Employing Affordance-Based Design to Improve the Usability of E-Learning User Interfaces

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Abstract: Given that a user interface interacts with users, a critical factor to be considered for improving the usability of e-learning content user interface is to design a more affordable user interface. Most studies on affordance are limited to the examination for the affordance of e-learning tools rather than the systematic design of such affordance. Using the approach of Maier and Fadel's affordance-based design methodology as a framework, the researchers identified affordance factors, developed affordance strategies and the user interface, and evaluated the user interface prototype. In addition, the effects of affordance design strategies on usability were examined. Implications are suggested for designing strategies that enhance affordances of user interfaces of e-learning contents.

Keywords: Affordance-based design methodology, User interface, E-learning content, Usability

INTRODUCTION

For successful e-learning, a user-centered interface design is critically important because a good design allows students to access effortlessly to the e-learning contents. Affordances are major factors that need to be considered in designing a user-centered interface; affordances are inherent properties of an object that induce certain user behaviors (Gibson, 1979; Norman, 1988). When a learner perceives e-learning content user interface as more affordable, they are likely to operate the e-learning user interface effortlessly and therefore, to show clearly desired learning behaviors.

Most studies on affordance have investigated the affordances of various media such as asynchronous video conferencing tools(Krauskopf, Zahn, Hesse, 2012), handheld devices (Song, 2011), 3-D Virtual environments (Dalgarno & Lee 2010), and blogs (Robertson, 2011). Although these studies examined educational affordances of different educational media by exploring users' perceptions about the affordances and constraints of the media, they are limited to the examination of e-learning tools affordance rather than systematic design of e-learning tools affordance.

Several studies have suggested some design strategies that support learning from an affordance perspective. They include button and icon design to increase interactions between the medium and the learner (Jona, Bell, & Birnbaum, 1991), design of learning agents that support active learning by reducing psychological distance from the medium (Johnson & Lester, 2000), and scaffolding strategies that help learners perform actively (Simons & Klein, 2007).

Despite that these strategies attempt to increase learning by actively influencing learners' behavior, specific affordances that stimulate learners' behaviors were not identified and systematically taken into account in the development process. As an attempt to address this issue, Bower (2007) proposes a methodology for matching the affordance requirement of learning task with affordances of technology tools. Implicit in this method is that simultaneous consideration for the affordance requirements of the tasks and for the affordance availability of the technology is needed for improving affordance of e-learning materials. To further develop proper affordance design strategies, design strategies should be developed from a comprehensive approach. Thus, a systematic approach is needed to identify and improve affordances that are pertinent to a specific technology for targeted learning tasks. Maier and Fadal(2009) suggests a method that analyzes, synthesizes, and organizes affordances in the field of architecture. However, little has been conducted in the development of e-learning contents. Therefore, a systematic approach is needed to develop design strategies that improve e-learning content user interface.

METHOD

For successful e-learning, a user-centered interface design is critically important because a good design allows students to access effortlessly to the e-learning contents. Affordances are major factors that need to be considered in designing a user-centered

Context

E-learning contents were obtained in this study from the EDUNET Cyber Home Learning System, Korea's largest education portal, which supports the distribution and utilization of a diverse range of high-quality educational content. The subjects were 'Information Technology Training' from Information Communication and Technology. The e-learning content was examined to see how affordable it was in aiding for students to induce the intended learning actions and how useful it was aiding them to learning content.

Research Design

Starting with the affordance-based design model presented by Maier and Fadel (2009), four main steps were carried out in this study: 1) identifying affordance structures, 2) identifying affordance design strategies, 3) developing the new user interface, and 4) evaluating the user interface. For this, ASM was used to identify, analyze, and refine, and select optimal affordance factors that need to be considered for components of an artifact.

Research Procedure

The researchers employed a series of processes to improve the usability of e-learning content user interface. A literature review suggested important components of e-learning content and their associated affordance factors.

Eight experts (two professors in Instructional Technology, two professors in Information Technology, two e-learning design specialists, one e-learning content-development expert, and one elementary-school teacher) were participated as Delphi experts. They participated in an expert heuristic evaluation to come up with identification of e-learning content component, e-learning affordance factors, prioritization of the identified affordance factors, and identification of affordance design strategies. Content validity index was used to prioritize the identified affordance. Suggested design strategies were incorporated into the development of new user interface. An experimental study allowed the researchers to determine which affordance features of user interface were improved. The questionnaire was completed by 171 fifth grade students at an elementary school.

Table 1 Methods, purpose, and numbers of participants in the study

Phase	Purpose	Participants	Methods
Identifying affordance structures	Identify components for targeted e-learning user interface Identify their associated affordance factors	Researchers	Literature review Delphi
Identifying affordance design strategies	Evaluate and prioritize affordance factors Identify design suggestions for improving affordance	Eight experts whose specialty is related with e-learning content user interface	Delphi Content validity index
Developing the user interface prototype	Create a new user interface prototype	Researchers	Affordance design strategies
Evaluating the user interface	Examine effects on usability of e-learning user interface	5^{h}–graders at an elementary school (n = 171	Experimental study

Identifying affordance structures.

The affordance of the artifact components was analyzed using ASM. First, the components of an artifact are placed in the upper portion of an ASM, where all components that are able to operate from the artifact must be separated and arranged. For this purpose, the components of e-learning, the EDUNET Cyber Home Learning user interface were analyzed and sorted. The resulting components included overall mood, titles, lists, location of the learner, learning content, media feature controls, screen changes, captions, tips, behavior-inducing messages, and learning support tools.

Next, the affordance factors are placed on the left side of the ASM as well. Cognitive, physical, and sensory affordance suggested by Hartson(2003) were used to extract the affordance factors. Delphi experts modified the affordance factors according to the characteristics of e-learning content. Cognitive type of affordance included four components: accurate representation, provision of tips, inaccurate content, and confusing. Physical type of affordance included nine components: convenient operation, inducing interaction, immediate interaction, abnormal termination, invalid connection, no movement, complex operation, cannot perform operation, and unresponsive. Sensory type of affordance included two components: appropriate visual effects and appropriate auditory effects.

Identifying affordance design strategies.

To identify affordance design strategies, the affordance factors of e-learning components first need to be evaluated and prioritized. For this, the identified components of e-learning content were marked differently according to their positive or negative affordance values. The positive artifact-user affordance factors were marked with a '+', and the negative artifact-user affordance factors were marked with a '-'. Next, priorities of affordance were determined based on the calculations of marked affordance factors. The sum and percentage of components marked with a '+' and the sum and percentage of those marked with a '-' were then calculated and noted. The number of '+' marks in the 'AUA +' area was added up and noted under 'sum of + affordances,' and the percentage

of affordances was then calculated. The ‘percentage of + affordances’ and the ‘percentage of - affordances’ were the percentage values that were obtained by dividing the ‘sum of + affordances’ and the ‘sum of - affordances’ by the ‘total +/- affordances.’ The ‘percentage difference’ is the difference generated by subtracting the ‘percentage of - affordances’ from the ‘percentage of + affordances’. The affordance design factors had to be determined based on the percentage difference between positive and negative affordances; components with a smaller positive value or a negative value would need to be improved (Maier, 2011; Maier & Fadel, 2009).

Once identifying the affordance factors, design strategies should be developed to improve components with a negative value. The e-learning content component with the lowest percentage difference was Media Features Control. Location of the learner, list, screen changes, learning support tools, learning contents, and title were followed. Affordance design strategies can be developed to reduce negative aspects and to improve effective and efficient use of the identified components.

FINDINGS

Affordance design strategies

Affordance design strategies were suggested for the affordance factors with percentage difference 50% below. A summary of design strategies to improve affordances for the identified e-learning components is provided. For example, for the media feature control, strategies for reducing negative-affordance items such as unexpected termination should be eliminated. For this reason, strategies such as ‘ensure that the learning window does not close unexpectedly’, ‘ensure error-free operation’, and ‘design buttons so that learners can perceive easily and operate’ were suggested to avoid negative affordances whereas the strategies of ‘ensure that operation methods are recognized as similar to those in the real world’ and ‘ensure immediate processing after operation’ were suggested as positive strategies.

New e-learning content user interface

Based on the results of suggested affordance design strategies, a new e-learning user interface was developed. Many changes were incorporated into new e-learning user interface. For instance, media feature control is the e-learning component with the lowest percentage difference that has many negative affordances and thus, needs to be improved. To decrease negative affordance, the new user interface has significant changes. Location of media control panel is moved from the bottom of the center to the bottom of right area in the screen. New location allows learners to easily operate screen. Familiar metaphors were included in the new media control panel so that students can better perceive the media features. Script view and audio control functions were also added for leaners to process learning efficiently.

The effects of affordance strategies on usability

Students in the affordance e-learning content group had a significantly higher usability score (M = 4.18, SD = .45) than students in the existing e-learning content group (M = 3.63, SD = .77); $t(110) = -5.42$, $p < .01$. Specifically, students in the affordance e-learning content group had a significantly higher effectiveness usability score (M = 4.37, SD = .47) than those in the existing e-learning content group (M = 3.72, SD = .85); $t(105) = -5.90$, $p < .01$, and those in the affordance e-learning content group had a significantly higher efficiency score (M = 3.94, SD = .60) than those in the existing e-learning content group (M = 3.54, SD = .80); $t(130) = -3.53$, $p < .01$. Finally, students in the affordance e-learning content group had a significantly higher satisfaction score (M = 4.14, SD = .71) than those in the existing e-learning content group (M = 3.57, SD = .87); $t(138) = -4.60$, $p < .01$.

CONCLUSION

The purpose of this study was to explore design strategies that facilitate users’ interactions with e-learning contents from an affordance perspective. To achieve this, affordance design strategies for e-learning content were identified by employing the core process of affordance-based design methodology. The effects of these affordance design strategies on usability were then examined.

Despite the importance of affordance design, most studies on affordance have examined the affordance

characteristics that are existed in e-learning tools. Previous studies have suggested design strategies that improve affordance attributes of e-learning, but these attempts have been limited by the lack of systematic approach in the development of such affordance. Such strategies will be possible when the properties that influence learner behavior are systematically considered with reference to affordance-based design methodology in this study. Improvements in the usability of e-learning user interface were achieved systematically through the use of affordance-based design methodology in this study. Using the approach of Maier and Fadel's (2007) affordance-based design methodology as a framework, the researchers identified affordance factors, identify affordance strategies, develop the user interface prototype, and evaluate the user interface prototype. The systematic affordance design approach of this study can provide designers with a guide to exploring affordance that are pertinent to critical components of e-learning user interface, improving the components of e-learning user interface by reducing negative impacts and enhancing positive impacts simultaneously according to critical progress on the development of e-learning user interface.

Affordance factors of e-learning content user interface were identified from Hartson's affordance classification: cognitive, physical, and sensory. The three types of affordance used in this study will provide designers with selection criteria that will be useful for identifying important affordance that are associated to e-learning user interface component. Given that the affordances differ according to the characteristics of the medium(Kirshner, 2002), future study may need to look for other types of affordance that are distinctive in educational contexts.

The new e-learning content that employed affordance design strategies resulted in significantly higher scores for all three components of usability (effectiveness, efficiency, and satisfaction). According to studies on affordances, when a person operates a specific system, the system affects the behavior of the user. Thus, enhancing the affordances inherent in the system help the learners to induce intended learning behaviors and thus, use the user interface effectively, efficiently, and satisfactorily (McGrenere & Ho, 2000). Results shows that elementary school students with new e-learning content tends to easily catch important information, clearly understand organized learning contents, operate learning support tools without troubles, easily find necessary information, and immediately move to desired learning content. The results also show that students with the new e-learning content perceived the use of new affordable e-learning contents as more valuable. The findings from this study confirm that affordance-based design is a critical vehicle in improving usability for e-learning content.

The affordance design strategies identified in this study had a positive impact on usability, indicating that if such strategies are properly utilized, e-learning contents that encourage more appropriate learner behavior can be better developed. The growing use of new learning tools, such as smart-phones, tablets, and digital textbooks, in educational settings emphasizes the need to apply affordance design strategies to various media to allow learners to respond actively to changes in their learning environment (Sheridan & Kortuem, 2006). In addition, because affordances are affected not only by users' intentions in using the media, but also by various user-related factors, such as age, learner characteristics, and previous e-learning experience, these user-centered variables should also be taken into consideration in future studies.

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