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Adaptive User Interface of Learning Management Systems for Education 4.0: A Research Perspective

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Adaptive User Interface of Learning Management Systems for Education 4.0: A Research Perspective

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Abstract.   The growth of education is dynamically changing along with emerging technology. Learning management systems (LMS) takes an essential place regarding support its process. By many kinds of improvement aspect within technology, adaptive user interface (AUI) has a significant role to maintain students engagement in learning activities. However, it is very significant to analyze the development of AUI in education 4.0 to understand its significant challenge at this stage. This paper discusses AUI in learning system which has been proposed and implemented by other researchers. We apply a comparative perspective between technology and heutagogical aspect in evaluating their approaches. By delivering this perspective, the paper presents a short review of LMS adaptivity trends and development challenges in the field of learning services for education 4.0.

1. Introduction
Technology has been growing very fast. The speed of this change which coming together with globalization would affect not only the industry but also in the field of education. In time to time, people think and learn differently because of the development of technology. For that reason, educational technology is also moving forward to build such appropriate facilities which dynamically improved during the learning process.

The idea of education 4.0 is one of the transformations leads to a different way of learning because of the development of technology. Education 4.0 focuses on empowering educational field to produce innovation as a response for the fourth industrial revolution (IR4.0) which do not only need human resources but also computational technology so that the collaboration between them can make new possibilities[1]. In this revolution of industry, web technologies enable strategies to achieve more knowledge and to produce innovative products. Web 2.0 has already put learning profile as a consideration and it also happened by using Web 3.0. In the context of web 4.0, there is a more in-depth interaction between users and the system. In other words, there is a match correlation between the webs evolution and education profiles [2].

To support learners for the new perspective in education 4.0, an awareness to keep the systems to be adaptive to users by an appropriate approach is needed. Applying adaptive user interface into LMS is one of the ways to increase students′ engagement. This intelligent user interface is not only to provide much more flexibility but also to allow learners to control their environment.

Furthermore, many LMS has tried to keep a learner engaged by applying some AUI methods. Providing contextual system based on people′s needs and characteristics, AUI work by monitoring the users′ activity so that it can identify usage patterns and automatically adjust

the interface components or content [4, 5]. This approach will give so much benefit such as to create personalized systems and improve interaction. That is why the user interface in LMS can also increase students′ engagement in learning by using the systems. It enables this virtual environment in the form of blended learning as a great tool to help users achieving their educational goals including experience, skills, and knowledge.

However, the transformation which leads technology to support the 4th revolution in education should align with a new way of learning due to the change of mindset in creating a future innovation. When web 2.0 focuses on applying LMS for easy access to learning material, education 3.0 era showed that there are some changes regarding how students consume and produce their knowledge while using the system [6]. To realize a stronger demand of the next edu-transformation as a respond of IR4.0, a user interface (UI) takes an important role which is not only for the virtual learning environment in the aspect of technology but also for students in heutagogical aspect. The concept of heutagogy itself has already designed a couple of decades ago which conceptualize self-determined learning as a way of learning in educational processes.

In this paper, we expose existing studies of AUI from a perspective of education 4.0. Accordingly, we also describe comparison perspectives between those approaches based on technology and heutagogical aspects so that the following approach will enlighten researchers in assessing UI adaptivity based on trends and challenges in the field of education 4.0.

2. Definition and Background

2.1. Adaptive User Interface

Enhancing the use of technology including platforms and devices, a user interface could be managed to be adaptive. A system with AUI could automatically identify a pattern of the usage of the system so that it will be able to adjust its interface components or content provided by the system[4, 7]. In the context of Human-Computer Interaction (HCI), this adaptation process has created an intelligent interface which depends on the use of technology and human as users.

Several methods have been applied to create AUI in LMS. Researchers have impressively contributed some adaptivity process. According to [4, 8], these are the three primary approaches:

- Artificial Intelligence (AI)
- User Modelling (UM)
- HCI using multimodal interfaces

2.2. Education 4.0

In this section, education 4.0 is defined as a revolution of the innovative learning environment by using an advanced-LMS which can respond to the new revolution of industry. The real world needs learners with the most relevant skills and competencies which have progressive self-upgrades and self-tuning. Hence, such critical skills can help people to cope with changes and improve their career opportunities [3]. This kind of challenge affects the development of LMS nowadays, which has to support a new way of learning so that the students can be motivated in learning, learn-to-innovate, and have a good experience while using the systems.

According to that purpose, education 4.0 means availability of high technologies such as web-driven e-learning organizations integrated with several AI applications. An AI-based learning portal integrates open educational resources with individual adaptive learning so that the students would be helped by adaptive mechanisms [3]. Not only to help co-developing education plans for students, but AI also enables adaptivity for handling some changes based on students profile, preferences, and goals.

2.3. Heutagogy

As we know that learners are facilitated by recent technologies in the era of high industrial challenges, heutagogical approach in learning and teaching has become popular. Heutagogy is defined as a self-determined learning when a student can determine how, what, and when learning takes place [9]. Heutagogy has come after andragogy, which learning processes are systematically arranged for students, starting from to find learning needs until to get the result based on an evaluation. In heutagogy perspective, the arrangement of learning is not needed. It offers learners potential intuition in seeking knowledge. Moreover, learners have competencies such as self-efficacy for responding such of complexity theory which also reflects the framework of emotional intelligence by Daniel Goleman through the emphasize of adaptability [9].

3. AUI for Education 4.0

We have analyzed some existing works of AUI adoption in LMS. By conducting a comprehensive review of each approach, we highlight some specific issues of some advance LMS in this revolution of education 4.0. The comparison promotes adaptivity which involves two aspects within the process: 1) Technological aspect, and 2) Heutagogical (individual) aspect, as can be seen in Figure 1.
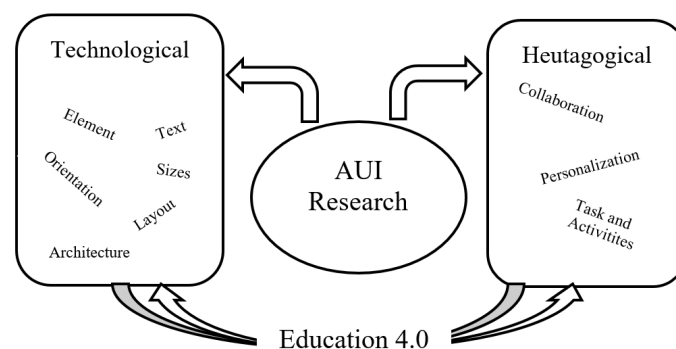

Figure 1. AUI Research for Education 4.0.

Considering these two critical aspects, we summarize some research approaches as shown in Table 1.

The dimensional concepts above describe some basic ideas in doing some existing and current works due to the development of AUI research. To promote a new way of learning in education 4.0, we analyze the combination of technological and heutagogical aspects is needed regarding the development of an advance LMS.

To meet heutagogy perspective, students are facilitated to interact more with the system. The perspective of this new edu-transformation also brings up a perspective of an advance LMS. An advance LMS will try to focus on creating an innovative learning environment which supports:

- Multiplatforms —a mobile learning
  Some devices such as desktops, laptops, tablets, or even smartphones are used nowadays to support distance learning so that the students can learn everywhere and explore more through the available LMS applications. According to [12], enabling mobility in learning will make a very powerful tool for the system. By providing adaptive learning through

Table 1. AUI Research.

Interface Adaptivity (Technological)	Innovative Research	Details
Elements (Layout, Screen Sizes, *etc.*)	Adaptive Layout Design [13, 14]	Graphical UI
Medium (Text, Image, Voice, Gestures, *etc.*)	Adaptive Medium User Interface [27] (Voice, Text, or Gestures Abstraction)	Touch Screen UI, Voice UI
Devices (PCs, laptop, tablets, smartphones, *etc.*)	Adaptive Mobile User Interface [12, 23] (Intelligent Mobile UI)	UI portability and multifunction UI
I/O interaction devices (keyboard, mouse, *etc.*)	Multimodal interfaces adaptivity [24]	Multimodal UI
Interface Adaptivity (Heutagogical)	**Innovative Research**	**Details**
Learning Style (Alzain, Kolbs, Felder Silverman, VAK/VARK, MBTI, Mixed, Gregore, Keefe, Honey and Mumford, *etc.*)	Adaptation using auto-detection using AI, evaluation analysis, literature-based [19, 20, 21, 18, 17, 16]	Personalization
Initial Knowledge (Cognitive, Expertise)	Adaptation using programmed pre-test result [13, 14]	Filtering problems and information overload
Learner Profiles and Behaviour (Disabilities, Age range, Ethnicity and culture, Upper limb usage)	Adaptive evaluation using user modelling, usability testing [26, 15, 25]	Personalization, Usage flexibility, Universal usability
Social Comparison	Adaptive sequencing using Mastery grids, comparative evaluation [22, 23]	Collaboration

mobile devices, the study showed that the student enjoyed learning because they would be able to learn without time or location restriction.

- High experience of collaboration —social learning
  Heutagogy in education leads a system to be capable of supporting an active double hands learning between users. Some decades ago, this self-determined learning was proposed so that students can have a higher level of autonomy and maturity in learning [9]. However, developing social-based learning will help them to define what is best to learn.

- Awarding features —gamified learning
  Gamification technique will enable learners to get motivated by challenges and solutions. Each step of some learning tasks might not be repetitive, boring, and demotivating if the system could apply a gamified-learning strategy. Moreover, it also brings positive outcomes such as higher engagement, increases attendance, and higher participation in learning [10].

A model of an advanced LMS as shown in Figure 2 described some enhancement after applying some adaptation techniques. Heutatogy and technology can enable both directly and indirectly to the formation of learning. The integration between those two is being analyzed based on
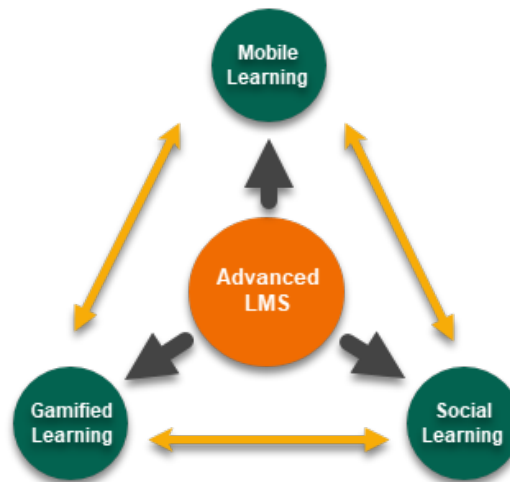
Figure 2. LMS for Education 4.0.

recent studies.

4. Discussions

Previously, there are three concerned values in education 4.0 such as the learn-to-innovate style of learning, users′ experience in using the system, and learners′ motivation and participation during a virtual learning process. Accordingly, these essential aspects bring up some underlined analysis based on reasonable questions (what, why, who, when, where, and how) in capturing the requirements for the system.

- *What.* What content should be provided to users? What kind of orientation to be presented to them? For this purpose, it is required to see heutagogical aspect from individuals so that the system can apply an appropriate approach which resolved by adaptation.

- *Why.* Why should one medium translate to being another medium? Why users have difficulties in controlling the systems? The set of questions in this area identifies the needs of users when interacting with the system.

- *Who.* Who are the targeted users? This question addresses a learner profile so that it could help to analyze a user interface adaptation.

- *When.* When the system provides the change? Is there any limitation of time when applying the change for adaptation? To understand this set of problems, the system should have some constraints based on both between technology and even heutagogical aspect.

- *Where.* Where should the elements be located in the system? By considering some heutagogical aspects within individuals, a learner profiles such as a left-hand user or even students with disabilities should be collected first.

- *How.* How could the change affect users′ learning performance? How efficient/effective the system can provide to increase users satisfaction? For these purposes, a user interface design needs an adaptivity evaluation to find a right match of adaptivity between both technology and heutagogy.

Based on the questions above, we can see that the two aspects technology and heutagogy-drive proper findings in identifying adaptation requirements.

There are several findings have promoted the integration of heutagogy and UI technologies to create adaptive learning. Accordingly, a personalization strategy is considered applicable to create an innovative environment for learners. An adaptation of content material cause some changes to an element of the UI which has been implemented into LMS system by using initial knowledge level of learners [13, 14]. Another study also uses knowledge level aspect to be visualized so that the students can see academic performances [15]. Driving by learners style of learning, the adaptation for UI also implemented to keep engaging students [16, 17, 14]. To implement AUI, weblogs analysis can be used to meet users' learning styles [17]. The interface could adapt based on the database which captured in SQL server database. There are also several learning styles which can be adapted based on geographical or countries issue [18]. Many studies concluding the learning environment based on learning styles affect to the better of students academic achievement [19, 20, 21]. Moreover, the heutagogical approach also needs a mechanism of transferring knowledge by realizing collaboration between learners. Various studies have found that users can be satisfied by the social activities supported by the system [22]. Another research also implemented gamification to motivate learners [23].

In addition, this integration of technology perspective to support heutagogical approach had also being researched in the case of UI technologies improvement. By using HCI approaches, adaptive multimodal interfaces could be developed to support a learning process based on users profile [24]. Accordingly, users' cognitive and physical performances also influence the interface of the system [?] Learners' behavior also could affect the enhancement of UI technology capabilities for the systems. Other studies showed that medium and devices are significantly beneficial for learnability [26, 27]. Varela (2013) [26] uses a proposed solution called Dandelion to develop an abstraction technology for integrating interaction devices so that it can support mobility for the system.

To the fact of advancement which has been implemented in recent studies, a new revolution in education creates a new way of learning which involves both technology and heutagogy. According to [11], heutagogy could give positive impact in controlling learning to be more flexible for learners. Heutagogy will force the system to adapt more to the world of users so that the interface can reach human adaptation. The research of user modeling, AI technologies, and many kinds of approach would be in an essential position for enabling the heutagogical approach so both aspects are needed to be analyzed so that technology can meet heutagogy and *vise versa*.

In this paper, some approaches stated in LMS for education 4.0 as; mobile learning, social learning, and gamified learning. By taking these three majors as learning environment goals, AUI takes an important role to support the process. However, the following explanations will elaborate the identified challenges.

- Multifunctional adaptation
  The opportunities for LMS advancement bring such of multifunctional adaptability within the system (See Figure 2). LMS is considerably analyzed to create socio-mobile learning which mainly focuses on social and mobile learning, social-gamification learning (social and gamified), mobile-gamification learning (mobile and gamified), or even socio-mobile-gamification (social, mobile, gamified). This challenge will need a UI adaptability framework which can innovate LMS system in supporting heutagogy perspective.

- Timeless adaptation process
  There are several combinations which involve both technology and heutagogy aspect, such as how some researchers have done in their previous works. To build an adaptation capability with multi-approaches, a methodology and evaluation might have many layers of UI adaptability. For making an efficient adaptation process, a proper methodology is needed regarding save time cost in designing AUI-based system.

- UI Design
  AUI technologies which offer more automation regarding learning process affect more changes to users. In a perspective of AI technologies, the changes also make systems to learn based on some inputs recover in adaptability. However, automation to generate UI design also gives impact to UI consistency.
- Proper evaluation
  Evaluating an adaptive LMS with a multifunctional way of learning should cover more approaches. The evaluation leads to the success of adaptation implementation to achieve goals for better learning.

5. Conclusion

The era of education 4.0 has driven AUI to give impact to the enhancement of technology and heutagogy. Both aspects are involved in creating innovative learning through a UI adaptation in advance LMS. The questions of what, why, who, when, where, and how formed the basis of adaptation processes. Some of the studies have proven that adaptability within the UI of LMS system can create students can be motivated in learning, learn-to-innovate, and have a good experience while using the systems.

However, analyzing education nowadays bring out several ways of learning to be considered regarding heutagogy perspective. The implementation of AUI in LMS for education 4.0 needs to achieve the new ways based on its environmental approaches such as mobile learning, social learning, and gamification learning. In this paper, related definition-background and discussions link for the challenges section.

Acknowledgement

References

[1] Haseeb A S M A 2018 Higher education in the era of IR 4 *New Straits Times* 14 *https://www.nst.com.my/education/2018/01/323591/higher-education-era-ir-40*
[2] Demartini C and Torino P 2010 From the Editors *Journal of Veterinary Cardiology* **12** 22528
[3] Ozyurt O and Ozyurt H 2015 Learning style based individualized adaptive e-learning environments: Content analysis of the articles published from 2005 to 2014 *Computers in Human Behavior* **52** 34958.
[4] Alvarez-Cortess V, Zayas-Perez B E, Zarate-Silva V H and Uresti J A R 2007 Current trends in adaptive user interfaces: Challenges and applications. Electronics *Proc. Int. Conf. on Robotics and Automotive Mechanics Conference* 31217.
[5] Ciolacu M, Tehrani A F, Beer R and Popp H 2017 Education 4.0 –Fostering student s performance with machine learning methods.
[6] Winstead S 2016 eLearning 4.0: Prospects and Challenges *https://elearningindustry.com/elearning-4-0-prospects-challenges*
[7] Liu J, Wong C K, and Hui K K 2003 Personalized Learning Intelligent Systems IEEE **18** 5257
[8] Gull F and Ceccacci S 2015 Ambient Assisted Living **11**
[9] Bhoyrub J, Hurley J Neilson G R, Ramsay M and Smith M 2010 Heutagogy: An alternative practice based learning approach *Nurse Education in Practice* **10** 32226.
[10] Bckle M, Micheel I and Bick M 2018 A Design Framework for Adaptive Gamification Applications *Proc. 51st Hawaii International Conference on System Sciences (HICSS 18)* 1227-36.
[11] Hase S and Kenyon C 2000 From andragogy to heutagogy *Ultibase Articles* **5** 110.
[12] Tortorella R A W and Graf S 2017 Considering learning styles and context-awareness for mobile adaptive learning *Education and Information Technologies* **22** 297-315.
[13] Ciolacu M and Beer R 2016 Adaptive user interface for higher education based on web technology *IEEE 22nd International Symposium for Design and Technology in Electronic Packaging (SIITME)* 300-03.
[14] Hariyanto D and Kohler T 2017 An Adaptive User Interface for an E-learning System by Accommodating Learning Style and Initial Knowledge *Proceedings of the International Conference on Technology and Vocational Teachers (ICTVT 2017)*.

[15] Barria-Pineda J, Guerra J, Huang Y and Brusilovsky P 2017 Concept-Level Knowledge Visualization For Supporting Self-Regulated Learning *Proceedings of the 22nd International Conference on Intelligent User Interfaces Companion - IUI 17 Companion* 141-44.

[16] Ahmad N, Tasir Z, Kasim J, and Sahat H 2013 Automatic Detection of Learning Styles in Learning Management Systems by Using Literature-based Method. Procedia - Social and Behavioral Sciences **103** 181-89.

[17] Kolekar S, Pai R M and Manohara Pai M M 2016 Adaptive user interface for e-learning applications based on learning styles using Web Logs analysis: A hybrid cloud architecture.

[18] Ovariyanti A S and Santoso H B 2017 An adaptation of the Index of Learning Style (ILS) to Indonesian version: A contribution to Index of Learning Style (ILS), validity and reliability score *2016 International Conference on Advanced Computer Science and Information Systems, ICACSIS 2016* 129-34.

[19] Own Z 2006 The application of an adaptive web-based learning environment on oxidationreduction reactions *International Journal of Science and Mathematics Education* **4** 73-96.

[20] Popescu E 2010 Adaptation provisioning with respect to learning styles in a web-based educational system: An experimental study *Journal of Computer Assisted Learning* **26** 243-57.

[21] Shaw R S 2012 A study of the relationships among learning styles, participation types, and performance in programming language learning supported by online forums *Computers & Education* **58** 111-20.

[22] Loboda T D, Guerra J, Hosseini R and Brusilovsky P 2014 Mastery Grids: An Open Source Social Educational Progress Visualization *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* **8719** 235-48.

[23] Fadhil A and Villafiorita A 2017 An Adaptive Learning with Gamification and Conversational UIs: The Rise of CiboPoliBot *Adjunct Publication of the 25th Conference on User Modeling, Adaptation and Personalization - UMAP* **17** 408-12.

[24] Fall C, Quevillon F, Blouin M, Latour S and Campeau-Lecours A 2017 A multimodal adaptive wireless control interface for people with upper-body disabilities *Proceedings - IEEE International Symposium on Circuits and Systems* **12** 564-75

[25] Lioulemes A 2016 Adaptive User and Haptic Interfaces for Smart Assessment and Training *Companion Publication of the 21st International Conference on Intelligent User Interfaces - IUI '16 Companion* 130-33

[26] Varela G 2013 Autonomous adaptation of user interfaces to support mobility in ambient intelligence systems *Proceedings of the 5th ACM SIGCHI Symposium on Engineering Interactive Computing Systems- EICS* **13** 179.

[27] Furqan A, Myers C and Zhu J 2017 Learnability through Adaptive Discovery Tools in Voice User Interfaces *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA '17* 1617-23