
Trends and issues of immersive learning environments in higher education from 2001 to 2020: perspectives on adaptive ubiquitous learning experiences

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Abstract: Immersive Learning Environments (ILE) has been applied in many learning disciplines as a tool for providing a virtual interactive learning environment. With the advantages of ILE that could provide a playful and active learning experience in the learning processes, the ILE has been considered as another effective learning methodology using in learning processes together with the ubiquitous learning that provides the ease of access to the learners and encourage with self-learning management. This paper reviewed the ILE related 75 studies which were collected from the web of Science database, then discovered the insights of the collected studies about the application of the ILE in various learning disciplines. The insights of integrating the adaptive learning experience toward the collected studies are discovered to present the ideas of ILE application with adaptive learning experience toward various learning disciplines. The review of ILE studies may provide the benefits for the education researchers by finding the technology used in the ILE studies, finding the ideas for integrating adaptive learning with ILE, and discovering new perspectives and ideas for studying and researching in the learning context.

Keywords: immersive learning environments; adaptive learning; higher education; pedagogical issues; teaching strategies.

Reference to this paper should be made as follows: Seprum, P. and Wongwatkit, C. (2022) 'Trends and issues of immersive learning environments in higher education from 2001 to 2020: perspectives on adaptive ubiquitous learning experiences', *Int. J. Mobile Learning and Organisation*, Vol. 16, No. 1, pp.95–122.

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1 Introduction

Immersive Learning Environments (ILE) is referred to as a learning process with a scenario, which it is created or developed by using techniques, technologies and software tools for providing the virtual interactive learning environment (Jantakoon et al., 2019). The ILE could be presented in many types, e.g., it could be game-based learning, simulation-based learning and virtual 3D worlds and environments (Panconesi and Guida, 2017). The benefits of ILE provide the virtual realistic learning environment and situations that can be interacted with for practicing or training the specific skills to the learners. Besides, the abilities of ILE could provide a playful and active learning experience through the processes of learning for the learners, and the interaction activities between the students, devices sensory, and the learning environment that could engage the students effectively in the provided learning experience. The ILE learning experience which could be provided to the learners can reduce the learning costs in training and secures the training process (Bhattacharjee et al., 2018). As the advancement of technologies has developed as the times moving on, the difference of the technologies that are applied in ILE can be separated into three periods. Three periods of time define and categorise the different technologies used in ILE. First, The First-Age of ILE which is the time (2001s–2007s) that technologies used in ILE were not advanced, there was the use of web-based technology and development of specific technology in ILE learning which could provide only a little immersive experience to the learners. Second, The Middle-Age of ILE (2008s–2015s) the age of time which were the advancement of popularities of technologies as Augmented Reality (AR) in the commercial context and learning context, this age of time offers a more realistic environment and experience for the learners as it offered the abilities for interaction between learners and the technologies. Third, The Late-Age of ILE (2016s–2020s) which is the age of last 5 years as the time this paper has been written, this age provide the most realistic learning environment for the learners as the popularities of Virtual Reality and Mixed Reality have been widely used around the world. It offers realistic sound, environment, and scenario for the learners' perception together with the interactive learning environment at the same time.

Additionally, there still are limitations of learning in each discipline in a Higher Education environment. Especially, the discipline that must depend on the practicing and training experience in a real-life situation, the wasting of resources, equipment and budget might occur between the process of learning (Luo et al., 2016). One of the disciplines which require various types of resources is the medical and nursing discipline, the medical and nursing learners must depend on practicing, testing, and experiment. While the processes of training and practicing are the necessary processes that must be

done. One of the limitations of the medical and nursing could be the human resources because there might be consequences, damaged and bad results as the processes require the real human-being to practice with (Ali et al., 2017). On the other hand, practicing with some practicing puppets or devices might prevent from causing damage, but cannot provide feedback to the learners unless the instructor must be there to provide guidance and feedback. It's still impossible for the instructors to provide suggestions and feedback to every learner closely, and it might cost a huge number of budgets to provide more instructors to supervise every learner. Another learning discipline which might require the training experience is language learning, it requires repetitive learning for the learners to help them remember the vocabularies, grammars, or sentences of the language which may reduce the engagement and attraction of the learning process (Reitz et al., 2016). Also, the social studies learning discipline require a field trip or the historical places and stories to help the students understand the history, cultural and geography knowledge in the course. It might cause a huge amount of budget to provide the real-field trip experience for every student in every course (Deffner and McElreath, 2020). These limitations of learning disciplines are one of the many learning disciplines which have similar problems, the obstacles and barriers still exist in the learning context at present.

Even though the technologies have been advanced since the past until the present time, the limitations in the learning context still exist in many ways. Therefore, to solve the limitations in each discipline on HE, the ILE could be the tool for extending the limitations of learning in each learning discipline. For further explanation about the impacts of ILE for decreasing the boundaries in each discipline in higher education, the limitations of medical and nursing disciplines would be referred to the ILE could simulate the virtual situation scenario for practicing with realistic patients to reduce the limitation in practicing and training in the real-life context. The application of the learning scenario in ILE practicing can be provided to the learners in various ways, the instructors could design the ILE learning process in under-pressure learning scenarios or non-under pressure scenarios. As well as providing feedback and guidance to the learners through immersive learning environment worlds, ILE provides guidance and feedback at the same time as learners go through learning processes. The learners could learn through trials and errors, fabricate as many mistakes as they could with non-additional costs, and following negative consequences required comparing to the real-life practicing and training. For the language learning discipline, the ILE technologies advantageousness could provide playful interactive and engaging learning for the students to reduce boredom and increase the enjoyment and attraction of the learning processes. The ILE can provide dynamic forms of learning tools like Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), robotic learning kits, and more. These could be considered as ILE technologies. Moreover, the ILE provides virtual field trips, history, geography and culture in many courses to give a realistic experience for the students in social studies learning. The simulation can be a realistic 3D, simulation or game-based learning experience for engaging the students with suitable learning methodologies. The ILE application could also reduce the costs of budgets, times and human resources which might occur without the application of ILE. Last but not least, the virtual, simulation and immersive experience are not the only experiences in ILE, the interactive learning also considered as one of the experiences which could be delivered to the learners for enhancing the ILE experience to make the learning experience more realistically, playfully, dynamically and flexibly.

Adaptive Learning Experience (ALE) can be explained as the learning experience related to online learning that provides personalised learning experiences as the data gathered from the learners' behaviour for designing the learning curriculum. ALE could be generated through the methods of algorithms development, learning data analytics, assessments and feedback data from the learners to assist the learners to achieve the knowledge in a suitable learning environment designs through ALE (Shelle et al., 2018). There are several ways of adaptive learning for adapting to the learning environment. Firstly, adaptive learning could be used to adapt the User Interface (UI) design for the learners, each of the learner's perceptions, and style preferences can be different in each one of them (Soh et al., 2017). With the ALE, the elements or environment that the learners would be provided could change and adjust in better ways, whether the adaptation of colours for the kids, teenagers, adults and the old people or the position of the UI elements to answer the need of people with astigmatism or adapt following the learners' behaviour. Secondly, the adaptation of the User Experience (UX) can be considered as the factor to determine the familiarity of the users and to determine the ease of use or learning for the learners toward the learning processes (Moniaga et al., 2019). Thirdly, the adaptation towards learning mechanics, the learning mechanics within the learning processes are another factor that could be adapted through ALE. For providing more suitable learning mechanics for learners, the learning behaviour data should be analysed and the ALE should be applied (Pastushenko et al., 2018). Fourth, the learning flow, each of the learner's learning processes may be suitable with a unique sequence of learning, and each of them may require specific knowledge before receiving the main knowledge of the content (Balasubramanian and Anuncia, 2018). Hence, the ALE could be used to provide the adaptive learning flow in the learning processes. The methodologies for adaptive learning could proceed in many ways. One of them is a manual adaptation, this method requires the instructor or teacher to analyse the learning data and outcomes from the learning, then the teacher could manage the adaptation of the learning following the analysis's result through the learning system. Another methodology is learning adaptation through the smart-adaptation system, by gathering data as the following examples; behaviour, result, outcome, performance, feedback data of the learners. These data could be collected while the learners go through the learning process, then these data would be used as the training data for Machine Learning (ML) model, Artificial Intelligent (AI) and related tools. Besides, the data might not need to be handled by the ML and AI, the data might be used as the factor for fixed condition algorithms of the learning system to provide the adaptive learning experience to the learners instead. Through the smart-adaptation system, the learning system could provide an adaptive learning experience to the learners for the suitable environment, the learning system might be designed as a system that would adapt the difficulty of the contents for each individual or the system could adapt the learning preference styles for each of the individuals to make the learning different and effective in each of the learner learning styles.

Furthermore, immersive learning could be provided through the mobile device, which means the learner can access the immersive learning experience from their desired places, and desired times for their learning activities in the present. Along with the effective learning activities from the adaptive learning experience that could analysed the learners learning preference for providing the suitable learning processes and achieving the effective learning outcomes of the learners. The adaptive learning experience can provide suitable learning processes to the immersive learning environment for finding a

better learning environment for the learners. The ALE enhances the learning experience for ILE as the system that can provide a personalised learning experience for the individuals to stabilise or increase the learning motivation, learning satisfaction, and learning outcomes of the learners while they are interacting with the ILE. The immersive learning experience with the adaptive learning experience could be considered as ubiquitous learning by providing the ability for ease of accessing learning experience both of time and place, ease of receiving and transferring the information to the learning processes. Besides, this method of ubiquitous learning also encourages self-learning management which the learners require for learning by themselves in their desired learning environment (Thanyaphongphat and Panjaburee, 2019).

With the advancement of the immersive learning technologies, the new dimension for learning has been provided to the learners whether in the perspective of the learners, more realistic simulation, and perception together with an interactive learning environment that could be designed for achieving various fields of learning discipline and skills. However, for the examination of the trend of immersive learning applications in the last 20 years, the related studies have been collected and analysed in this paper. According to the collected studies related to the immersive learning environment that has been found and analysed, the perspective on the adaptive learning environment towards those studies would be applied to find the opportunities for enhancing and improving the learning methodologies.

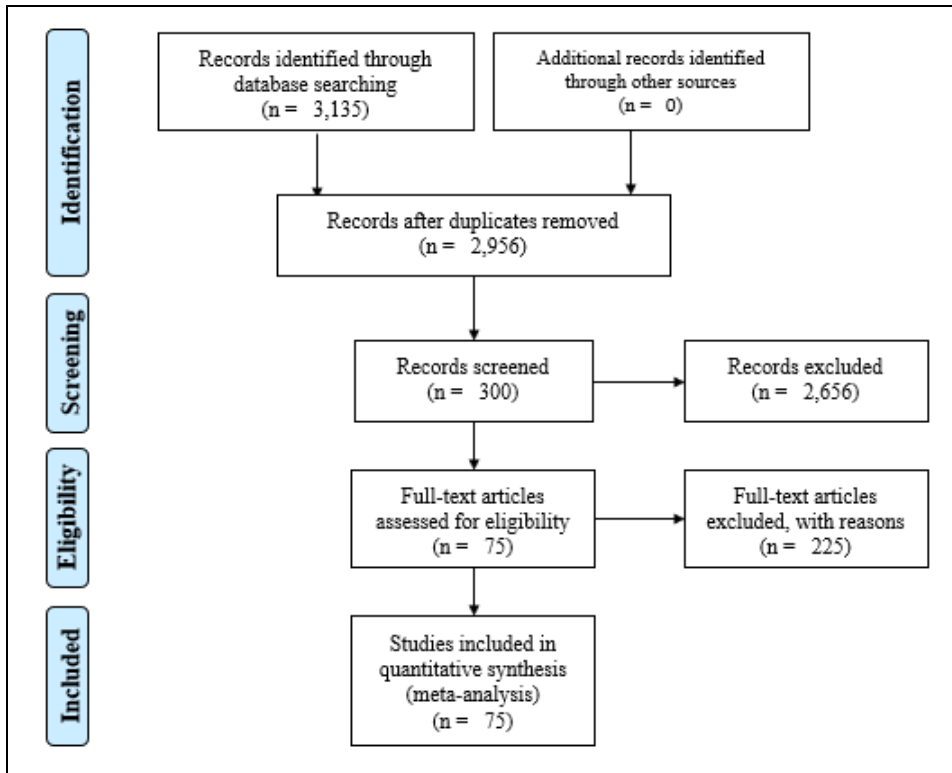
2 Research methods

2.1 Resources

This study followed the PRISMA or Preferred Reporting Items for Systematic Reviews and Meta-Analyses model as the guidelines for study identification and selection. Figure 1 illustrates a whole process according to PRISMA's guidelines. To find the studies which are covered in an immersive learning environment field, the journal publication scope must be set for finding the related studies to be used for the review. In this paper, the authors have gathered the studies from the web of Science Core Collection database as it is one of the most highly significant databases that collected high-quality researches and frequently used as the source database in scientific trends analysis (Ale Ebrahim et al., 2019; Chen et al., 2016; Kasurinen and Knutas, 2018). The top 10 journals from journal ranking of the E-learning subject category in the Index of Social Sciences Citation Index (SSCI) have been selected. The length of time of the gathered studies is between 2001 and 2020. The process of gathering has been done through searching by the following 2 groups of keywords. The first group is the keywords for setting the scope of the results to be related in the immersive learning field, and the second group of keywords is for determining the results which are applied in higher education. The first group of keywords serves as the keyword for determining the relevant studies about immersive learning and interactive learning which studied the effects, outcomes, and results of applying the ILE in learning consisting of 'immersive learning', 'virtual reality', 'augmented reality', 'virtual learning environments', 'VLEs', 'mixed reality', 'VR', 'AR' and 'MR'. The second group of keywords serves as the keyword for determining the relevant studies that applied the ILE in the higher education context consisting of 'higher education', 'university', 'undergraduate', 'pre-service

teachers' and 'college'. Both of the groups of keywords were linked together by 'AND' for querying the relevant studies of immersive learning in the context of higher education, e.g.: 'immersive learning' AND 'higher education', 'virtual reality' AND 'undergraduate'. Once the scope of the journal has been narrowed, the total results of the studies identified through database searching are shown as 3135 results. Then, the types of results have been filtered by focusing only on the article type to narrow the undesired type, and sorted by relevance to mix the years of publication, topics, and sequences. The amounts of the studies after filtering and sorting were found as 2956 results in every journal included. The relevant studies about 10% of 2956 studies or 300 studies have been screened for finding the eligibility studies as a sampling group and removed another 2656 studies.

Figure 1 Resource analysis process from the web of science core collection database



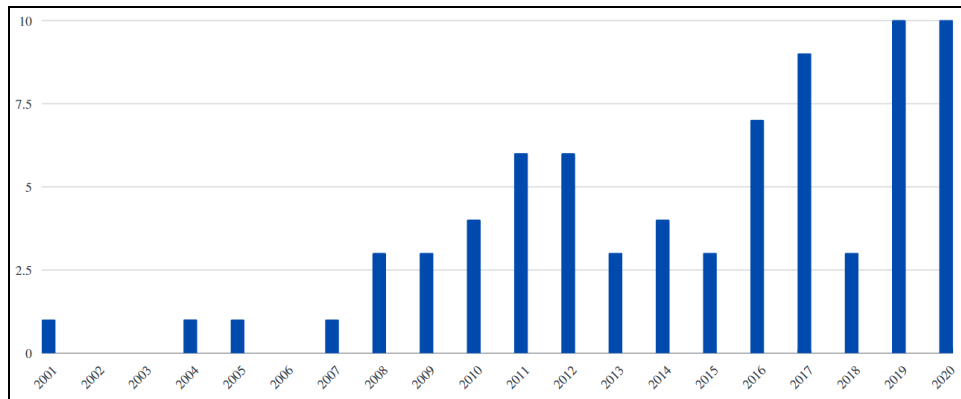
Through the screening process, 75 studies have been assessed as eligibility studies through the process of the studies' title, abstract and methodology reviewing. The inclusion studies must be related and applied immersive learning in higher education and must be full English text studies. Those selected studies have been considered as the immersive learning experience studies in higher education. The immersive learning studies can be explained as the studies which provide an engaging perspective environment and interactive learning activities for students to immerse students in the

learning process. Instead, the exclusion studies have been explored and removed for several reasons as the follows: (1) The studies not covered in higher education reviewing by the title, abstract and content of the studies (e.g., fireman training, policeman training and miner training), the number of studies is 19 studies (2) The studies have covered in the educations which are lower than undergraduate education (e.g., middle school learning, elementary school learning, K-12), the number of studies is 85 studies (3) the studies which did not provide the immersive learning experience (e.g., using podcasting in student, examine student flexible thinking, examine student PC using behaviour), the number of those studies is 115 studies (4) the studies that were the review studies, the number of studies is 6 studies.

2.2 Data distribution

The authors have explored the final 75 studies and found that the length of the studies' publication year is distributed during 2001–2020. According to Figure 2, the result has shown that there were a few numbers of studies in the time between 2001 and 2010 each year, but the studies about immersive learning in higher education have been very popular in 2011–2020. The number of studies has been increasing continuously compared between both periods of the times, the number of studies from 2011–2020 has been increased about 4 times more than 2001–2010. With the discovered result, it can be summarised that immersive learning is popular and can be used in learning in a large number of studies according to the advancement of technologies as time goes by.

Figure 2 Immersive learning environment papers publishing trend by year during 2001–2020



According to Figure 3, which shows the trend of the related studies of immersive learning in each continent. There is a near number of studies between Asia and the European continent, which are 26 studies for Asia and 24 studies for Europe. The following goes by North America with the number of studies equals to 18 studies, and the least one is Oceania equals 7 studies. Even though the difference is not much by looking at the continent's trend, there are huge differences in the country's trend according to Figure 4. The country which the greatest number of studies trends belongs

to is the USA, there are 17 studies published. Looking at Taiwan, Taiwan possesses 14 studies about immersive learning which can be said as half of the whole Asia continent’s overall studies.

Figure 3 Authors’ continent of immersive learning in higher education papers publishing

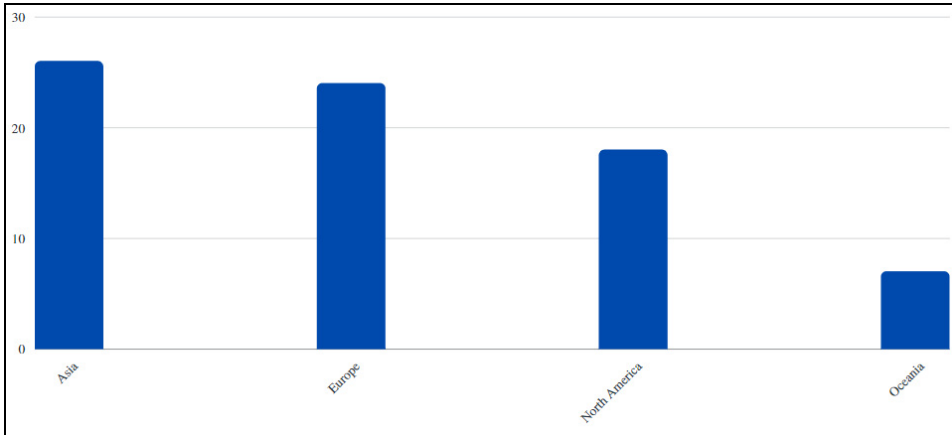
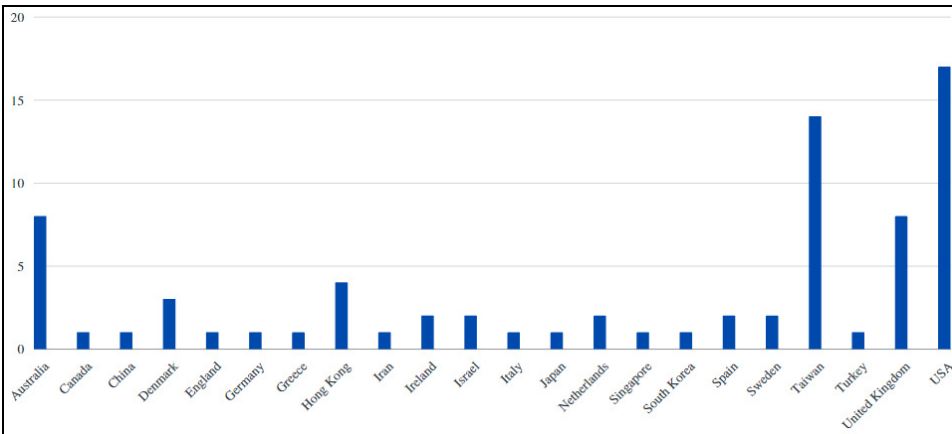
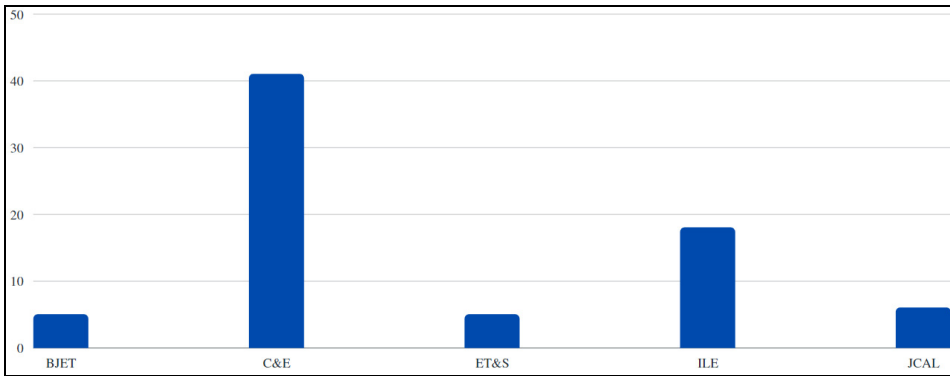


Figure 4 Countries publishing immersive learning-related papers in higher education



Like Figure 5, the trend of applying immersive learning in higher education of the studies around the world is very high in the *Computer and Education (C&E)* journal, in which 41 studies are published. Another journal that has the highest number of studies after C&E is *Interactive Learning Environments (ILE)*, the number of related studies that has been found is 18 studies. Followed by the *British Journal of Educational Technology (BJET)* with 5 studies, *Journal of Computer Assisted Learning (JCAL)* with 6 studies and *Educational Technology and Society (ET&S)* with 5 studies.

Figure 5 Immersive learning environment papers related published in 5 journals

2.3 Coding schemes

Once the final studies have been collected, the process for setting up the coding scheme must be followed. The purpose of setting the coding scheme was to categorise all of the studies which are gathered and divide them according to the studies' topics, methods and objectives. Another objective is for using the collected studies to review both of the ILE applications on the studies to immersive learning and explanation on the authors toward those selected studies.

After the exploration of the studies, the coding schemes have been categorised, this study categorised the coding schemes in 3 dimensions, including learning, training based on the objective and methodology of the studies that aim to provide ILE experience to the learners. However, some of the studies have provided ILE in more than one coding scheme, e.g., the study that provided the law education presentation training and assessment has been coded in both 'training' and 'assessment'. Each of the coding schemes would be described as the following:

- 1) *Learning*: The studies in which immersive learning has been applied and used in the classroom or used in learning some of the topics, contents, or subjects that are relevant to learning would be defined as matched with this coding scheme. For example the application of a virtual learning environment to provide the knowledge on using a turning lathe (Antonietti et al., 2001).
- 2) *Training*: Some studies have been used for enhancing the skills in a practical way for the learners, and also applied with an immersive learning environment. The studies which correspond to this field of the coding scheme could be applied in various industries and branches of training. Moreover, the ILE in training context allows the opportunities for practice in some specific career skills that are necessary and required intensive interaction or training in real-life for the trainees besides learning context, and also prevent from a risk or dangerous effects from hazardous situations (Makransky et al., 2019). To illustrate, the integration of an immersive learning environment to apply with the dental training for Healthcare education students (Diego et al., 2012).

- 3) *Assessment*: This paper also reviewed the studies which were used for quizzing, testing, examination, assessment, and diagnostic. As the studies which were applied to any of the mentioned fields with an immersive learning environment could be considered as the Assessment dimension. For example, the study applied virtual reality technology in the evaluation of the student to improve student skills through smartphones (McFaul and FitzGerald, 2020).

After the coding schemes have been defined, the data distribution has been discovered after applying the coding scheme, like the following: (1) Learning, the number of studies that relate to the learning and studying fields is equal to 60 studies. (2) Training, the studies in training fields were identified and the number is equal to 14 studies. (3) Assessment, the number of assessment studies field is equal to 8 studies.

3 Applications of immersive learning environment in higher education

3.1 Immersive learning environment on learning applications

For the context of learning, the studies that are considered as the application of the ILE in the learning field could be explained by looking at the methodology, process and objective. Whether the studies aim for applying the ILE for enhancing the knowledge dependent/independent, collaborative/competitive, or participant/avoidant of learning for the students (Cassidy, 2004); these learning styles could be considered as the application of the ILE in the learning context. The authors found and categorised the studies in the learning context which were defined as the following: (1) Game-based learning, learning provides the game learning environment to the students for increasing interaction, engagement, enjoyment and more (Chang et al., 2017; Hamari et al., 2016; Qian and Clark, 2016). (2) Simulation-based learning which provides the immerse situation scenarios of the learning pedagogy for the students (Muckler, 2017; Sarfati et al., 2019). (3) Video-based learning, the type of learning which provides media like learning materials for the students (Mitrovic et al., 2017; Mota et al., 2018), e.g., animations, videos, or 3D-modeling scenarios, with interactive or without interactive activities. (4) Blended reality learning, the learning which is designed for linking the real-world and virtual-world environment together. The case studies for each of the mention groups will be explained next (Bower et al., 2017).

For further explanation about the application of ILE in the learning context, the 4 categorised studies will be explained. First, the case studies for game-based learning that applied with an immersive learning environment would be explained. Many studies have integrated the game context with an immersive learning context, whether for the investigation, comparison, or just providing education knowledge in the studies. For example, Merchant et al. (2014) compared the effectiveness of game-based, simulation and virtual worlds learning to investigate the learning outcomes of the learners. Another case study that used game-based learning in an immersive learning environment was conducted by Chen and Hsu (2020), the study was conducted in a virtual learning environment that provides English learning through a mobile application that has the dialog, content and test items for the students. Many studies revealed that game-based learning can provide the students with effective learning engagement and learning experience during and after the students went through the learning processes (Chen and

Hsu, 2020; Ferguson et al., 2020; Lamb et al., 2018; Maratou et al., 2016; Whitton et al., 2014). Second, simulation-based learning. In 2017, Jang et al. (2017) studied the learning outcomes between a 3D virtual environment with an interactive activity and the 3D virtual environment with non-interaction activity, the anatomical knowledge was provided for the learners in this study. The additional case study for simulation-based learning was published in 2017. Dubovi et al. (2017) created and investigated the effectiveness of medication administration learning through virtual reality simulation for using as the learning tool for nursing students. Simulation-based learning can provide cognitive understanding through interactive learning experiences together with the support of the knowledge construction processes. As the interactive simulation-based learning can be designed as nearly realistically as the real-world physical, the students can gain the most benefits from the learning outcome (Ijaz et al., 2017; Jang et al., 2017; Lin et al., 2013; Rogers, 2011). Third, video-based learning provides interactive learning media for the students in the learning process. Lin et al. (2013) provided the interactive video-based virtual reality for enhancing the engagement and environmental knowledge of the learners. Besides, Video-based learning can deliver more concrete learning knowledge and practicing skills, it also provides a better learning experience and higher learning efficiency (Chang et al., 2019; Chen and Hwang, 2020; Yip et al., 2019). Fourth, blended reality learning, the case study is conducted by Bower et al. (2017), this study is the application of a virtual learning environment which is connected with the Face-to-Face learning environment in the real-world for finding the response outcomes of the learners. Providing the feeling of being a presence between the virtual world and real-worlds for the students as they connect to the classroom remotely.

The application of ILE for learning can be summarised as the method to provide a more interactive and engaging learning experience for the students with the ability to reduce the costs of budget and consists of realistic graphic visual, interaction, sounds and the environment in learning while the learning processes are being proceeded. Additionally, the ILE also provides ubiquitous learning for the students as they can access the learning by themselves from their comfort places in their free time or learning time and repeat the knowledge through the ILE. The possibility of improving the learning outcome of the students may require the interactive learning experience with the suitable learning presentation media for the students to make the learning processes have the most effective learning outcomes or results that could respond to the objectives of the learning disciplines.

3.2 Immersive learning environment on training applications

In the training context, the studies which applied the ILE in the training context could be investigated through the studies' topics, methodologies and objectives whether the studies were conducted for the training of the instructors or learners (Bujdosó, 2016; Stavroulia et al., 2018). The ILE in the training context was applied in many studies and many disciplines to conduct the virtual training processes that may require many factors in the real-life situation. The required factors in real-life context may consist of the high number of budgets, a huge number of trainers and trainees, the specific places and specific tools, and more; the mentioned factors may hard to acquire for many reasons but the ILE was applied to reduce those limitations and increase the opportunities for stimulating the realistic training experience. As the studies have been explored, the authors analysed and then found the studies that could be considered as the studies that

applied ILE in the training context on higher education. The analysed studies were categorised as the following: (1) Soft-skill training, the training that aims for the development of communication, emotional intelligence, self-management, and leadership (Thomas and Santiago, 2019). (2) Hard-skill training, the training that aims for the specific skills or technical skill training (Laker and Powell, 2011).

The training in soft-skills in a real-life context may require experience for communication, management, emotional intelligence skill development, the process for the development of these skills may take a huge amount of time, human resources (trainers and trainees), budgets and places. The limitation of soft-skills development can cause an obstacle and prevent students from achieving effective training outcomes. The case studies for integrating ILE in training for soft skill development were conducted many times. Chen et al. (2011) conducted a study for using the ILE in business negotiation training for the students. McFaul and FitzGerald (2020) examined the application of ILE on presentation skills in law education that recorded the video of the presentation of the students and gave feedback on the student's presentation skills. The soft-skills training with ILE could provide distance training and practice for both students and teachers, the students could access the learning processes in distance without the restriction of times and places to practice soft-skills while teachers could also access the learning system to provide feedback and evaluation of the students (Chen et al., 2011; Gunn et al., 2018; McFaul and FitzGerald, 2020; Petrakou, 2010). Some studies also suggested that teachers and pre-service teachers could be provided with the teaching practicing system as the same as students (Cheong, 2010; Dalinger et al., 2020). The limitations of the practicing and training are the same as soft-skills training for hard-skills training applications in ILE, but the additional limitations of hard-skills training are the chances of properties damaged and wasted of budgets, equipment and times. The case studies of hard-skills training were explored and analysed, one of the studies was conducted in 2018, Gunn et al. (2018) conducted the application of ILE on medical diagnostic radiography technical skills for the students. Another case study is conducted by Winkelmann et al. (2020), in which the study applied the ILE on comparing between virtual chemistry experiment lab and real-life experiment lab. The hard-skills training application with ILE that could be used to provide the dynamic, flexible and various learning scenarios for the students, the learning engagement and interaction were enhanced and provided to the students with effective training processes and learning outcomes (Diego et al., 2012; Makransky et al., 2019; Ramasundaram et al., 2005; Rogers, 2011).

The ILE could be used in the training context to provide new scenarios and pedagogies for both of the trainers and trainees, reducing the costs of times, budgets and failure risks in the real-life situation. The processes of training in ILE could also be used to enhance both the soft-skills and hard-skills for the students as the studies have been explored, depending on the learning disciplines' goals and objectives that require the students to achieve. The opportunities for improving the future training application for ILE might be suggested that with the realistic interaction between the learners and the learning processes as it might be the same as real-world physical, the better learning experience and learning outcome that the students may receive according to the explored studies.

3.3 Immersive learning environment on assessment applications

The application of ILE in the assessment context has been explored, the assessment studies that applied the ILE in processes of the studies could be explained as the studies that use the ILE technologies, techniques and experiences integrated for providing the assessment, evaluation, quiz and diagnostic. In this study, the studies that could define the ILE application in assessment have been explored and categorised in groups as the following: (1) The assessment of the ILE, which the studies applied and evaluated the ILE in learning and training for discovering the outcomes and results of the ILE that was used in the learning environment for the learners (Rogers et al., 2017). (2) The assessment of the learners, the evaluation that requires the participant(s) to interact, and learns with the ILE in the studies for providing the assessment and evaluation of the students whether the learning processes result in the effective learning outcome or not (Meyer et al., 2019).

One of the case studies for the assessment of ILE has been explored and conducted in 2009. Jarmon et al. (2009) conducted a study that applied the ILE in teaching, learning and assessment on interdisciplinary communication collaborative learning. Another case study has been studied by Bridge et al. (2007), the study was conducted for discovering and evaluating the hybrid virtual environment with a controller for radiotherapy learning. The ILE assessment studies were used for discovering and analysing the application of ILE toward the learning processes, the effective learning outcome and experience could be provided through the methodology of ILE applying in many learning disciplines for increasing the engagement, attraction and sometimes spatial ability of the students (Lorenzo et al., 2012; Traphagan et al., 2010). The case studies for the assessment of the learners have also been explored. One of the case studies in the learners' assessment context was studied by McFaul and FitzGerald (2020), the study used the ILE for applying in law education presentation skills, then the study recorded, assessed, and gave feedback to the students. Another case study has been conducted by Kuo-Hung et al. (2016), by integrating ILE in learning and training of cooking performance assessment for the students. The student assessment studies that applied with ILE could be integrated to help the instructors or teachers in each learning discipline providing feedbacks and evaluating the student' learning performance while they going through the learning processes, also the ILE could provide more data to be collected and investigated during the learning processes for the instructors to analyse and investigate the performance in immersive learning context dimension (Cheryan et al., 2011; Merchant et al., 2012).

The ILE could be beneficial for both the instructors and learners for providing effective learning processes and learning evaluation/assessment tools. The instructors seem to be more beneficial in ILE assessment application and they could take advantages of the ILE for providing the interactive learning process in form of immersive learning, the ILE could also be used as the tool for remoting learning assessment and evaluation of the students learning performances together with the ability to track the learning process of the students in the immersive learning context. While the students seem to be more beneficial in learner assessment application of ILE and they could also be provided with the effective learning processes and ILE interactive performance assessment from the instructors.

4 Perspectives of adaptive learning experiences on mobile and ubiquitous learning

Although the adaptive learning experience can provide the dynamically learning process to the learners in many ways, there still are several gaps that must be considered. Additionally, mobile and ubiquitous learning could be applied for enhancing the benefits of the ALE to reduce many limitations in the learning experience. For this reason, the mobile and ubiquitous learning in adaptive learning can provide the ability of accessibility in place and time to the learners as they can use their smart device, e.g., mobile, tablet and laptop, to access the ALE experience easier in their comfortable learning places and free times. Accordingly, the authors have applied the mobile and ubiquitous ALE perspective in the collected studies to provide the idea and insight into three perspectives, those are (1) The adaptive learning mechanics in ILE (2) The adaptive user interface and learning environment perspective in ILE (3) The learning analytics perspective in ILE. The mobile and ubiquitous ALE perspective in ILE related studies will be provided in this section to find the insights and ideas to the readers.

4.1 The adaptive learning mechanics perspective on immersive learning environment

The adaptive learning mechanics could be applied to the study in many ways and methods. The adaptive learning mechanics provide the adaptive mechanics in the learning processes to provide the suitable learning processes for the individuals whose behaviour and performance could be used to analyse while the individuals proceeding in the learning processes (Li and Chou, 2018; Meng et al., 2018; Wang et al., 2016). The learning mechanics could be adapted in many ways, e.g.: (1) The media presentation styles could be changed and adapt themselves according to the preference of the learners individually or in group patterns (Verawardina, 2017). (2) The choices or options in the learning processes can be changed and adapted for providing suitable learning choices and options for the students (Farashahi et al., 2017). (3) The examination, quiz, pre-test and post-test are adaptable in the learning processes to make the learning processes testing system knowledge stay at the same level with the students' knowledge (Ross et al., 2018). (4) The activities in the learning processes can be adapted and changed following the students learning behaviour in learning, some of the students might prefer game-based learning, collaborative learning, or competitive learning, and more (Gallego-Durán et al., 2018). For many reasons the adaptive learning mechanics could be designed for providing more suitable learning processes for the students and could provide a better learning outcome for each of the learners individually or in a group with smart adaptive or manual adaptive dependence on the advanced and complex of the ILE learning processes.

The authors' perspective toward adaptive learning mechanics experience in the existing studies were carefully analysed and will be explained in this section. Starting from the ILE studies that could be integrated and applied for improving and filling the missing gaps in the studies with the adaptive learning mechanics in learning. The first study that the authors suggest for integrating the adaptive learning mechanics in the work would be the study of Yip et al. (2019) that provide the study of improving the teaching and learning of threading task in sewing shop by using AR technology as the learning tool for supporting the learning and teaching. The AR video-based learning could be used

to provide more motivation in learning for the students, but the study may lack the flexibility and dynamic for both learning content and process without the adaptive learning mechanics. With the adaptive learning mechanics applying in the study, the ability to adapt the learning processes in learning flow and sequences could be provided for increasing additional motivation of the study and also with the suitable learning flow and sequence in learning for the students both in individual or in group adaptation. The second study which would be suggested for integrating with adaptive learning mechanics is the study for applying ILE in problem-based learning on paramedic and healthcare education by Beaumont et al. (2014) using Second Life (SL) software as the tool for learning through the scenarios. The learning tasks, objectives, and scenarios in the virtual world have been designed and developed for the students to learn in the same scenario and situations, this could lead to the same level of knowledge provided in the virtual world. For providing the personalised learning processes, the adaptive learning mechanics could be applied to lead to the adaptive tasks, scenarios, missions, and objectives through learning processes. The additional possibilities with the adaptive learning mechanics applied in the study could be explained by the adaptive learning materials. The adaptive learning materials that are used for providing knowledge to the students including items, sounds, videos, tips and tricks in the learning processes, with this way of applying the ALE the students could be filled with the knowledge that could provide the dynamic learning experience.

To explain the authors' perspective for applying the adaptive learning mechanics in the studies, the methodologies, the challenges, and the results for integrating will be explained. From the study of Yip et al. (2019) whose study was conducted for integrating the ILE in learning and teaching support, and other studies (Chen and Hsu, 2020; Habig, 2020; Wang, 2017) that could be integrated with adaptive learning mechanics. The researchers (Yip et al., 2019) mentioned the limitations in the study about the speed of the video, subtitles, and capturing the steps' detail. With the limitations of the study, it may result in learning drawbacks about learning outcomes, engagements, and learning motivation. The part which the authors see as the opportunities for improving the study is the part of putting the adaptive learning mechanics in learning processes, flows, and sequences adaptation that may reduce the gap of the knowledge between the students with high-level of prior knowledge and students with low-level of prior knowledge. The adaptive learning mechanics may be used for providing the speed and subtitle of the video for the low-priority knowledge students to assist in learning and the feeling of easiness in learning for enhancing the learning motivation.

4.2 The adaptive learning user interface on immersive learning environment

For the adaptation of the User Interface (UI), the adaptive UI could be considered to be applied in the studies related to the positions, rotations, colours, or looks and feels of the learning environment. The adaptive UI provides the abilities for changing and adapting the worlds and elements that the learners can see throughout the learning processes, the traditional UI which is designed for a specific user group may not be suitable for some or every individual(s) who partake in the learning processes (Pavlov et al., 2018). The example possibilities of the adaptation that could be provided by the adaptive UI were analysed and listed as the following: (1) The colours and themes, the design's colour and theme that are used in the study could be adapted for the individuals through the adaptive UI, especially for the individuals who possess the symptoms about the eyes like colour

blindness (Khan et al., 2018). (2) The scenes, places, or episodes of the learning could be adjusted or adapted for the learners for enhancing the motivation and reducing boredom while the learners partake in the learning processes (Huang et al., 2017). (3) The positions and movements of the elements that could be adjusted through the adaptive UI for providing a better effective learning experience to the students (Batalla et al., 2020). (4) the graphics and styles that are used for presenting the learning content of learning processes, for providing the suitable graphics like 2D, 3D graphics dimension and the art styles like cartoon style for the kids or realistic style for the teenagers or adults (Jin et al., 2016). (5) The adaptive learning materials like sounds, audio and vocal for the individual who may possess the ear symptoms or can receive a different level of loudness (Czyzewski et al., 2016).

For a clearer explanation, the studies that the authors would suggest for integrating the work with the adaptive UI will be explained. The first study that could consider for applying the adaptive UI in the work would be the study of integrating the virtual reality technology in space-themed education video with immersive learning experience by Rupp et al. (2019). The study found the results in motion sickness in the participant groups while conducting the learning processes of the virtual spaces in the virtual world, this is the reason that the authors viewed the opportunities for integrating the adaptive UI for assisting in reducing the motion sickness. With the integrating of adaptive UI in the study, the adaptive UI could provide adaptable motion sensitivity, colours, positions and movements in the virtual world for the individual group whose motion sickness symptom occurred while partook in the virtual learning world. The additional abilities of the adaptive UI could be used for providing a suitable learning environment for providing the tips, tricks and information of the learning for some individuals and increasing the attraction and motivation in learning for the students while and after their learning. The mentioned possible abilities and benefits of adaptive UI could be provided to the existing studies (Bridge et al., 2007; Lau and Lee, 2015; Tüzün and Özdiñç, 2016) which the authors could see as the opportunities for decreasing the limitations in the user interfaces and user interfaces environment of the studies in the future work. Another study that could be suggested for integrating adaptive UI for further explanation of another dimension that could be an adaptive learning experience in UI was conducted by Zhong et al. (2020) for the application of ILE using virtual reality in the animal vocal behaviour sound learning. With the study using the graphics and audio sounds like the learning materials of the learning processes, another limitation of the limitation in the perspective of adaptive learning experience could be explained as the limitation of the dynamic and various materials for the students. The adaptive UI could be used to provide the ability for adapting of the study visualisation whether the learners prefer in the realistic or unrealistic graphic, also with the sounds that were used in the study that could be adapted for handing the various sounds that could respond with the memory systems of the students in remembering the sounds and visuals of the animals. The other studies (Chen and Hsu, 2020; Dan and Reiner, 2018; Fassbender et al., 2012; Gunn et al., 2018; Richards and Taylor, 2015; Wang, 2017) that used the graphic and audio as the main learning materials could also be considered for applying the adaptive UI in learning processes to enhance the learning experience of the students.

The methodologies for applying the adaptive UI will be explained from the perspective of the authors that will suggest the ideas toward the studies, together with the possible challenges and results of integrating the adaptive UI in the studies. With the study of Rupp et al. (2019) whose study could be applied with the adaptive UI in the

virtual reality visual dimension of the study for reducing motion sickness in some type of VR technology. The challenge of applying the adaptive UI in the study requires the processes of User Experience (UX) for researching the symptoms of motion sickness. The factors like the speeding and delaying of the motion sensors or device's gyroscope vertical causing the learners to have nausea and motion sickness for learning for some period of times, the other factors like colour theme, degrees of content presentation area, lacking the reference point in horizontal or vertical in the UI in the learning system. With the adaptive UI applied with the study, the abilities for settings and adapting the mentioned problems of speed and delay, colour themes, content presentation area and lacking reference point could be analysed and adjusted for providing a suitable learning environment to the students individually.

4.3 The learning analytics perspective on immersive learning environment

In the adaptive learning experience context, learning analytics is one of the effective methodologies for providing the adaptive experience in the learning processes. With the ability of the learning analytics that could be provided in various types of smart adaptive learning systems. The traditional learning processes without learning analytics has limitations in providing the suitable learning content, material and pedagogy for the student individually or generically, the learning analytics could be used for delivering more effective ways in dynamic learning processes. The learning analytics could be integrated into the learning in the following ways: (1) Artificial Intelligence (AI), the AI could be used as an effective tool for assisting in the adaptive learning experience, to provide the smart adaptive learning experience in the study (Cukurova, 2019). (2) Machine Learning (ML), the ML could be embedded as a part of the smart adaptive agent, similar to the AI but the ML could be considered as the less advanced technology in the study (Sacco et al., 2020). (3) Adaptive algorithms, by using mathematics and logic skills and computer coding languages which could be developed and provided to the instructors for use in the learning processes, to provide the adaptive learning analytics in the learning (Khabbaz et al., 2019).

The studies that could be suggested for the integration of learning analytics to indicate the opportunities, challenges and possible results for providing the smart adaptive learning experience in the existing studies would be demonstrated. The group of studies that the authors see as the studies which could be enhanced in the same direction of the learning processes by integrating the learning analytics (Jang et al., 2017; Limniou et al., 2008; Sun and Cheng, 2009; Van Ginkel et al., 2019). With the traditional learning processes, the students were able to learn through the same or few pedagogy designs, the difference of students' prior-knowledge, prior-abilities and prior-learning styles result in different learning outcomes depending on the mentioned factors. The learning analytics could be used to analyse the individuals' learning behaviours and factors in learning, then provide the learning processes that could be considered as effective and suitable for the group or individual students. The difficult levels of learning processes and contents could be designed as the adaptive learning experience for applying the learning analytics to provide the qualified learning processes difficulty and complexity to fit with the students' knowledge level.

To provide the application of the learning analytics in the studies, the methodologies would relate in defining the group of the students with high or low potential, ability and knowledge than providing the most suitable learning contents, sequences and difficulties

of learning processes for the defined group to make the most qualified learning processes to the students. The prior process before defining the group of the students or learners would be the processes of pedagogy design to find the factors for defining the students' behaviour, knowledge and potential, then use these factors as the analysis factors through the AI, ML, fixed algorithms or manual adaptation. The processes of the adaptation could be done while the students go through each learning unit, topic and chapter; to provide the best learning processes and sequences to display/effect in learning of the students immediately.

5 Discussion and conclusion

5.1 Discussions

The interesting findings in this paper have shown the application of ILE toward many learning disciplines for both learning and training activities. One of the interesting applications is the popularity of ILE for both language learning education and medical education application, the ILE has been applied for language learning (Wang et al., 2019) and medical education (Chang et al., 2019) in many studies for providing the engaging and interacting learning environment for the learners. Another interesting point from the studies review is the technology which has been used popularly since the past to the almost present time is the Second Life (SL) (Andreas et al., 2010; Huang et al., 2016; Lorenzo et al., 2012), the SL is the learning platform which has been used for providing a virtual learning environment in the learning disciplines with the abilities of SL that could be customised to apply with the learning pedagogy design for the instructors.

On the other hand, the unexpected findings as the authors have found while collecting the related ILE studies also considered for explanation further. As the SL technology has been integrated into many studies, the obstacles for applying the algorithms or specific functions for specific objectives might be harder than the studies that developed their learning system. Moreover, Beaumont et al. (2014) found that SL requires quite high demands of computer hardware specs, and SL also provides complex and high information on UI. Another finding which the authors found that they were few studies which integrated the ILE for, it is the application of ILE with adaptive learning or learning analytics for providing the dashboard, graph and data visualisation for the instructors for review the learners' behaviour while they have gone through the learning processes in the immersive virtual learning world. Additionally, the discovered insights on the finding result revealed the number of ILE applied in learning (60), training (14) and assessment (8) context in higher education. Therefore, the ILE most popular applying context is the ILE for learning, the authors will interpret this insight as the easiness of applying the ILE for learning is the easiest and fastest way among learning, training, and assessment. As the reason, the ILE in the learning context required the process of transforming the content into the ILE learning activities, while the training context requires specific skill knowledge, specific content and specific training activities in the ILE. Also, the ILE for assessment required the specific algorithms, and functions in the ILE learning system to transfer the assessment information between the learners and instructors. The application of ILE in many learning disciplines has been conducted, but the fact that the ILE also has been applied for many children, kids, and teens or K-12 education besides higher education application of ILE. The studies that applied ILE

technology in K-12 education, some could be described as the studies that aim for enhancing the learning outcomes for the K-12 students (Cheng & Tsai, 2019; Cheng et al., 2015; Wei et al., 2015) and some of them aim for examining the feedbacks, learning outcomes and learning results for finding the usability and efficiency of ILE toward the students (Chien et al., 2020; Van Ginkel et al., 2020; Wang et al., 2019). Furthermore, another fact that has been found about the ILE application is the application of ILE toward children with autism has been discovered in a high number of studies (Ip et al., 2018; Ke and Lee, 2016; Lee, 2020). Both of the studies which applied the ILE in K-12 and children with autism have also been excluded as they did not cover higher education which is the main objective for the review in this paper. However, this article remains some limitations to be addressed. Regarding the searched keywords relevant to higher education, the pre-service learning context was relatively included in this study as some countries provide this service at the higher education level, e.g., Thailand, while the words such as tertiary education and postsecondary were missed. Moreover, the additional limitation of this article included the screened papers of top the 10% of all the found articles by their ranks and indexed on Web of Science.

5.2 Potential research issues

The suggestion for further research and experiment about the adaptive learning experience for ILE, the researchers could consider for researching about the adaptive learning content, learning difficult level and learning sequences as the adaptive learning experience could provide the better learning experience for the individuals which may help both the learners and instructors for finding the best learning processes and outcomes from the ILE experience. Moreover, the adaptive learning that should be researched further for ILE would be the adaptive learning for applying in the learning disciplines, e.g., the adaptive learning used for providing the suitable scenario for language learning students in ILE, or the adaptive learning for providing the additional medical content knowledge which the students need to know but still missing based on pre-test, quiz and exercise.

The technologies for adaptive learning could be suggested to develop for the ILE learning experience as the technology for assisting in the adaptive learning experience. One of the technologies is the software-assisted adaptive learning experience, e.g., web-based, application and learning systems. The software-assisted adaptive learning experience could be used for providing the dashboards and graphs of students learning behaviour, this will provide deep insights for the instructors whether the learning processes could provide better learning outcomes or not or the pedagogy design which used for providing the learning processes for the students are truly enhancing students' knowledge or not. Besides, the web-based, application, or learning system could also be used as a real-time tool to adapt the learning content for the instructors after finding the insights from the learning behaviour. Moreover, adaptive ILE learning could significantly enhance the students learning performance, learning outcome, learning motivation, and self-learning management by applying the ubiquitous learning or mobile learning approach to the learning processes (Srisuwan and Panjaburee, 2020). Additionally, for effective designing of ubiquitous ILE learning experience and low-cost ILE, the researchers could consider using the Google Cardboard SDK for VR learning experience, and Vuforia for AR learning experience as one of the most popular software used for the development of ILE. Still, the researchers may need to examine the mobile

device whether it has a gyroscope sensor or not, and the spec of hardware device that could handle the software without delay in an ILE environment. Instead, the delaying of the ILE environment and hardware may cause negative effects to both learners and learning processes in the end.

The application in various learning disciplines of ILE has been explored, but to enhance the learning experience for both the instructors and learners, adaptive learning is suggested to be integrated. The learning disciplines like medical that require the training processes in real-life, adaptive learning could be applied for gathering the learning behaviour data then the gathered data could be used for analysing through instructors or learning system. For example, the surgery training can be done through the ILE virtual world and with adaptive learning which could adapt the scenario, case, content knowledge and content sequence to provide the dynamic learning processes through the ILE experience. Another learning discipline that has been studied and applied with ILE by many researchers is the language learning discipline, the learning process which could be enhanced through the adaptive learning experience is recommended. The ILE could be used for providing the learning system that has a better immersive learning environment than other methods, but adaptive learning could enhance the language learning experience similarly with the medical learning discipline by adapt the learning scenario, content knowledge, and sequence in extra to the voice or vocal analysis to be another factor of the adaptive learning experience. On the other hand, the learning discipline that could be applied in ILE for providing a better learning experience for the students, but few studies that have been applied with ILE together with the adaptive learning experience is the mathematics learning discipline. The mathematics learning discipline could be considered as another foundation of the knowledge, then the application of mathematics learning with ILE and adaptive learning experience is also recommended for the researchers for studying. For applying the ALE experience in the ILE, researchers may consider the man-power for data analysis and data storing. The objective of ALE can be the factor that could define the qualitative and quantitative data that must be gathered from the learners, also the approaches of ALE in the ILE experience that could be used. One of the easiest ways for providing the ALE experience that could help the learning is the fixed-condition algorithm approach, and another one is the manual adaptive ALE that required the teacher to analyse the insights from the learner's behaviour and provide the suitable ALE environment to the learners.

5.3 Conclusions

In conclusion, this paper has reviewed and explored the studies for finding insights into related ILE studies in higher education. This paper discovered the technologies that were used for integrating with the ILE experience in many studies, e.g., Augmented Reality, Mixed-Reality, Virtual Reality, Second-Life and more. Furthermore, this paper has found the application of ILE in learning, training and assessment ways, and providing the suggestion in authors perspective in adaptive learning experience toward the collected studies for presenting the ideas and brief guidelines in the perspective of adaptive learning mechanics, user interfaces, and learning analytics to the researchers. Besides, this paper provides the journal review in the dimension of adaptive ILE for contribution to finding the insights of related studies as new perspectives and ideas for studying and

researching in the learning context, also providing a modern learning technology perspective for enhancing the learning methodology to another level. Moreover, the suggestion for future researchers will be clarified in each issue, learning, training, assessment and adaptive learning as follows:

- *Learning*: The ILE learning trend has been reviewed and found the insights on the ILE application in learning disciplines. The popular learning disciplines on ILE are nursing, medical, language-learning disciplines. Additionally, some studies conducted the ILE on cooking, communication, business, science and social learning disciplines. Although, there are also learning disciplines applying with ILE which are not reviewed in this study, e.g., engineering, mathematic, multimedia, artistic, etc. However, for easier providing the ILE experience to the learners, future researchers may consider using a mobile device like a smart-phone and tablet.
- *Training*: In the training context, this study found that ILE has been applied in some studies as the following learning disciplines, business, law, teaching, medical and science. Furthermore, the ILE in training has been applied in both soft-skill and hard-skill training, the future researchers may use this idea to provide the learning experience which covers one of the soft/hard skills or both.
- *Assessment*: The ILE for assessment has been used for assessing the following learning disciplines, law, communication, medical, science, teaching and cooking. Moreover, as the ILE can provide various data for performance insight analysis, future researchers may consider taking the examination of the course with ILE for providing more interactive and engagement assessment.
- *Adaptive learning*: Future researchers can use the data, learning log and learning feedbacks to provide adaptive ILE learning for improving the learning process effectively and suitable for the student learning styles. Moreover, to provide the adaptive ILE learning experience the researchers may need experts for the most effective adaptive learning process about the content, environment and experience adaptation.

In addition, this paper could provide the insights, ideas and benefits to many roles of people, by reviewing and suggesting the ideas of ILE toward adaptive learning experience to the readers. One of the people who could be beneficial from this paper is the researchers, with the information provided in this paper about the existing studies like publication by trend, continents, countries and ILE journal publications. Another role of people that could receive the benefits from this paper is the college students, the college students could use the ideas and guidelines for applying, developing, enhancing and integrating the methodology of the existing study or the new idea in senior project subject in the college. Other roles that may be considered for applying this paper's insights and ideas for integrating the ILE and adaptive learning experience to enhancing the learning processes and learning experience in their institution are the teachers, instructors, professors and institution administrators who have the authority for providing the effective learning methodology and experience for the students the most.

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