (2014) prevents them from having a sense of belonging. Preventing food and break naps in the space also limits the students' sense of control and reduces their comfort according to Duvivier (2019), McDaniel (2014) and Kim (2019).

Comparing the characteristics of a formal and informal learning space in theory 1 by Duvivier (2019), it is found that PFC is considered a formal learning space as it supports only formal learning activities, while it prevents daily living activities such as food, lack of pantry or food preparing area, limited time accessibility and limited control for the students over the space.

These limitations and issues can be addressed to further enhance the sustainability of the space and allow it to support the future changes in the learning models and styles, as well as heighten the students' comfort, joy and participation in the learning process.

8. CONCLUSIO

The findings of this research show that PFC provides a very good physical settings and learning technologies according to Duvivier (2019), McDaniel (2014), Kim (2019) and Niemi (2018). However, improving the sustainability of the space even further can be done through addressing several issues in terms of physical design, technology and management. Addressing these issues can be made through focusing on merging the daily activities of the students into the learning process (Duvivier, 2019. McDaniel, 2014. and Kim, 2019), providing a more flexible access to the space and improving the network speed and coverage (Duvivier, 2019. McDaniel, 2014. Kim, 2019. And Niemi, 2018). These recommendations can enhance the sustainability of the space, improve the learning experience of the students. These goals can also lead to improving the overall higher education quality in public universities in Malaysia which would allow the students to gain the necessary knowledge and skills to participate in their future careers and contribute well to the community.

ACKNOWLEDGEMENTS

Acknowledgement and appreciation to Dr. Sharifah Intan Sharina, Dr. Marzni Mohamed Mokhtar, Dr. Mas Nida Fes and PFC management staff who contribute their time and assistance on this research project.

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