

## What designers of an Innovative Learning Environment should know about I.R.4.0 and its impact on Spatial Design.

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Received: 1<sup>st</sup> May 2020

Final version received: 23<sup>rd</sup> July 2020

The aim of this paper is to study the relationship between the global changes of the fourth industrial revolution (I.R.4.0) and how it affected the learning environment. Understanding this relationship could help architects and designers to design innovative learning spaces that responds to the changes in the needs of education and the users. This paper outlines the many important phases of I.R.4.0 and how it affected our lives and changed our needs and ways of learning. Subsequently, the design of learning environments should respond accordingly in order to adapt to these changes. These changes are part of the Malaysia Education Blueprint 2015-2025 for Higher Education, which states its goal as to focus on improving the learning outcomes rather than inputs. In addition, it also aims to integrate technologies and learning innovations to improve and personalize the learning experience in order to respond to the needs of the students. The findings of this paper will help architects and designers to understand the new types of learning styles and trends and therefore design a learning space that can serve these trends and other future learning styles.

**Keywords:** Future learning, Internet Of Things, Education 4.0, Learning Experience, Personalization

### 1. INTRODUCTION

The constant changes and the new technologies and innovations in the global market are putting pressure on the workforce and more pressure on the fresh graduates who are facing high expectations from the moment of graduation. This pressure can only be reduced by improving the student's social skills and prepare them to become future proof through the innovative and collaborative learning styles. Parrish (2016) states that the main goal of the higher educational institutions is to prepare the graduating students to be employable, future proof, and to be able to achieve their goals by responding to the changes of the 21st century which require these institutions to provide high quality learning

environment that is personalized, future-oriented and student-focused.

Global changes such as I.R.4.0, technology changes and the internet have changed the way we think, live, work, and learn. The education sector is one of the sectors that was greatly affected by I.R.4.0, by merging the internet and new technologies with the learning process. This has led to the changes in the educational models and the learning models which will continue to develop as long as the world develops (Alaloul, Liew, Zawawi, & Mohammed, 2018). These new learning models require different settings in physical environment to enable them to support the needs of learning.

According to McDaniel (2014), along with the changes in the learning models, comes the growing population of the students in higher education institutions. It is partly due to the increasing role of higher education in employment and professional-oriented jobs popularity. The diversity of the students has resulted in universities learning environment to be unable to fulfil the different needs of these students.

## **2. THE FOUR INDUSTRIAL REVOLUTIONS**

In the past years, the role of the internet and digitalization has grown bigger than ever. It has taken a major role in our education, industry, healthcare, security, and every other aspect in our life. This revolutionary transformation of the modern life is referred to as Industrial Revolution 4.0 (I.R.4.0). This transformation has come after three other industrial revolutions that led to its success.

According to Schwab (2016), the first industrial revolution, in the 1760s can be seen in machine production, water and steam power. The second, in the 1870s which was also called technological revolution used telephones and electrical power. The third, in the 1950s and also called as the digital revolution was a transition from mechanical power to digital technology, and the fourth industrial revolution which can be characterized by enhancing the connection between man and machine which is used to automate human activities by using applications (apps) and software.

### **2.1 THE FOURTH INDUSTRIAL REVOLUTION (I.R. 4.0)**

Idris (2019) stated that the fourth industrial revolution has led to the improvement of the efficiency of the industrial production by connecting human to the production process which has resulted in a full-time control and less production errors. I.R.4.0 has also led to the creation of smart hospitals, smart restaurants, smart universities and smart factories which can be remotely controlled through handphones. I.R.4.0 adaption was a big part of the success of the Malaysian industry as it reduced the production cost, improved the quality and

increased the profit by using smart systems in the Malaysian factories and production process. With the many benefits of I.R.4.0, the smart systems and robots have taken over many of the manual jobs which led to many professions to go out of date and obsolete.

According to Ślusarczyk (2018), there are many important characteristics of the I.R.4.0 as shown in figure 1. Naleer (2015) states that Cloud computing can be defined as a large number of systems that are connected through a network that allows them to work together to create an infrastructure. Madni & Sievers (2014) defined system integration as connecting multiple components with separate individual systems to enable the control of multiple specialties by a single operator for a better infrastructure. According to White & Ingalls (2009), simulation is the process of creating a model of a real system in order to improve the system before creating it. Additive Manufacturing or 3D Printing, is defined by Dehghanhadikolaei, Namdari, & Mohammadian (2018) as the process of modeling by material layering based on digital 3d data. Islam, Hong, & Sattar (2019) stated that autonomous robots are robots with provided sensors and microcontrollers that have the same purpose of data evaluation and processing as human senses and brains. Riahi & Riahi (2018) defined Big Data as analyzing a large amount of data and resources that require a special type of processing.

Augmented reality is the process of using screens, VR, cameras or other display devices to merge the digital world with the real world (Carmigniani & Furht, 2011). The famous game 'Pokemon Go2' is an example of augmented reality. According to Abomhara & Koien (2015) Cybersecurity is the security methods used against hacking, of data, privacy or confidentiality. Internet of Things is the use of remotely connected devices and systems that are connected through sensors and other embedded physical parts (Patel, Patel, & Scholar, 2016). Almost every device that are used today (smart phones, computers, cameras, cars) have the sensors to connect to the internet which is how IOT affects our life today.

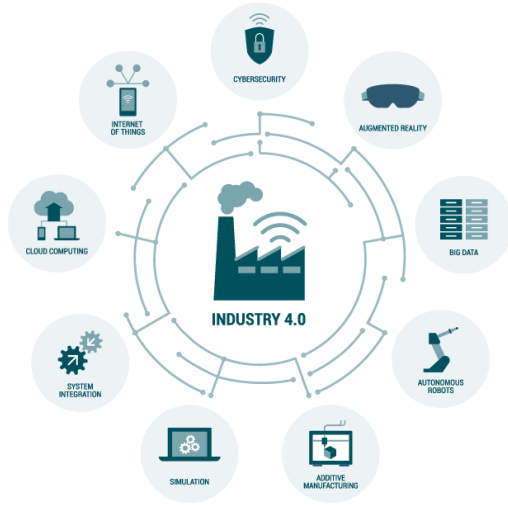


Figure 1. The main phases of I.R.4.0 (Ślusarczyk, 2018).

## 2.2 INTERNET OF THINGS (IOT)

It is agreed by many that the IOT has changed our entire world. It has already changed our science, industry, education, communication and businesses. According to Granell, Commission, Kotsev, Commission, & Ostermann (2020), the internet is considered to be the biggest invention in the history, and IOT can be considered the next evolution of the internet that uses its abilities to the fullest to gather, analyze, and share data for knowledge.

IOT can be considered as a system made out of multi networks that remotely control multiple systems and objects with added security which can improve the control and reliability of these systems for better achievements (Patel et al., 2016). IOT therefore applies to every field. From industry to retail to healthcare to construction. Granell et al. (2020) also stated that there are many obstructions that stands on the way of IOT development such as limited energy resources, and shared standards. However, these obstructions are being handled with new innovations.

According to Patel et al. (2016), the IOT has affected our lives through its effect on five major aspects which are; business and manufacturing, healthcare, retail, security, transportation and education, which is referred to as Education 4.0.

## 3. EDUCATION 4.0

Just like any other aspect, the education has been widely affected by I.R.4.0 and specifically the IOT. These changes can be seen in the new learning methods and spaces that merge the internet and technologies in the learning process. There are many factors that contributed in the transformation of education such as the advancement in technology, the increasing number of non-traditional learners, the increasing opportunities for professional-oriented jobs and reduction of traditional manual jobs that has been taken over by machines (Wagner & Wallner, 2016). According to Keser & Semerci (2019), this transition also required students to have higher social skills for surviving and problem solving to have the ability to respond to the fast-changing market demands.

Mourtzis, Vlachou, Dimitrakopoulos, & Zogopoulos (2018), stated that the innovations resulted from the IOT made learning possible anytime and anywhere through smartphones, computers and other IOT communication devices. The impact can already be seen in virtual and open universities that made distant learning available for anyone. According to Pai, Vikhyath, Shivani, Sanket & Shruti (2017) in their report titled 'IOT Application in Education', as shown in figure 2, IOT has affected Education in many ways such as:

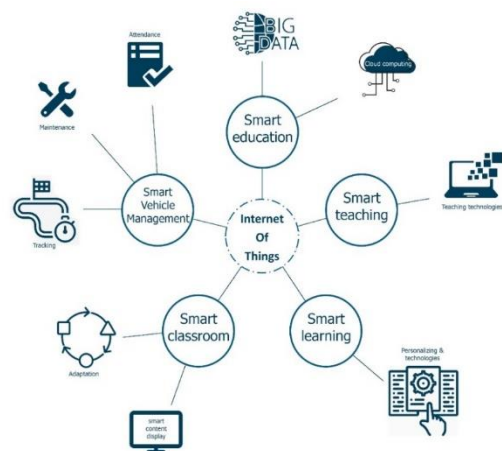


Figure 2. IOT in Education (Pai et al., 2017)

### ***Smart Teaching***

According to Saunders, Oradini, & Clements (2017), The new models of teaching that were only possible with the new technologies that it can use to deliver quality content.

### ***Smart Learning***

Pai et al., (2017) defined smart learning as personalized learning that uses smart technologies to be available anytime and anywhere for all.

### ***Smart Classroom***

An active learning space that is equipped with adaptive technologies and smart content display gadget to support any kind of learning model (Pai et al., 2017). Most of the requirements of a smart classroom cannot be seen in traditional classrooms which makes these classrooms unsuitable for smart learning.

### ***Smart Vehicle Management***

Helps remotely tracked and managed vehicles for more safety and reliability (Wolff, Kortuem, & Cavero, 2015). This can be used to monitor vehicle roots, alert when maintenance is required or monitor student's attendance at all time.

### ***Smart Education***

Pai et al., (2017) states that smart education was created by merging the IOT technologies into the learning process such as Big Data and Cloud Computing in order to improve the education quality. According to (Pai et al., 2017), IOT new technologies and innovations has affected education in many ways: Improving the learning experience of the learners by creating a perfect learning platform using the IOT technologies (Pervez et al., 2018).

The technologies of the IOT can help create better content display and delivery. Improved operational efficiency by easily managing operational system through the IOT technologies (Pervez et al., 2018). This can help to keep track of staff, students and resources for more reliability. Also, using different IOT technologies in the management system reduces the cost of management and observation as it will be done automatically using smart devices (Pai et al., 2017). This will also cause many manual jobs to be outdated and replaced with technology. According to Pai et al. (2017), using the IOT technologies in the management system leads to

improve the reliability and effectiveness of the system and therefore higher profit. The new IOT technologies can also be used in the educational institutions to keep track of the users' behavior and movement, improve the fire safety system and effectively manage the outdoor spaces (Pai et al., 2017). With the on-time monitoring and observation the safety and reliability of the entire educational system can be improved.

## **4. THE CHANGING NATURE OF THE STUDENTS**

The availability of the internet and the technologies worldwide has changed the way students learn and receive the information. Students today seek freedom and control in their learning process which caused traditional learning models to be unable to serve their needs (Glasby, 2015). Furthermore, the increasing popularity of professionally oriented jobs and higher education has led to the increasing number and diversity of students to include different nationalities, age and culture which also let to their diversity of needs and expectations (Altbach, P. G., Reisberg, L. and Rumbley, 2018). According to Glasby, 2015, students of today:

- i. They avoid face to face social interaction as the internet has provided different kinds on interaction
- ii. They consider the time spent on technologies and social media a rest time.
- iii. Fast responding to communication through social media
- iv. They have higher awareness gained by the indirect learning through the internet.
- v. They have higher language skills and learning abilities due to social media interaction.

Therefore, flexibility and connectivity in new education is required to support the expectations and the needs of these students. This kind of flexibility can no longer be provided by traditional learning models which is increasing the gap between the students' needs and what the current educational institutions are able to offer.

## 5. LEARNING MODELS IN EDUCATION 4.0

Learning in this era or Education 4.0 should be flexible and have the ability to offer multiple learning models that supports the needs of wide diversity of students with different background. Redecker et al. (2016) stated that many specialists agree that a supportive learning should focus mainly on personalization, collaboration and informalization (figure 3) along with merging the new learning technologies in the learning process can also support and improve the social skills of the students to adapt with the continuing changes in the market demands and work in different working environment.

### *Personalization in education*

With today's wide diversity of students from different cultures and backgrounds, learning environment should be personalized and custom made to serve any type of students (Glasby, 2015). Which according to Redecker et al. (2016) will also help students with issues to acknowledge and face the issue, to further engage in their community.

### *Collaboration in education*

Communities worldwide tend to move toward flexibility and interculturality. This causes fresh graduates to struggle into finding their place in community (Glasby, 2015). To help with that, educational institutions should work on improving the learning aims to adapt to the social needs and teach the students how to be an active member in community.

### *Informalization in education*

According to Redecker et al. (2016), as information and learning opportunities became available anytime and anywhere through the internet, educational institutions' role is no longer to give the information to the learner rather than to monitor their progress, leading them into the learning opportunities that best supports their needs and support them in difficulties.

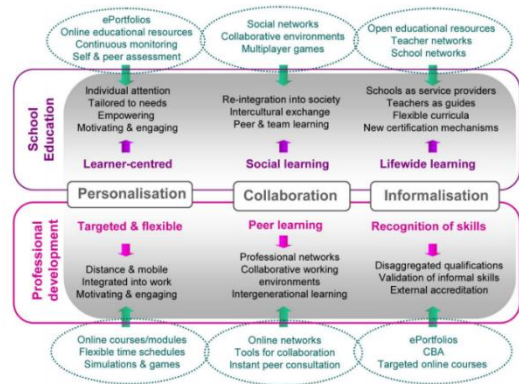


Figure 3. Learning of the future (Redecker et al., 2016).

### *New learning models*

Several new learning models are being presented in schools and universities. These models can be personalized and collaborative to support the students' needs: **Online learning** Is a type of distance learning that takes place over the internet, which enables it to be taken across distance instead of traditional classroom (Stern, 2014). Virtual universities and online courses are a good example of online learning. According to Boruvkova & Emanovsky (2016), **group learning** is learning that accrues with a group of individuals who are related emotionally, culturally or educationally in the same interests in learning, problem solving, and product creating whereas learning comes by sharing knowledge and interacting with others.

**Crossover learning** consists of enriching the traditional classroom learning with informal learning (Sahaja, Priyanka, Anisha, Murthy, & Road, 2019). Learning institutions sometimes use field trips, clubs or museum visits in an attempt to create crossover learning. **Computer assisted learning** is learning that is supported by computer programs and multimedia that can be customized to support every individual's needs (Holt et al., 2016). Computer assisted learning can be distant learning or within the learning space with the help of an instructor. Andresen, Boud, & Cohen, (2016) stated **Experience-based learning** is where learning is enriched with experience. Students reflect the knowledge on the experience that they have to conceptualize and come up with a conclusion about what they have observed. **Informal / Indirect learning**, also called self-teaching, according to Peeters et al. (2014)

informal learning consists of learning by performing self-tasks and projects to gain knowledge without assistance which can be intentional and unintentional.

## 6. PHYSICAL LEARNING ENVIRONMENT IN RELATION TO EDUCATION 4.0 LEARNING MODELS

There are many theories on the characteristics of a learning space that supports the new learning models and can be flexible and adaptive to support the future changes in the learning types. According to Duvivier (2019), flexible learning can be done in any space as long as that it has internet access and provide comfort (figure 4). This is why many modern style cafes merges the living activities and internet access with the working environment. This type of environment is supportive and encouraging for learning and collaboration.



Figure 4. Informal learning spaces (Duvivier, 2019)

Brown (2018) stated that new technologies need to be integrated into the learning space as merging the physical and the virtual learning has become a way of life and it continue to grow more importantly as time goes. Furthermore, the increasing number and diversity of students with different backgrounds and interests is becoming a bigger challenge everyday as most educational institutions are not designed to serve these kinds of students which according to McDaniel (2014) can only be overcome by creating flexible learning spaces that can be adjusted and customized based on students' needs. McDaniel also stated that universities and educational institutions need to offer a variety of learning spaces and models in order to survive the changes in the educational style and student's needs.

Learning spaces need to be flexible and supportive to both formal and informal learning activities and encourage students' individual and group learning. A successful learning space should provide comfort for the students by having a variety of comfortable furniture types along with chairs and tables of different sizes. Pantry and food service areas are also important to help students merge their living activities with learning (McDaniel, 2014). Most of the theories on smart or future learning spaces focus mostly on merging the daily living activities with learning activities.

According to Kim (2019), a researcher in Steelcase (a leading manufacturer and developer of classrooms, work spaces and office spaces), a successful learning space should focus on having 3 elements: pedagogy, technology and flexible space. He proposed the Flipped Classroom (figure 5) as a learning space model that promoted active and collaboration learning between the students. It consists of flexible furniture and round tables with different sizes to support individual and different group sizes.



Figure 5. Informal learning spaces (Duvivier, 2019)

It also contains lounge corners for comfortable seating and natural elements. The arrangement of the classroom is designed to allow easy movement of the instructors and the students. It's proven that students spend more time at the space when they feel control over its elements (McDaniel, 2014). That's why using flexible and movable furniture and allowing students control over the heating, cooling, food service and encourages their engagement in the space and learning.

Merging technologies in the space is also a very important part of a successful and future proof learning space. According to Niemi, (2018),



using different types of display options such as screens, projectors and other interactive working surfaces along with the traditional white board or chalk board helps with easier content display. Also providing space dividers and storage spaces helps students feel more control and comfort in the space which leads to encouraging their engagement in the learning process.

## 7. CONCLUSION

The main purpose of higher education today is to improve the employability opportunities and to respond to market demands. However, as the market demands constantly change according to new technologies and innovations, the educational sector is still mostly the same. Therefore, urgent changes and developments are required to fill the gap between the current education aims and market demands (Parrish, 2016). Multiple new learning models are being presented today by educational institutions. However, the traditional learning spaces in these institutions were not designed to support these finds of learning models which is why most students today prefer working in café style spaces that gives them more comfort and better supports their needs (Niemi, 2018). And even though the new communication technologies have introduced us to new types of communication, a face-to-face interaction still plays a very important role in the learning of the modern learner. The findings of this study will help architects and designers to understand the new types of learning styles and trends and therefore design a learning space that can serve these trends and other future learning styles.

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