IVUL Model: An Intelligent Learning Development Process

https://doi.org/10.3991/ijet.v17i14.31527

Sakchai Chaiyarak(✉), Prachyanun Nilsook, Panita Wannapiroon
King Mongkut's University of Technology North Bangkok, Bangkok, Thailand
chaiyarak.s@email.kmutnb.ac.th

Abstract—The purposes of this research study are to develop an intelligent virtual universal learning (IVUL) model and to evaluate its appropriateness. The study consisted of two phases. Phase 1 involved the development of the IVUL model for universal learning. The conceptual frameworks and theories in the documents and research studies on universal design for learning, intelligent learning and virtual learning were studied by the researchers. All main components were then synthesised to design the IVUL model. This process can be divided into three main steps: engagement, representation, and action and expression. Each step has sub-steps: access, build and internalise. However, the details of these are dependent on the main steps. The second component is the intelligent learning process, an important process of the model that drives learners to automatically learn by themselves. Artificial intelligence is used as a crucial component that promotes and supports each learner to meet learning goals and objectives according to the universal learning model. The third component is the virtual learning process, which results in learning through computer environments and the Internet. Phase 2 involved an evaluation of the appropriateness of the IVUL model, with in-depth interviews with 20 experts in education and digital technologies. The appropriateness of the model was evaluated using the 5-point Likert scale. The findings show that the designed IVUL model can be used for learning development at the highest level.

Keywords—universal learning process, intelligent learning process, virtual learning process, IVUL model

1 Introduction

Human civilisation is now in the digital era, an era of technologies affecting all aspects of people's daily lives [1]. The COVID-19 pandemic has resulted in inevitable radical changes across almost all areas of daily life, and became a global threat to public health, including the broadly and severely in education and the economy, millions of people have had to work and learn from their home due to the pandemic [2][3]. It has rapidly induced scientific and technological developments to overcome the limitations of adaptations for survival across many aspects of human life [4][5]. The COVID-19 crisis has also induced new learning models for continued education, with online education as an alternative solution [6][7], and online education with new technologies have begun to be used in an ongoing digital transformation across the board in education, and to increase the quality of the education on offer [8][9]. Online education uses virtual learning environments via computer systems that can stimulate learners to learn and work in ways similar to in normal classrooms [10][11]. Encouraging learners to efficiently access, search for and manage data by themselves, as well as work together via online systems, is the foundation for digital skills needed for future education and social participation [12][13]. For self-learning, learners are developed via digital platforms that are flexible in terms of time management, venues, opportunities and needs. Learners and instructors interact with educational environments as digital platforms that can provide new opportunities for lifelong education [14][15]. Online education are being developed using artificial intelligence (AI) for stimulating and improving education for learners at all levels, and AI will also inevitably affect many future social activities [16]. The development of AI has changed many people's daily lives quickly and completely. Originally, AI was developed to mimic human behaviours by learning from examples, gaining experiences, memorising objects, comparing understanding, responding to languages and symbols, making decisions and solving problems similarly to humans [17]. However, AI tends to perceive and react to people automatically and naturally, so it can be a facilitator for learners to study by themselves [18]. AI will ultimately be a virtual assistant for each learner and will observe and analyse the learner efficiently [19]. Self-learning platforms with AI will provide appropriate education for each learner – for example, support and guidance as well as academic evaluations will be conducted automatically. AI will create learning environments that stimulate learners to efficiently learn by themselves and improve their education [20].

Therefore, the researchers were interested in developing an intelligent virtual universal learning (IVUL) model, using AI and virtual learning environments, for all learners, with their different learning needs and including those with learning disabilities, to efficiently learn and improve themselves.

2 Research objectives

To develop and evaluate an IVUL model to be used in creating and developing an educational platform for all learners, with their different learning needs, to efficiently learn by themselves.

3 Research methodology

The researchers conducted the study in two phases.

Phase 1: Develop the IVUL model by studying conceptual frameworks, principles and theories from relevant documents and studies, according to the following steps.

1. Study and synthesise the main components of universal learning. Design and develop a universal learning process with components that apply to providing and developing education for learners, according to the research objective.

2. Study and synthesise the main components of intelligent learning. Design and develop an intelligent learning process with components to be used as the mechanism for driving the IVUL model for providing and developing education for learners of all learning needs, automatically and according to the research objective and goal.
3. Study and synthesise the main components of virtual learning. Design and develop each component into a supporting component of the IVUL model to enable the intelligent learning process to use each element of the virtual learning process to support and develop education for learners, according to each step.
4. Develop the IVUL model by analysing the process synthesis for each main component to create linkage and design a model that can be used for automatically providing education for learners. Using AI is crucial for driving the model through virtual learning environments across online networks [21]. This will help each learner to systematically learn and apply knowledge, via activities and processes, to develop skills and abilities according to the learning objectives and goals and their individual potential.

Phase 2: Evaluate the appropriateness of the IVUL model by conducting in-depth interviews with and detailing the steps and processes for 20 experts in education and information technologies. Apply the 5-point Likert scale to evaluate the appropriateness of the IVUL model. Analyse the data from the expert evaluations with basic statistics, including mean and standard deviation. Set the criteria for the appropriateness of the model as follows: 1.00–1.50 is the lowest level, 1.51–2.50 is the low level, 2.51–3.50 is the moderate level, 3.51–4.50 is the high level and 4.51–5.00 is the highest level [22].

4 Result

4.1 Model development

The IVUL model consists of several components. The first component is the universal learning process – the main component of the model. It comprises three main steps: engagement, representation, and action and expression. These are processes that can encourage all learners to achieve learning goals according to their potential. Each step has sub-activities: access, build and internalise. However, the activities are conducted differently and according to the framework of the main steps. The second component is the intelligent learning process. This is an automatic system that drives learners to learn by themselves according to the model. It consists of four main systems: intelligent learning system, automatic learners' analysis system, intelligent knowledge presentation and automatic intelligent suggestion system. These are considered important systems that can automatically drive the IVUL model in virtual learning environments. The third component is the virtual learning process, containing virtual learning environments of the online systems that can promote the intelligent learning process. The activities and steps can be taken virtually through the online systems. There are five main elements: virtual learners' interaction, virtual learning content, virtual media and resources, virtual learning activities and virtual assessments. The three overarching components follow three steps according to the universal learning process as follows.

Step 1: Engagement is the step that stimulates learners to engage with learning. It is the first step of the universal learning process. It starts from the main interactions between the components of the intelligent learning process in the intelligent learning system and components of the virtual learning process with learners' interactions that occur through the online learning environments. The intelligent learning system communicates and interacts with the learners when they enter the learning model. This results in virtual interactions between the learners and the learning model. The intelligent learning process then takes the following steps of engagement.

- Access is a step of the intelligent learning process that stimulates learners to be interested in and engaged with self-learning according to their needs. For this step, the registration was designed and developed by the researchers to allow learners to sign up and then view lessons to stimulate and provide opportunity for them to choose and engage with lessons according to their interests and needs.
- Build is a step of the intelligent learning process that builds learners' understanding of the objectives of the chosen lessons. For this step, the descriptions were designed and developed by the researchers to explain the objectives and goals of the chosen lessons.
- Internalise is a step of the intelligent learning process that encourages learners to internalise the stimuli and motivations of the previous steps to stimulate them prior to receiving details of the education and to identify focal points and areas for improvement. For this step, the pre-test was designed and developed by the researchers to encourage learners to take the test and view the results to evaluate their knowledge and understanding before each lesson, as well as enabling the automatic learners' analysis system to analyse the data from the pre-test and identify any lacking in understanding that need to be conveyed to the learners.

Step 2: Representation is the second step of the universal learning process that helps learners learn and understand content. There are consistent and related processes: the intelligent learning process, the automatic learners' analysis system, the intelligent knowledge presentation, the virtual learning process with virtual learning content and the virtual media and resources with virtual learning activities. The automatic learners' analysis system considers the analysed data from the pre-test to identify aspects of the lessons on which the learners should focus. Then, the intelligent knowledge presentation uses the virtual learning content as well as the virtual media and resources to explain and provide examples as well as improve the understanding of the learners. This involves virtual learning activities. The intelligent learning process contains the following steps.

- Access is a step of the intelligent learning process. The automatic learners' analysis system and the intelligent knowledge representation provide interesting content to stimulate learners to access lesson descriptions and topics they will learn. For this step, the activity was designed and developed by the researchers to display the topics and encourage learners to choose and access content before or after learning the content respectively suggested by the automatic learner's analysis system.

- Build is a step of the intelligent learning system. The automatic learners' analysis system and the intelligent knowledge presentation help learners understand the content they choose by providing important information. The descriptions and examples are provided in various forms of multimedia. The intelligent knowledge presentation automatically presents the virtual learning content as well as the virtual media and resources of the virtual learning system to learners. For this step, the activity was designed and developed by the researchers to provide examples and illustrations to encourage learners to learn and thoroughly understand the content according to the objectives and goals of the lessons. The automatic learners' system analyses learners' facial expressions, actions and gestures, elucidating their interests. If it is found that the learners are bored or uninterested in learning, the data is sent to the intelligent knowledge representation. The new activities and learning methods produced then stimulate and attract the learners.
- Internalise is a step of the intelligent learning process. The automatic learners' analysis system and the intelligent presentation encourage learners to absorb the lessons. The learners receive suggestions via the summaries and techniques to understand the lessons. This step was designed and developed by the researchers for the learners to summarise the main points of a lesson to obtain pertinent knowledge that applies to solving problems or achieving the learning objectives and goals. For this step, the learners can download the lesson content, save it and review it when offline.

Step 3: Action and Expression is the third step of the universal learning model that develops learners' skills and allows them to demonstrate their abilities after processing the knowledge they obtain. This is considered an important step of the learning process and develops learners' skills according to the learning objectives and goals. This is consistent with the intelligent learning process, the automatic learners' analysis, the automatic intelligent suggestion system and the virtual learning process consisting of the virtual learning activities and assessments. The intelligent learning process contains the following steps.

- Access is a step of the intelligent learning model. The automatic learners' analysis system and the intelligent suggestion system enable learners to access the activity topics and choose from them according to their interests and needs. This step was designed and developed by the researchers to encourage learners to choose the topics of lesson activities according to their interests and needs as well as the order of the topics suggested by the automatic learners' analysis system.
- Build is a step of the intelligent learning model. The automatic learners' analysis system and the intelligent suggestion system are the assistants and consultants of the learners until they develop skills from the practices according to the various steps. This step was designed and developed by the researchers into a practice set. The intelligent suggestion system implements practice steps and provides reinforcement to develop learners' skills according to the learning objectives and goals. This step is an important process that develops skills according to the objectives and goals of each lesson.
- Internalise is a step of the intelligent learning process. The automatic learners' analysis system and the intelligent suggestion system encourage learners to absorb the

lessons by engaging in activities and demonstrating their skills. This step was designed and developed by the researchers to summarise the results and encourage learners to take the post-test and display their results. The learners learn concrete skills that can be applied to problem-solving in future situations. The automatic learners' analysis system can evaluate the level of the learners' skills according to the objectives and goals of the lessons.

Each step of the IVUL model continuously records data in the system. The learners can exit the lessons at any time, and they can resume lessons, as automatically suggested and displayed by the system, if they return to the platform. After learners take the post-test for each lesson, the system automatically analyses the results. The automatic intelligent suggestion system provides suggestions on what they should learn and understand. All of the systems require learners to take all lessons. Even though they learn and develop all skills from all lessons.

The main components of the universal learning model, the intelligent learning process and the virtual learning process were linked by the researchers and designed into images that reflect the model and its consistent and relevant functions, as shown in Figure 1.

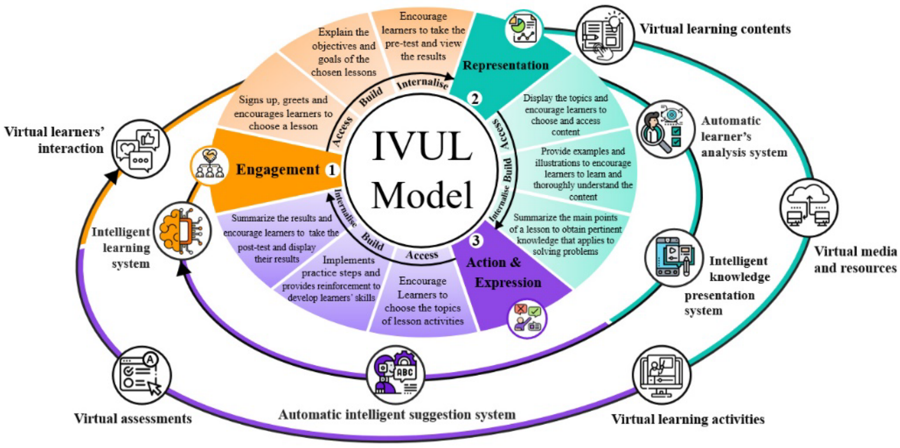

Fig. 1. The IVUL model

As per Figure 1, the IVUL model consists of main components that are consistent and relevant. The inner ellipse shows the universal learning process with its three main steps: engagement, representation, and action and expression. These are the steps that encourage all learners to learn and achieve learning goals according to their potential. The second part, in the outer ellipse, is the intelligent learning process. This has four main systems: the intelligent learning system, the automatic learners' analysis system, the intelligent knowledge presentation and the automatic intelligent suggestion system. These are the main systems of the model that automatically drive the universal learning process and the virtual learning process. The third part, the outermost part, is the virtual learning process, which has five main components: the virtual learners' interaction, the virtual learning content, the virtual media and resources, the virtual learning activities and the virtual assessments. These are the main components of the virtual learning environments of the online systems that support the intelligent learning process, which can competently implement the virtual learning activities and steps according to the model.

4.2 The evaluation results of the IVUL model

The IVUL model evaluation results from 20 experts in education and information technologies are as follows.

As per Table 1, the appropriateness of each item was at the highest level. For the steps of representation, internalise is the activity that summarises the main points of a lesson to provide durable knowledge for the learners to apply to problem-solving. It has the highest mean ($\bar{x}$ = 5.00 S.D. = 0.00). The total average of the evaluation results of the IVUL model is at the highest appropriateness level ($\bar{x}$ = 4.79 S.D. = 0.45).

Table 1. The appropriateness of the IVUL model

Item	Appropriateness level		
	$\bar{x}$	*S.D.*	*Interpretation*
1. The IVUL Model is consistent with the basic principles and concepts of learning system developments.	4.80	0.41	Highest
2. The components of the model are as follows 2.1 The overview of the components of the universal learning process.	4.65	0.59	Highest
2.1.1 Engagement is the first step that stimulates and attracts the learners to participate in learning.	4.80	0.52	Highest
- Access is the activity for registration that signs up, greets and encourages learners to choose a lesson according to their interests or needs.	4.80	0.41	Highest
- Build is the activity that provides and encourage learners to understand the objectives and goals of the lessons.	4.90	0.31	Highest
- Internalise is the activity that provides and encourage learners to take the pre-test and view the results to evaluate their knowledge and understanding before each lesson.	4.80	0.41	Highest
2.1.2 Representation is the step that presents interesting content that learners can understand easily.	4.90	0.31	Highest
- Access is the activity that shows the topics and encourages learners to choose content according to their interests or needs.	4.90	0.45	Highest
- Build is the activity that provides examples and illustrations for learners to learn and thoroughly understand the content according to the objectives and goals of the lessons.	4.90	0.31	Highest
- Internalise is the activity that summarises the main points of a lesson to develop durable knowledge that learners can apply to solving problems or other practices.	5.00	0.00	Highest
2.1.3 Action and expression is the step where learners take action and demonstrate their abilities after learning the content of each lesson.	4.95	0.22	Highest

- Access is the activity that encourages learners to choose the topics of a lesson activities according to their interests or needs.	4.95	0.22	Highest
- Build is the activity that implements the practice steps and provides reinforcement to develop learners' skills according to the objectives and goals of the lessons. It is an important process that supports the developments according to the objectives and goals.	4.95	0.22	Highest
- Internalise is the activity that summarises results and encourages learners to take the post-test and display these results to develop learners' durable skills for problem-solving in various situations. The learners learn concrete skills that can be applied to problem-solving in future situations.	4.85	0.37	Highest
2.2 The overview of the components of the intelligent learning system.	4.80	0.41	Highest
2.2.1 The intelligent learning system is the system that replaces teachers, implementing all learning processes.	4.75	0.55	Highest
2.2.2 The automatic learners' analysis system is the system that analyses the learning behaviours of the learners in each step.	4.75	0.44	Highest
2.2.3 The intelligent knowledge presentation system is the system with the main duty to present and explain the content and examples.	4.80	0.52	Highest
2.2.4 The automatic intelligent suggestion system is the system with the main duty to train learners and allow them to demonstrate their skills. It supports the developments of their skills according to the learning objectives and goals.	4.70	0.57	Highest
2.3 The overview of the components of the virtual learning process.	4.80	0.41	Highest
2.3.1 The virtual learners' interactions are the interactions and communication between the learners and the intelligent learning system in the virtual learning environments.	4.65	0.67	Highest
2.3.2 The virtual learning content is the content collected and stored in digital files on the online systems to enable the intelligent knowledge presentation to present the knowledge to learners and allow them to conveniently and quickly access the content through the virtual learning system.	4.70	0.57	Highest
2.3.3 The virtual media and resources are the learning materials supporting learners and the sources of the data collected and stored in files on the virtual learning system.	4.75	0.44	Highest
2.3.4 The virtual learning activities are the activities and learning processes of learners on the virtual systems or computer networks, which can be accessed via any device with an Internet connection.	4.67	0.59	Highest
2.3.5 The virtual assessments check the behaviour of the learners to measure and evaluate results via the online systems, using AI.	4.60	0.60	Highest
3. The instructions of all components of the intelligent learning model are clear and connected.	4.75	0.44	Highest
4. The components of the IVUL model are consistent.	4.80	0.41	Highest
5. The orders of the components in the virtual learning model are appropriate and easy to understand.	4.60	0.50	Highest
6. The overview of the components of the IVUL model is complete and meets the requirements and research objectives.	4.85	0.37	Highest
7. The processes of the IVUL model are applicable.	4.65	0.59	Highest
Total	4.79	0.45	Highest

5 Discussion

It is possible to apply the IVUL model for developing learners and meeting individual learning requirements by making it consistent with the universal designs based on the conceptual frameworks and guidelines of the universal learning developments of the Centre for Applied Special Technology, for improving the efficiency of the education for all learners (CAST) [23][24]. It is a process that supports all learners, with physical, emotional, social and intellectual differences and those with learning disabilities, to learn and develop skills and to meet the learning goals according to their potential [5][6]. It is also the framework that is most acceptable, applicable and referenced because it is based on qualitative scientific data on various learning methods consistent with the functions of the three parts of the brain [25][26]. The first step, engagement, is the step stimulating learners' brains to be active and participate in learning. It stimulates the emotion to learn and is the preparation for attracting and motivating learners. The main goal is to stimulate and motivate learners to be interested and participate in learning as much as possible [8][11]. There must be various and interesting methods to attract and stimulate learners to participate in learning. The second step, representation, is the step stimulating learners' brains to perceive and remember the information. It presents the information to learners. It is the important step that encourages learners to absorb the content. The main goal is to present content that is interesting and understandable according to individual learning styles [9][18]. The third step, action and expression, is the step stimulating learners' brains to think during practices and expression by applying the knowledge. It prepares learners to practice and express learnt behaviour and skills by applying their knowledge. It develops analytical thinking, leading to effective decision-making. The main goal is conducting activities according to the learning objectives that systematically develop learners' skills and abilities [6][15].

The intelligent learning process is the part of the system that encourages learners to automatically learn by themselves, according to the intelligent suggestions on the system [1][17][27]. It consists of AI that supports learners, according to their interests, to meet the learning objectives and goals [16][28]. It involves processes and steps, including the virtual learning process, allowing learners to learn within the computer environments [11][29][30]. There are various supporting components of the online system, a system which learners can directly access via the Internet inside or outside of their classroom [10][12][31]. The virtual learning environments of the future will be environments accessed through computer systems using digital technologies, computer graphics, multimedia and virtual 3D hologram [7][13][32]. These will enable learners to interact with the learning content and processes of the virtual systems using avatars, supporting immersive interaction with the virtual learning environment and improving the attractiveness and challenges of educational developments [19][33].

6 Conclusions

The IVUL model was developed by studying and synthesising theoretical concepts in documents and research studies on universal learning, intelligent learning and virtual learning. All components were synthesised to design a new and contemporary model by combining AI and online virtual learning to drive universal learning. Its design could lead to the development of future intelligent learning platforms, with automatic systems replacing instructors and stimulating users to be interested in learning by providing suggestions and presenting content and guidelines according to users' learning styles. Learners will engage with practices to develop their skills and be asked questions that stimulate them to learn appropriately. The platforms will evaluate learners' results according to their personal traits, report the evaluation results to learners for their improvement, be applicable to continued education, improve learners' skills (up skills and re-skills), meet learners' different needs equally and meet the learning objectives and goals according to learners' potential. An intelligent learning model is one that supports learners to automatically learn through the AI system by themselves. They are the systems supporting all learners, with different interests, to meet the learning objectives and goals. For virtual learning, learners are in online environments supported by online systems that can be accessed inside or outside of the classroom. Learners can learn in any place, at any time if they can connect to the Internet, supporting convenient and safe learning that can occur even in situations such as the COVID-19 pandemic that necessitate social distancing and online education. The AI and virtual learning technologies will design and manage the learning model appropriate to the individual, but the limitation of developing the platforms completely requires a very high budget.

7 Acknowledgment

This research and innovation activity is funded by National Research Council of Thailand (NRCT). The researchers would like to thank the experts in education and information technology and everyone who provided useful advice and suggestions on the model design and development. A special thank you to those in the Doctor of Philosophy program in Information and Communication Technology for Education at the Faculty of Technical Education - Graduate School, King Mongkut's University of Technology North Bangkok, and Suan Dusit University, who greatly supported the entire research process until its successful completion.

8 References

[1] Y. Zhang, "Research on Artificial Intelligence Machine Learning Character Recognition Based on Online Machine Learning Method," in 2020 IEEE 3rd International Conference of Safe Production and Informatization (IICSPI), 2020, pp. 649–652. https://doi.org/10.1109/IICSPI51290.2020.9332382

[2] T. Karakose, R. Yirci, and S. Papadakis, "Exploring the Interrelationship between COVID-19 Phobia, Work–Family Conflict, Family–Work Conflict, and Life Satisfaction among School Administrators for Advancing Sustainable Management," Sustainability, vol. 13, no. 15, 2021. http://dx.doi.org/10.3390/su13158654

[3] T. Karakose, R. Yirci, S. Papadakis, T. Y. Ozdemir, M. Demirkol, and H. Polat, "Science mapping of the global knowledge base on management, leadership, and administration

related to COVID-19 for promoting the sustainability of scientific research," Sustain., vol. 13, no. 17, 2021. http://dx.doi.org/10.3390/su13179631
[4] H. Lan et al., "COVID-Scraper: An Open-Source Toolset for Automatically Scraping and Processing Global Multi-Scale Spatiotemporal COVID-19 Records," IEEE Access, vol. 9, pp. 84783–84798, 2021. https://doi.org/10.1109/ACCESS.2021.3085682
[5] J. Pang, Y. Huang, Z. Xie, J. Li, and Z. Cai, "Collaborative city digital twin for the COVID-19 pandemic: A federated learning solution," Tsinghua Sci. Technol., vol. 26, no. 5, pp. 759–771, 2021. https://doi.org/10.26599/TST.2021.9010026
[6] UNESCO, "Education in a post covid world : ine ideas for public action international commission on the futures of education," 2020. [Online]. Available: https://en.unesco.org/news/education-post-covid-world-nine-ideas-public-action [Accessed: 13-Aug-2020]
[7] P. Wannapiroon, P. Nilsook, J. Jitsupa, and S. Chaiyarak, "Technology acceptance of online instruction for vocational instructors in new normal education," World J. Educ. Technol. Curr. Issues, vol. 13, no. 4, pp. 635–650, 2021. https://doi.org/10.18844/wjet.v13i4.6234
[8] T. Karakose, H. Polat, and S. Papadakis, "Examining teachers' perspectives on school principals' digital leadership roles and technology capabilities during the covid-19 pandemic," Sustain., vol. 13, no. 23, 2021. http://dx.doi.org/10.3390/su132313448
[9] S. Poultsakis, S. Papadakis, M. Kalogiannakis, and S. Psycharis, "The management of Digital Learning Objects of Natural Sciences and Digital Experiment Simulation Tools by teachers", AMLER, vol. 1, no. 2, pp. 58-71, Jun. 2021. https://doi.org/10.25082/AMLER.2021.02.002
[10] S. Papadakis, M. Kalogiannakis, E. Sifaki, and N. Vidakis, "Evaluating Moodle use via Smart Mobile Phones. A case study in a Greek University," EAI Endorsed Trans. Creat. Technol., vol. 5, no. 16, p. 156382, 2018. http://dx.doi.org/10.4108/eai.10-4-2018.156382
[11] T. T. De Back, A. M. Tinga, and M. M. Louwerse, "Learning in immersed collaborative virtual environments: design and implementation," Interact. Learn. Environ., pp. 1–19, Dec. 2021. https://doi.org/10.1080/10494820.2021.2006238
[12] S. Ennouamani, Z. Mahani, and L. Akharraz, A context-aware mobile learning system for adapting learning content and format of presentation: design, validation and evaluation. Education and Information Technologies, 2020. https://doi.org/10.1007/s10639-020-10149-9
[13] K. Palaniappan and N. Md Noor, "Gamification Strategy to Support Self-Directed Learning in an Online Learning Environment," Int. J. Emerg. Technol. Learn., vol. 17, no. 03 SE-Papers, pp. 104–116, Feb. 2022. https://doi.org/10.3991/ijet.v17i03.27489
[14] B. Alojaiman, "Toward Selection of Trustworthy and Efficient E-Learning Platform," IEEE Access, vol. 9, pp. 133889–133901, 2021. https://doi.org/10.1109/ACCESS.2021.3114150
[15] K. Schmidt-Hönig and G. Pröbstl, "The World in Children's Minds – or Sustainable Entrepreneurship Education as Empowerment to Shape a Desirable Future," Discourse Commun. Sustain. Educ., vol. 11, no. 2, pp. 33–44, 2020. https://doi.org/10.2478/dcse-2020-0017
[16] A. Eguchi, H. Okada, and Y. Muto, "Contextualizing AI Education for K-12 Students to Enhance Their Learning of AI Literacy Through Culturally Responsive Approaches," KI - Künstliche Intelligenz, vol. 35, no. 2, pp. 153–161, 2021. https://doi.org/10.1007/s13218-021-00737-3
[17] M. M. M. Peeters et al., "Hybrid collective intelligence in a human–AI society," AI Soc., vol. 36, no. 1, pp. 217–238, 2021. https://doi.org/10.1007/s00146-020-01005-y
[18] S. Pratsri, P. Nilsook, and P. Wannapiroon, "Augmented Intelligence Coaching System," Proc. - 2021 Res. Invent. Innov. Congr. Innov. Electr. Electron. RI2C 2021, pp. 176–182, 2021. https://doi.org/10.1109/RI2C51727.2021.9559817

[19] V. Dignum, "The role and challenges of education for responsible ai," London Rev. Educ., vol. 19, no. 1, pp. 1–11, 2021. https://doi.org/10.14324/LRE.19.1.01
[20] J. Zhou, "Design of AI-based self-learning platform for college English listening," Proc. - 2020 2nd Int. Conf. Mach. Learn. Big Data Bus. Intell. MLBDBI 2020, pp. 544–547, 2020. https://doi.org/10.1109/MLBDBI51377.2020.00114
[21] P. Wannapiroon, P. Nilsook, N. Kaewrattanapat, N. Wannapiroon, and W. Supa, "The Virtual Learning Resource Center for the Digital Manpower," Int. Educ. Stud., vol. 14, no. 9, p. 28, 2021. https://doi.org/10.5539/ies.v14n9p28
[22] K. Sarnok, P. Wannapiroon, and P. Nilsook, "Digital Learning Ecosystem by Using Digital Storytelling for Teacher Profession Students," Int. J. Inf. Educ. Technol., vol. 9, no. 1, pp. 21–26, 2019. https://doi.org/10.18178/ijiet.2019.9.1.1167
[23] S. Chaiyarak, P. Nilsook, and P. Wannapiroon, "An empirical study of intelligent virtual universal learning platforms," in 2021 Research, Invention, and Innovation Congress: Innovation Electricals and Electronics (RI2C), 2021, pp. 66–73. https://doi.org/10.1109/RI2C51727.2021.9559785
[24] Amanda Morin, "What Is Universal Design for Learning (UDL)?," 2020. [Online]. Available: https://www.understood.org/en/learning-thinking-differences/treatments-approaches/educational-strategies/universal-design-for-learning-what-it-is-and-how-it-works. [Accessed: 13-Aug-2020].
[25] M. Roski, M. Walkowiak, and A. Nehring, "Universal design for learning: The more, the better?," Educ. Sci., vol. 11, no. 4, 2021. https://doi.org/10.3390/educsci11040164
[26] K. J. Dickinson and S. L. Gronseth, "Application of Universal Design for Learning (UDL) Principles to Surgical Education During the COVID-19 Pandemic," J. Surg. Educ., pp. 1–5, 2020. https://doi.org/10.1016/j.jsurg.2020.06.005
[27] J. Zhao and J. Xuan, "Special issue on intelligent computing methodologies in machine learning for IoT applications," Neural Comput. Appl., vol. 33, no. 14, pp. 8105–8106, 2021. https://doi.org/10.1007/s00521-021-06186-1
[28] L. Zhang and X. Yu, "Intelligent retrieval method of mobile learning resources in the intelligent higher education system," Int. J. Syst. Assur. Eng. Manag., 2021. https://doi.org/10.1007/s13198-021-01455-7
[29] N. Mavengere and M. Ruohonen, "Context and user needs in virtual learning in pursuit of qualities of learning," Educ. Inf. Technol., vol. 23, no. 4, pp. 1607–1620, 2018. https://doi.org/10.1007/s10639-017-9681-3
[30] K. Hoernke, H. McGrath, J. Q. Teh, and O. Salazar, "Virtual Learning Innovations for Continuing Clinical Education during COVID-19," Med. Sci. Educ., vol. 30, no. 4, pp. 1345–1346, 2020. https://doi.org/10.1007/s40670-020-01090-0
[31] J. Ariza, M. Jimeno, R. Villanueva-Polanco, and J. Capacho, "Provisioning Computational Resources for Cloud-Based e-Learning Platforms Using Deep Learning Techniques," IEEE Access, vol. 9, pp. 89798–89811, 2021. https://doi.org/10.1109/ACCESS.2021.3090366
[32] S. Xu, "Recommendation of Online Learning Resources for Personalized Fragmented Learning Based on Mobile Devices," Int. J. Emerg. Technol. Learn., vol. 17, no. 03 SE-Papers, pp. 34–49, Feb. 2022. https://doi.org/10.3991/ijet.v17i03.29427
[33] N. Songkram, N. Songkram, S. Chootongchai, and T. Samanakupt, "Developing Students' Learning and Innovation Skills Using the Virtual Smart Classroom," Int. J. Emerg. Technol. Learn., vol. 16, no. 04 SE-Papers, pp. 34–51, Feb. 2021. https://doi.org/10.3991/ijet.v16i04.15221

9 Authors

Sakchai Chaiyarak is a Ph.D. Candidate in Division of Information and Communication Technology for Education King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand. He currently works as a lecturer at the Faculty of Education, Suan Dusit University, Thailand (email: sakchai_cha@dusit.ac.th).

Prachyanun Nilsook is the Professor at the Division of Information and Communication Technology for Education, the Faculty of Education, King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand. He currently works in the field of ICT for Education and Head of Vocational Education Technology Research Centre. He is a member of Professional Societies in the Thai Association for Educational Communications and Technology (Thai AECT) (email: prachyanun.n@fte.kmutnb.ac.th).

Panita Wannapiroon is the Associate Professor at the Division of Information and Communication Technology for Education, the Faculty of Education, King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand. She currently works in the field of ICT for Education and Director at Innovation and Technology Management Research Center. She is a member of Professional Societies in the Thai Association for Educational Communications and Technology (Thai AECT) (email: panita.w@fte.kmutnb.ac.th).

Article submitted 2022-04-07. Resubmitted 2022-05-25. Final acceptance 2022-05-25. Final version published as submitted by the authors.