A tailor-made learning environment workspace for generation y graduates using product service system concept

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Abstract. This paper presents a workspace design of a tailor-made learning environment for students using the product-service systems (PSS) concept. Existing research regarding workspace design focuses on the design of the interior of classrooms to ensure that the learning process proceeds with minimum stress and maximum effectiveness. None of the current research had discussed the workspace outside of the classroom. Therefore, the main objective of this study is to propose a learning environment workspace in which students can gather, study, relax, socialize, eat, and work during class gaps. For this purpose, a questionnaire was distributed to identify the behavior of the users to generate a list of requirements in the development of the learning workspace. This paper focused on students at the Engineering Faculty and the learning environment workspace was called the OneForAll Center. Out of 10 functions of the proposed OneForAll Center, only four functions had the highest priority: a space to use a laptop and internet connection, a television, a vending machine and a printing section. The OneForAll Center has been illustrated in a 3D model and shown to the students, in which most of them agreed with the proposed services and facilities such as a space to use the laptop and internet connection and a printing section with a printing service. The OneForAll Center has been identified as a solution to improve learning outside the classroom, specifically to the provision of services to students.

1. Introduction
Generally, ‘workspace’ is a term which refers to the working process taking place in a room. The term ‘workspace design’ is inspired by a research at MIT School of Architecture and Planning which proposed to overcome the architectural issues of the workspace and layout of buildings [1]. As a result of the growth of the telecommunication technology, today’s workspace designers should consider the impact of their designs on the human population, specifically the generation Y born between 1981 to 1999. The majority of the generation Y are now pursuing their education at university level. This
generation is identified as confident and technologically advanced, and they come with a sense of entitlement [2]. Therefore, today’s university students are pushing academicians and workspace designers to address the learning spaces beyond classroom walls. They also require a flexible space that allows social interactions in which students and faculty members can meet informally to discuss the current news and study [3].

In recent years, there has been an increased interest in the design of a flexible and smart workspace to improve the diversity in learning activities. For example, Ellis and Holm [4] promoted the integration between a virtual and physical learning space. The research was conducted by assimilating services and support that line up to the results shaped by curriculum requirements, particularly technologically-mediated to offer personalized services and learning support to the students. The results of the study showed that the relationship between the virtual learning space and the physical learning space was not straightforward, but was rather complex and was best understood from the perspective of learning by the students.

Another study by Martinez-Maldonado et al. [5] looked into the approach of exploiting the collaboration between teachers and students by providing a tool called a multi-tabletop classroom system as a way to monitor classroom activities. The work was aimed towards helping students to work in a group in a classroom. For this purpose, a software system was developed, and it was monitored by the teacher who conducted the class. As a result, the multi-tabletop classroom was a method for a teacher to monitor collaborative learning activities. Also, the workspace design focused on solving communication issues to support information exchange during learning activities.

Research to date tended to focus on workspace design for improving learning activities, but none of the existing approaches provided the method to support the customer’s activities related to the use of the physical workspace. In one of a public university, the gen-Y engineering students are facing of workspace that has been designed without supporting their activities throughout a day. New age university should provide facilities where students not only gain knowledge but also develop soft skills to succeed both academically and professionally. This indicates the importance and necessity of developing a workspace design that support both academic and professional activities of the gen-Y engineering students.

Therefore, the aim of this paper is to use the product-service systems (PSS) concept to support innovative ways to integrate the physical space and offer services that are based on student activities that have high use of information and communication technology. PSS is an innovation strategy that produces an added value through the integration of products and services by adopting customer-centered activities [6], [7], [8]. The systems focus on fulfilling customers’ needs than on product purchases i.e. “I need a printer to print my paper”. Value creation during the product and service innovation can be achieved by knowing how the customer recognizes value [7]. Therefore, the role of a designer is challenged to move into a paradigm shift to synthesize different concurrent perspectives such as culture and society needs with respect to certain technological needs.

2. Literature review

2.1. PSS structure

1.1 PSS Structure

According to Morelli [9], the design of a PSS can be outlined by the following:

- The design of a PSS is a suggestion of a new combination of technological artefacts on the basis of functional factors designated by the designer.
- The contact between the designer of the service and the consumer or user is not refereed by the industrial artefact.

To create a PSS, the designer would have little control over the product life cycle because the product is usually a combination of an existing product. The product life cycle element which the designer can control is the stage of use [10]. Another challenge for the designer is the integration of intangible value to promote a long-lasting relationship with the customer. The word ‘intangible’ based on Webster’s New
World Dictionary is defined as something that cannot be touched, incorporeal, impalpable; that represents value but has no intrinsic value or material being; that cannot be easily defined, formulated or grasped [11].

There are seven main design challenges regarding value proposition. The first one is defining the value proposition. This is because of the challenge in obtaining a clear definition of value proposition for the users. Most companies tend to create long a relation with users, thus making excellent value proposition becomes a key element to make the relation last longer. The second challenge is maintaining the value proposition over time. This means maintaining the interaction with the user. The third challenge is creating meaningful high-quality interactions which is by understanding the component of the human. The fourth is creating coherence in a smart PSS. Coherence is important because it has multiple touch points in the system. The fifth challenge is stakeholder management.

This is because multiple stakeholders will be involved, thus management of the stakeholder is an important factor. The sixth challenge is clear communication tools to create a shared vision. The last challenge is the selection of the means and tools for the design process. This is because designing a smart PSS requires good tools and methods to support the design [12].

The development of a PSS needs to consider the procedure and tools used to create the product. PSS can be defined as systems which make up service units and physical objects. Therefore, the design of PSS requires an approach that can link physical objects and services. The physical objects are functional entities that convey the elementary functions of the system, while the service units are entities which are mainly technical that determine the smooth functioning of the whole system [13]. One of the approach is User Centred Design (UCD), which is considered as the key to the usefulness and usability of the product as an effective approach to overcome the limitations of an out-dated system centred design [14].

2.2. User-centered design as a catalyst for innovation

User-centered design (UCD) can be described as a design process in which the user has an impact on the design process for building better and more practical space [15]. UCD is a multiple design approach based on the involvement of users to increase consumer understanding and service requirements and evaluation.

The product engineer should consider the consumer as an individual, possessing individual aptitudes, experiences, and characteristics while taking note the skills and limitations of all potential consumers [16]. Products designed in this way will be suitable to be used by people with the broadest possible range of skills, within the broadest range of conditions, reaching most potential end users. Therefore, UCD is an approach that designs a system in such a way that aims at consumers' attitudes and behaviours as they relate to the tasks that the system is being developed to support. As a result, UCD offers a product that is more efficient, satisfying, and user-friendly for consumers, which may increase sales and customer loyalty.

3. Designing learning environment method

The method that is used to design the OneForAll Center is based on the integration of product and service as discussed in the PSS concept proposed by Morelli [10]. However, the method to identify customer needs accurately and extensively is not mentioned in his method. Therefore, this paper extended his work by integrating the statistical analysis for designing a learning environment workspace for Gen-Y (figure 1). Survey and interview were used to elicit the user requirements in this study.
The focus of this case study was limited to students at the Engineering Faculty at a public university. The students were provided with good facilities on teaching and learning. However, the learning environment outside the classroom had some deficiencies. Therefore, the OneForAll Center referred to the learning environment outside the classroom. The design of the OneForAll Center was not based towards the learning process, but on the environment of the workspace design of the OneForAll Center which will then affect the learning process.

4. Results and Discussion
The learning environment workspace is called the OneForAll Center. The proposed workspace is a PSS-based design that aims to provide a comfortable area by fulfilling the customer’s intangible value in a physical workspace design. The customer’s intangible value in this case study referred to the basis of this work which suggested that outdoor activity increases motivation and self-esteem [17].

4.1. Validity of questionnaire
The participants included diploma students, undergraduate students and master students of the Manufacturing Engineering Faculty who attended classes or discussions at UTeM. A total of 389 participants were involved in this survey as shown in Table 1. The Cronbach alpha value for the overall questionnaire was 0.841.

4.2. Demographic Result
The first part of the questionnaire aimed to identify and obtain a picture of the background of the potential users. The questions were formulated to picture the students’ lifestyle and their expectations of the OCS development. For this purpose, six questions on demographics were asked including gender, the year of study, whether the student owns a transportation, their current place to stay during class gaps and his/her activity during class gaps.

Table 1 shows the places that students prefer to stay at during a class gap. Most of the students preferred the cafe and the faculty’s lobby as the place to stay during a class gap. Based on the feedback from 389 respondents, a significant correlation was found between the year of study and the place to stay during the year of study. In this paper, the authors used the correlation that was proposed by Kotrlik et al. [18]. The more surprising correlation was between transportation and gender, year of study, and the place to stay during the year of study. The correlation was interesting because it showed the mobility of the student on campus. As the students change the year of study, and due to the University’s policy, they must stay in a rental house nearby campus. Therefore, there is a need of a motorcycle or car for mobility.

![Figure 1. The proposed approach.](image-url)
4.3. Characteristics of learning environment workspace
The second and third parts of the questionnaire aimed to elicit the characteristics of the proposed learning environment workspace. The characterization of the OneForAll Center was based on the requirements and the identified facilities. Table 2 shows the 12 statements on the feedback on requirements and facilities demanded. Due to limited space only a few statements are shown.

| Notation | Functional Components |
|----------|-----------------------|
| B1       | I am certain that students need a place to stay for a while waiting for the next class session. |
| B2       | I really would like to have a place that I can use laptops and connect to the internet |
| B3       | It is good to have a place for discussions. |
| B9       | Is it good to have washroom in the OneForAll Center area |
| B10      | I find it helpful if there is a gym in the OneForAll Center |
| B11      | I would like if a café is placed inside the OneForAll Center |
| B12      | It is good to have a game corners which provide board and card games for the students |

The top half of Figure 2 presents the intercorrelation among the six measures of demographics. Interestingly, there is a significant positive correlation (0.829, p<0.01) between the year of study and place to stay during the year of study, either at a hostel or rental house. Most of the students stayed outside the campus as hostels accommodated first-year students only. From this data, it can be seen that the transportation used in campus also has a correlation with gender (0.261, p<0.01), year of study (-0.227, p<0.01) and place to stay during the year of study (-0.193, p<0.01). Although the correlation is low, this shows that many factors influence a student to have his/her own transportation. Most of the students who did not have their own transportation liked to stay in campus due to the hot weather. Another factor was that they may not like to use the scheduled buses provided by the university to move between the rented house and campus or around the campus. Also, a carpool concept seemed popular among female students to cater to their student activities as well as reduce their expenses.
The bottom half of the table shows the intercorrelation among the 12 measures of customers’ requirements. It is apparent from this table that requirement on printing services (B5) has a high correlation with the place to stay while waiting for the next class session (B1) (0.519, p<0.01), as well as a place to hold discussions (B3) (0.506, p<0.01).

![Table of correlations]

**Figure 2.** The correlation between demography and functional requirements.

The more surprising correlation is for the OneForAll Center to have a place for discussion (B3) and a vending machine (B4) (0.494, p<0.01). The results showed the importance of a vending machine in the OneForAll Center. Similarly, the requirement of the vending machine (B4) has a positive relation with the requirement on printing services (B5) which is 0.521, p<0.01. Nowadays, many companies equip vending machines with cookies or chocolates. Having a short break or some refreshment during discussions or when printing assignments shows the need of a vending machine at the OneForAll Center. Also, there is a positive correlation of 0.545, p<0.01 between students requiring a green environment (B8) and a washroom.

4.4. The facilities and its services

A mean perception score was considered for assessing the functional requirement of the facilities and its services. The functional requirement refers to the area that was required in the OneForAll Center. The respondents were asked to determine the activities they would do if the OneForAll Center exists. Also, a rough design of the OneForAll Center was shown to the respondents during the interview to gain their trust to use the offered services in the future. The evaluation of each functional requirement varied from 1 (the functional requirement is not very important) to 5 (the functional requirement is very important). The results shown in figure 3.
The functional requirement area with the highest mean perception scores in the OneForAll Center was the area that has a place for the student to use their laptop and be connected to the network. This finding was consistent with Sudiran [19], who found the importance of the internet among students at the University of Muhammadiyah Malang with a mean perception score of 4.61. The mean perception scores showed that students were heavily dependent on the internet to find reading materials to complete their assignments and communicate with friends on social media. The internet had replaced the textbook in the library and became a way for students to solve problems for their assignments.

To ensure the students would frequently use the functional requirement, it is important to offer a suitable service that can be provided to them. Thus, the next important step is the identification of services to each area that was identified in previous steps through desktop study and the results of the interview. As a result, table 3 shows the tabulated data which consists of the functional components, attributes, and importance of a tentative architecture of the OneForAll Center.

**Table 3. The specification and related services of OneForAll Center.**

| Functional Requirement         | Priority | Attributes                                      | Services                                                                 |
|--------------------------------|----------|-------------------------------------------------|--------------------------------------------------------------------------|
| Area for discussion            | High     | Wide space                                      | Equipped with internet access                                           |
|                                |          | Can be used for 6 - 8 students                  | Well-maintenance of facilities                                          |
|                                |          | Comfortable                                     | Provides rental projector for easy discussion                           |
|                                |          |                                                 | Provides a way to easy rental projector                                 |
| Area to use laptop/internet   | High     | Equipped with internet access                   | Well-maintenance of facilities                                          |
|                                |          | Equipped with electrical sockets                |                                                                          |
|                                |          | Comfortable                                     |                                                                          |
|                                |          | Soundproof for privacy                          |                                                                          |
| Area for printing and photocopy| High     | Easy to access                                  | Provides other services such as binding, paper, poster printing,         |
|                                |          | Easy to use                                     | and colour printing.                                                    |
|                                |          | Equipped at least 2 photocopy machines           | Well-maintenance of facilities                                          |
|                                |          | Equipped with 2-4 printers.                     | Provides a way to easy payment                                          |
| Area for vending machine       | High     | Easy to access                                  | Well-maintenance of facilities                                          |
|                                |          | Easy to use                                     | Provides a way to easy payment                                          |
|                                |          |                                                 | Provides coupon to allow refill water                                   |
5. Conclusions

This paper introduced a new method to develop a learning environment that promoted out-of-class activities based on the preferences of students. This study was innovative by integrating the PSS concept in producing a series of services in relation to the functional requirement of the proposed area. This study proposed a place whereby the user can have access to a variety of services in one place. However, this study was unable to analyse the cost that would be required to develop the real building. The center was focused on services built in a single location which would lead to greater overall satisfaction. For a designer, PSS facilitates the users to interpret technological and cultural frames embedded in existing products, services and infrastructures, and to search for convergences between the cultural frames expressed by all the actors (people and technologies) involved in the development of the project.

Another advantage of the OneForAll Center is that indirect learning may happen inside the proposed learning environment which eventually may strengthen the social connection outside the classroom. This may happen as students who come and stay inside the proposed OneForAll Center during their class gaps may eventually start to socialize with each other inside the proposed learning environment.

Other than the social aspect, the OneForAll Center is also a sustainable environment, such as by reducing the need for many buildings. This is because the OneForAll Center is a building which has many facilities inside, thus making it much more efficient. With the OneForAll Center, it could reduce the amount of building material used. This will also help the environment in the long run because there would be less construction needed. Other than that, one of the OneForAll Center services and facilities introduces a bicycle renting service. This could establish a green environment lifestyle. With bicycles, the amount of toxic gas emitted by vehicles such as cars or motorcycles could be lessened. This would end up in creating a clean atmosphere around the campus in the future.

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