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Mobile Learning and Accessibility from Universal Design for Learning Perspectives

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Abstract

Considering the openness movement in education, the goal of this conceptual paper is to discuss how universal design of learning (UDL) can leverage new opportunities created by emerging technologies, especially focusing on the accessibility of mobile learning. The paper first presents the historical evolution of UDL frameworks and the role of technology in UDL. The, it discusses two main challenges underlying the adoption of UDL in practices: (1) abstract principles difficult to understand and apply in practices, and (2) ad-hoc integration approaches. To design inclusive and accessible mobile learning, this paper suggests that there should be a transition from technical standards to UDL principles that support flexible and personalized learning.

Keywords : universal design for learning (UDL), mobile learning, accessibility guidelines, learning technology

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보편적 학습설계 관점에서 모바일러닝과 접근성

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[요 약]

교육의 개방성이 확대되는 시대적 상황에서, 본 연구는 신기술을 활용한 보편적 학습설계의 가능성을 모바일러닝의 접근성 관점에서 논의하였다. 먼저 UDL의 역사적 발전과정을 제시하고, UDL의 원칙을 실행함에 있어서 테크놀로지의 역할을 크게 학습과 보조공학적 측면에서 논의하였다. 더불어, UDL을 실제적으로 적용할 때의 문제점을 (1) 이해와 실행에 적용하기 어려운 추상적 원칙과 (2) 즉흥적(add-hoc) 통합 방법의 두 가지 측면에서 제시하였다. 본 연구는 향후 포용적이고 접근가능한 모바일러닝을 설계하기 위해서는 기술적 표준을 넘어서서 유연하며 개별화를 지원하는 UDL 원칙으로의 전환이 필요함을 제시한다.

주요어: 보편적 학습설계, 모바일 러닝, 접근성 가이드라인, 학습공학

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Ⅰ. Introduction

Leveraging the affordances of emerging technologies such as mobiles and cloud computing, learning is becoming increasingly more open, accessible, and universal to learners with diverse backgrounds and disabilities. Recent initiatives on mobile learning, for instance, demonstrate that with the rapid penetration of mobile technologies and devices, there is growing recognition that learning can take place beyond the walls of classrooms and formal learning contexts. Furthermore, the emergence of MOOCs (Massive Open Online Courses), OCW (Open Courseware), and OER (Open Education Resources) in education scenes indicate the growing interests and efforts towards creating learning opportunities to reach out to a wide range of learners.

Considering the openness movement in education, the goal of this conceptual paper is to discuss how universal design of learning (UDL) can leverage new opportunities created by emerging technologies, especially focusing on the accessibility of mobile learning. In particular, this paper suggests that it is timely to discuss what should constitute the next generation of UDL if we are to take the advantages of learning opportunities enhanced and extended by the mediation of emerging technologies that makes learning experiences open, participatory and pervasive.

Ⅱ. Universal Design for Learning: Past and Present

1. A Historical Review of UDL

Historically, UDL is rooted in the philosophy and notion of universal design (UD) in the field of architecture, which is defined as “the design of product and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” (Mace, 1997). The original idea of universal design includes seven principles to design products and environments accessible to a wide range of people (The Center for Universal Design, 1997). The seven principles are: 1) equitable use, 2) flexibility in use, 3) simple and intuitive

use, 4) perceptible information, 5)tolerance for error, 6) low physical effort, and 7) size and space for approach and use. As UD was conceived in the context of architectural design, the seven principles were structured around the design of physical objects and built environments that people use or are situated in.

When the idea of universal design was adopted in education, the initial focus was on designing inclusive curricula that enable all learners to gain the necessary knowledge and skills. Table 1 shows the comparison between the original UD principles and UD frameworks in education. For instance, Scott, McGuire, and Shaw (2001) proposed the idea of Universal Design for Instruction (UDI) derived from the original UD framework with two additional principles specific to learning situations, namely community of learners and support and instructional climate. Later, Burgstahler (2007, 2015) from the DO-IT project at University of Washington proposed the UDL framework with nine principles, focusing on the design of instructional materials and activities that enable learning of individual learners with diverse abilities in physical, cognitive, and language domains. Burgstahler (2007) further emphasized the criticality of flexibility and early integration in UDL, stating that "Universal design for learning is achieved by means of flexible curricular abilities. These alternatives are built into the instructional design and operating systems of educational materials – they are not added on after-the-fact" (p. 1).

Table 1. UD and UDL design frameworks (Park, So, & Cha, 2019)

Universal Design	Universal Design for Instruction (UDI)	Universal Design of Instruction (UDI)
The Center for Universal Design (1997)	Scott, McGuire & Shaw (2001)	Burgstahler (2007, 2015)
1. Equitable use 2. Flexibility in use 3. Simple and intuitive use 4. Perceptible information 5. Tolerance for error 6. Low physical effort 7. Size and space for approach and use	1. Equitable use 2. Flexibility in use 3. Simple and intuitive 4. Perceptible information 5. Tolerance for error 6. Low physical effort 7. Size and space for approach and use 8. Community of learners and support 9. Instructional climate	1. Class climate 2. Interaction 3. Physical environments and products 4. Delivery methods 5. Information resources and technology 6. Feedback & assessment 7. Accommodation

The Center for Applied Special Technology (CAST) developed a set of concrete guidelines for UDL, which is widely used in instructional design and implementation. As shown in Table 2, the UDL guidelines by CAST have gone through several updates since its first publication. In 2008, the first version of UDL was published with three main principles that highlight the importance of providing multiple means of representation, expression, and engagement, followed by nine guidelines. In 2011, CAST published the updated version 2.0 to reflect research findings in the learning sciences and technologies for "the design of instructional goals, assessment, methods, and materials that can be customized and adjusted to meet individual needs" (CAST, 2011). In this updated version, the core principles of UDL (i.e., multiple means of representation, expression, and engagement) remain the same, and each core principle includes three guidelines with specific strategies. In 2014 and 2018, CAST updated Version 2.0 based on the feedback received from the field. One major change in Version 2.1 and Version 2.2 is that the guideline begins with 'provide multiple means of engagement', which was placed as the last principle in the previous versions, to highlight the critical role of engagement in learning processes.

Table 2. The evolution of CAST's UDL guidelines

Version 1.0 (CAST, 2008)	Version 2.0 (CAST, 2011)	Version 2.1 (CAST, 2014)	Version 2.2 (CAST, 2018)
I. Provide multiple means of representation	I. Provide multiple means of representation	I. Provide multiple means of engagement	I. Provide multiple means of engagement
1. Perception 2. Language & symbols 3 Comprehension	1. Perception 2. Language, mathematical expressions & symbols 3. Comprehension	1. Self-regulation 2. Sustaining effort & persistence 3. Recruiting interest	1. Recruiting interest 2. Sustaining effort & persistence 3. Self-regulation
II. Provide multiple means of action & expression	II. Provide multiple means of action & expression	II. Provide multiple means of representation	II. Provide multiple means of representation
4. Physical action 5. Expressive skills & fluency 6. Executive functions	4. Physical action 5. Expression & communication 6. Executive functions	4. Comprehension 5. Language, mathematical expressions & symbols 6. Perception	4. Perception 5. Language & symbols 6. Comprehension

III. Provide multiple means of engagement	III. Provide multiple means of engagement	III. Provide multiple means of action & expression	III. Provide multiple means of action & expression
7. Recruiting interest 8. Sustaining effort & persistence 9. Self-regulation	7. Recruiting interest 8. Sustaining effort & persistence 9. Self-regulation	7. Executive functions 8. Expression & communication 9. Physical action	7. Physical action 8. Expression & communication 9. Executive functions

2. The Role of Technology in UDL

While some differences exist across the diverse UDL frameworks proposed by researchers, one commonality is that UDL principles emphasize both pedagogical strategies and technological tools. In particular, technology plays a critical role when designing learning materials and activities with built-in mechanisms that allow alternative and multiple ways for representation, expression, and engagement. That is, while it is true that UDL is possible without technology, the core principles of UDL such as flexibility and adaptability can be greatly enhanced with the appropriation of technological tools. In some contexts, UDL would not be possible without the help of technology.

Two aspects of technology are considered in UDL: *assistive* and *learning*. Rose et al. (2005) discussed the different roles of assistive technology and learning technology. They argue that UDL focuses on learning environments rather than particular students, stating "Its purpose is to identify potential barriers to learning in a curriculum or classroom and to reduce such barriers through better initial designs, designs with the inherent flexibility to enable the curriculum itself to adjust to individual learners" (Rose et al., 2005, p. 508). It was suggested that while assistive technology is based on the *individual* view focusing on the level of individuals with disabilities, UDL is driven by the *environmental* view about how to create curricular and environments that accommodate and support learners with diverse abilities and disabilities. In the environmental view of UDL, hence, the role of technology is concerned with instructional strategies and learning design that reduce barriers in learning environments to make learning accessible to people whose learning opportunities are often limited in traditional approaches.

King-Sears (2009) caution that UDL is not solely about the use of technology, but about pedagogy and instructional strategies that make learning more accessible to a wide range of learners. Under this view, technological design affects how learners access learning content in multiple ways, whereas pedagogy affects how much learners understand the content. King-Sears views the role of technology mainly as a medium of accessing and delivering content.

3. Critical Views on UDL: Why UDL Practices are Lagging Behind?

While the notion of UDL has been well understood, translating UDL principles into practices has been slow and challenging. So far, we have not seen the wide adoption and implementation of UDL in educational practices. That is, while the core principles of UDL have been widely communicated and disseminated for the past decade, UDL practices seem lagging behind. There are several challenges in UDL with the increasing diversity in the student population. For instance, as UDL embraces the culture of participatory learning, it has to be conceptualized at multiple levels beyond individuals and small groups. Then, how can UDL be realized as a whole-school approach and a large learning community rather than an individualized lesson and a single classroom implementation?

This paper discusses two main challenges underlying the adoption of UDL in practices. First, from teachers' perspectives, UDL guidelines are written in abstract principles that are often difficult for teachers and instructional designers/developers to understand and apply in practices. Hence, it is of the teachers' and designers' responsibility to interpret and imagine what each principle looks like in real situations. The fundamental challenge in applying UDL principles would lie in the difference of design in between architecture and learning. Interaction patterns in the built environment are rather static, whereas interaction in learning environments is difficult to predict due to the complexity of unforeseen and confounding variables (Edyburn, 2010). Despite that, several UDL frameworks do not appear to include strategies regarding how teachers can accommodate such a complex nature of instructional variables, thereby creating some misconceptions and confusion about UDL. Nelson and Basham (2014) discussed 10 common misconceptions about UDL. For instance, the first misconception is that teachers automatically assume that they are implementing UDL when using technology that supports flexible methods and

materials. However, they argue technology alone does not define UDL. Instead, how technology is used decides whether it supports UDL or not.

Table 3. Propositions and misconceptions about UDL

Propositions (Edyburn, 2010)	Common misconceptions (Nelson & Basham, 2014)
1. Universal design in education is fundamentally different from universal design in the built environment. 2. UDL is fundamentally about proactively valuing diversity. 3. UDL is ultimately about design. 4. UDL is not just good teaching. 5. UDL does not occur naturally. 6. Technology is essential for implementing UDL. 7. UDL is not assistive technology. 8. It is necessary to measure the primary and secondary impact of UDL. 9. Claims about UDL must be evaluated on the basis of enhanced student performance. 10. UDL is much more complex than we originally thought.	1. It is about technology. 2. It is only for kids with disabilities. 3. It is an instructional strategy. 4. It is what good teachers already do 5. It is the same as differentiation. 6. It can only be done for small groups of kids. 7. It is only for certain types of teachers. 8. It is for specific subject areas 9. If I'm using a "UDL product", I'm doing UDL. 10. There is no research behind it.

The second challenge is associated with integration approaches in many situations where adaptation and accommodation are made in an ad-hoc manner rather than from the beginning of designing instructional materials and technology-mediated learning environments. Schwanke, Smith, and Edyburn (2001) discussed such challenges in accommodating the principles of UDL with the A3 model that explains a three-phase developmental cycle of UDL to achieve universal accessibility. The A3 model includes the following three phases:

- Phase 1 Advocacy - Raising awareness
- Phase II Accommodation - Modify inaccessible materials. Usually done upon request as a post-hoc and add-on approach
- Phase III Accessibility - Environments where access is provided to everyone.

Phase I advocacy involves understanding UDL at conceptual levels whereas Phase II accommodation means doing UDL intentionally by translating UDL principles into concrete practices. Phase III accessibility involves doing UDL seemingly with the widespread availability of UDL. The transition from the accommodation to the accessibility phase happens when UDL becomes ubiquitously available from the start, thereby the amount of modification and add-hoc strategies required by teachers and developers can be greatly reduced. Then, a central question is how to reach the accessibility phase where learning environments are easily accessible by all learners without many efforts for post-hoc accommodation. The following section discusses this question with considerations of new emerging technologies that have the great potential to create open, accessible, and universal learning environments.

III. Universal Design for Learning in the Mobile Age

1. Changing Nature of Teaching and Learning in the Mobile Age

During the past decade, the nature of teaching and learning has changed significantly. There is a growing recognition that learning can happen outside of school and that students learn a great deal of information and knowledge in informal learning settings (Pedro et al., 2018). Mobile technology is one of the critical factors that have influenced such changes in how we teach and learn. There are some unique affordances of mobile devices that make them an appropriate tool for universal learning: affordability, portability, connectivity, and multi-functionality. Mobile devices and broadband services are becoming increasingly affordable even in underdeveloped areas with competition among mobile network operators and affordability of mobile services and devices. Portability and connectivity are key attributes that make mobiles the most accessible device in the world. With built-in functions and sensors (e.g., camera, speakers, GPS, etc.), mobile devices can perform multi-functions beyond a simple communication tool. The promise of mobile learning can be considered from the following five perspectives (So, Kim, & Looi, 2008):

- The portability and versatility of mobile devices have significant potential to promote a pedagogical shift from traditional teacher-centered to learner-centered

and participatory learning environments

- The nature of mobility as a continuous attribute should be a critical element of mobile learning scenarios. Mobility enables a shift from one-to-one to many-to-many communication, individual to collaborative interaction, and centralized to decentralized systems
- Mobile learning challenges our conception of learning to move beyond a dichotomy between formal learning and informal learning, for the design of a seamless learning space linking the two modes of learning
- Mobile technology and devices can support collaborative meaning-making processes
- Mobile learning emphasizes the socially situated nature of learning and practice

Of course, the above promises of mobile learning do not occur naturally. With the tight coupling of mobile technologies and pedagogical design, learning can be more accessible to a wide range of learners. For instance, the rise of opportunities for online learning and open education resources easily accessible by mobile devices is indicative of new opportunities for learning in the age with ubiquitous connectivity.

2. Opportunities Arising from Mobile Learning: Are they Accessible?

There has been relatively little work and research to design accessible and inclusive mobile learning. Before students can engage in any mobile learning activities, it is fundamental to reduce the barriers to mobile accessibility. In recent years, MOOCs are commonly used in university classrooms. With the idea of flipped learning, for instance, instructors often ask students to learn basic knowledge through MOOCs and OER, and classroom time is devoted to discussion and activities (Bond, 2020). It is expected that MOOCs grow with the participation of more educational institutions worldwide. In Korea, consistent with the global trend on the open learning movement, the Korean government has initiated the establishment of KOCW (Korean Open CourseWare) to support the opportunities for lifelong learning to access university courses and online resources.

MOOCs can provide alternative learning opportunities for people with disabilities who could not attend schools through traditional means. However, it is still questionable whether MOOCs are really open and universal to learners with

disabilities. For instance, Park et al. (2019) found that mobile MOOC platforms have serious accessibility problems that prevent learners with visual impairment from fully participating in MOOC courses. The accessibility problems were found in several areas in the design of MOOCs platforms such as translation, language selection, text alternatives, and time-based media. Similarly, Iniesto et al. (2022) found that MOOCs providers (e.g., accessibility specialists, course teams, technical specialists, and educational content specialists) are aware of the reality that the current MOOCs platforms have several barriers to accessibility, However, MOOC providers tended to prioritize legislation and technical standards over the needs and preferences of learners with disabilities.

IV. Towards Accessible Mobile Learning from UDL Perspectives

1. Transition From Technical Standards to UDL

With the rise of online learning opportunities, there have been some concerns regarding whether online learning platforms and courses are accessible to a wide range of learners with disabilities. An early debate on online learning accessibility has been around the technical guidelines and standards. Online learning platforms and courses were evaluated according to the web accessibility standards. In 2018, the Web Content Accessibility Guidelines (WCAG) 2.1 was published based on WCAG 2.0 by improving accessibility for three groups: users with cognitive or learning disabilities, users with low vision, and new accessibility requirements related to mobile devices (W3C, 2018). The WCAG 2.1 includes four fundamental principles of Web accessibility: perceivable, operable, understandable, and robust, followed by 13 guidelines that make web content more accessible. For each guideline, there are testable success criteria with three levels of conformance: A (lowest), AA, and AAA (highest).

However, technical standards alone would not change real practices in education. Instead, new learning opportunities created by emerging technologies should be viewed from multiple lenses encompassing pedagogical, relational, and participatory

aspects of learning to make it more accessible and inclusive (Guglielman, 2010). On a similar note, Seale (2006) proposes a contextualized model of accessible e-learning practice in higher education that considers the interplay of multiple stakeholders, drivers, and mediators:

- Multiple stakeholders: learners, educators, administrators, content developers, authoring tool developers, etc.
- Drivers of accessibility: legislation, universal guidelines, universal standards
- Mediators of accessibility: views of disability and accessibility

Seale (2006) argues that accessibility issues in e-learning practices do not change simply by the external drivers such as legislation, accessibility guidelines, and standards. In reality, the validity and practicality of guidelines and standards are questionable and cause some confusion and misinterpretations.

Ellis and Kent (2011) argue that there are three stages of accessibility to online environments for people with disabilities. In the first stage, online platforms are accessible but not distributed widely. As an example, the early version of World Wide Web (WWW) was largely text-based, hence making it easy for people with disabilities to access. In the second stage, as online platforms are widely distributed with popularity, they often become no longer accessible as part of the redesign. With more functions are integrated, platforms become more inaccessible to people with disabilities. In the third stage, with the recognition of inaccessibility issues, designers and programs retrofit access measures. It appears that this vicious cycle of accessibility and inaccessibility is repeated when each new platform has emerged in the commercial market. The fourth stage of accessibility can be reached when universal design is considered and built in at the early stage of developing a new platform.

2. Designing Inclusive and Accessible Mobile Learning

Then, how can online learning be designed to be more accessible and universal to learners with disabilities? Elias (2011) provides specific recommendations for designing inclusive mobile learning, with respect to the eight principles of UDL (Table 4). Some principles are more critical in mobile learning than in online learning. For instance, simplicity in interface and content design is more important in mobile learning due to the small screen size of mobile devices. Organizing and

delivering learning units in small chunks is also an important consideration when designing materials and resources for mobile learning.

Table 4. UDL principles and recommendations for online learning and mobile learning (Elias, 2011)

UDL Principles	Online distance education recommendations	Mobile learning recommendations
1. Equitable use	• Put content online • Provide translation	• Deliver content in the simplest possible format • Use cloud-computing file storage and sharing sites
2. Flexible use	• Present content and accept assignments in multiple formats • Offer choice and additional information	• Package content in small chunks • Consider unconventional assignment options • Leave it to learners to illustrate and animate courses
3. Simple and intuitive	• Simplify interface • Offer offline and text-only options	• Keep code simple • Use open-source software
4. Perceptible Information	• Add captions, descriptors and transcriptions	
5. Tolerance for Error	• Allow students to edit posts • Issue warnings using sound and text	• Scaffold and support situated learning methods
6. Low physical and technical effort	• Incorporate assistive technologies • Consider issues of physical effort • Check browser capabilities	• Use available SMS readers and other mobile-specific assistive technologies
7. Community of learners and support	• Include study groups and tools • Easy-to-find links to support services	• Encourage multiple methods of communication • Group learners according to technological access and/or preferences
8. Instructional climate	• Make contact and stay involved	• Push regular reminders, quizzes and questions to students • Pull in learners-generated content

Recently, Iniesto et al. (2022) suggested some important considerations to support accessibility in MOOCs. The suggestions include the (a) platform design and access (simple and customizable design), (b) course main page (personalized functions and filtering), (c) educational resources (captions, transcripts and sign languages), (d) discussion, assignments, tests, and quizzes (easy to follow, feedback), and (e) help (options for reporting barriers). They also suggest that participating learners with disabilities in course design will greatly reduce accessibility barriers in MOOCs, beyond the WCAG compliance.

3. Conclusion: The Next Generation of UDL

The first decade of UDL was mainly about advocacy and accommodation. The wide application of UDL, however, has been slow. Edyburn (2010) argues that a fundamental question about whether UDL makes teachers function effectively in daily teaching has not been addressed, questioning that "are teachers the principle stakeholders as they design and deliver instruction in accordance with UDL principles? Or is UDL a task for developers who make instructional products?" (p. 37). While teachers are required to make some necessary adaptations and accommodations to apply UDL, it should not be teachers' sole responsibility. The burdens and demands required by teachers need to be reduced in order to see the wide adoption of UDL in educational contexts.

With that, this paper suggests that the use of emerging technologies could provide some solutions for designing learning environments that are more open, accessible, and universal to learners. Such emerging technologies increasingly support embedded and pervasive functions. Mobile devices, as an example, come with various sensors, voice recognition, and text-to-speech functions that readily support multiple means of engagement, expression, and participation by learners with disabilities. Online video sites such as Youtube use Google Translate to provide auto-translated captions in several languages. Web technologies are also promising with the integration of semantic and intelligent functions that support users to easily create content.

When conceptualizing the next generation of UDL, we cannot ignore such possibilities offered by emerging technologies. This is not to say that technology is a panacea. Instead, the point is that by actively exploring possibilities of emerging

technologies coupled with appropriate pedagogical design, we can open a new decade of UDL with great flexibility and scalability where all learners can easily access to and participate in learning activities. For instance, MOOCs as discussed in this paper provide learners with great learning opportunities to easily access online courses and resources. As such an open education movement becomes a major trend in teaching and learning for the next decade, we need to explore how to make open courses and resources more accessible and universal to learners. This trend is particularly important considering the recent experiences during the COVID-19 pandemic where online remote has become the main mode of learning for all educational contexts and all types of learners (Armour, 2022).

Achieving the ultimate goal of UDL in the next decade will be a complex endeavor that requires synergy among multiple stakeholders and long-term investment. External regulations, standards, and add-hoc solutions will not change UDL practices. There should be more bottom-up efforts and initiatives that address UDL from the early stage of designing any technology-mediated learning environments and applications.

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