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Development of Sound Design Strategies for Promoting Self-regulated Learning Behaviors in Mobile Learning Environments

Taehyun KIM
Chungkang College of Cultural Industries
Korea

Students mostly precede their learning without any direct support of instructor in e-learning and mobile educational environment. Many useful strategies and tools to facilitate self-regulated learning behaviors in e-learning environment have been introduced, yet, the limit has been reached by only suggesting self-regulated strategies with visual information in the most researches. Accordingly, this research is intent to propose the sound design strategies that facilitate learner's self-regulated learning behaviors in mobile learning environment. To achieve the objective of the research, two research questions are presented. First, what are the sound design strategies that facilitate the self -regulated learning behaviors in mobile learning environment?. Second, what are the results of evaluating the developed sound design strategies in terms of facilitating self-regulated learning behaviors?. To solve these research questions, the literature reviews on characteristics of mobile learning, concepts and features of self-regulated learning and sound were done to establish the sound design strategies. Through formative research method targeting instructional designers, sound design strategies were modified and supplemented. The research to validate these was performed and to verify the effect of the derived sound design strategies, the usability test aimed at instructional designer and learners was conducted. The final sound design strategies through this research process were six general design strategies and the sixteen detailed strategies. This research is meaningful because this offers the basic research on sound information design which has been lacking and help upgrade the upper limit of instructional design which mainly focused on visual information in mobile learning environment that shows information in a small screen.

Keywords: Self-regulated learning, Mobile learning, Sound design strategy, Audio information design

Introduction

There has been an increased amount of attention toward mobile learning due to an availability of various mobile devices such as smartphones and tablet PCs (McCrea, 2010). High spatiotemporal usages and portability of mobile devices compared to web based learning come from the characteristics of mobile learning environment (Hoppe *et al.*, 2003; Kossen, 2001; Kukulska-Hulme, 2008; Lee, Song, & Lee, 2006; Quinn, 2009). Despite a rapid growth in mobile related contents, there is lack of research in instructional design strategies or learning strategies for mobile learning. Therefore, the researches related to systematic instructional designs and strategies are exigent in this era of rapid development of mobile learning.

Learners tend to study independently in mobile- and e-learning environments, thus self-regulated learning ability of learners is demanded. The effects of self-regulated learning skills on learning process and achievement have been empirically proven by many researchers (Artelt *et al.*, 2000; Baumert *et al.*, 1998; Lim, 2001; Pressley & Ghatala, 1990; Pintrich, 2000; Pintrich & De Groot, 1990; Shin, 1998; Schunk & Zimmerman, 1998; Weinstein & Mayer, 1986; Yang, 2000; Zimmerman, 1989; Zimmerman & Martinez-Pons, 1986). However, the researches show that many learners are not effectively self-regulated in e- or mobile-learning environments (Perry & Winne, 2006; Schunk & Zimmerman, 1998; Winne, 1995). Accordingly, it can be said that various strategies and tools for promoting learners' self-regulated learning behaviors in mobile learning environments are necessary.

Mobile learning devices have relatively small displays compared to e-learning environments. This research would like to suggest the utilization of audio resources as an alternative to withstand the limited display space in mobile environments. Audio information application in mobile learning environments is an optimal information representation method since the mobile learning environments have portability and mobility features. This can be explained by an escalating number of learning contents in language such as English conversation practice, basic Chinese

conversation, and elementary Korean (Durlacher Research, 2009; Lim, 2008; Korea IT Industry Promotion Agency, 2007).

Sound in instructional design is an important design factor along with visual information. Existing advanced researches present useful sound strategies related to menu and auditory feedback design in mobile environment, however, they do not provide general contents design or sound design strategies. Therefore, this research would focus on developing design strategies using sound to promote learners' self-regulated learning behaviors in mobile learning environments. Through the results of this research, sound utilized design strategies can overcome its restriction in screen size and promote learners' self-regulated learning behaviors.

Literature Review

Characteristics of mobile learning

Mobile learning is defined variously according to its application and keynote aspect however, the definition share commonality where learning is progressed by using portable mobile devices (Hoppe, *et al.*, 2003; Kossen, 2001; Kukulska-Hulme, 2008; Quinn, 2009). For the purpose of this research, only the handheld type that can be carried easily with one hand will be a sole object of mobile learning. Therefore, this research would limit the scope of research to the mobile learning with small display without laptop. Mobile learning as an advanced version of e-learning can be defined as a learners' self-initiated learning format through various resources and interactions without tempo-spatial restrictions (Whang & Kim, 2005).

To understand the characteristics of mobile learning, the characteristics of mobile environments have to be understood. Characteristics of mobile environments are mobility, accessibility, personal identify, interactivity, instant connectivity and so on (Kalakota & Robinson, 2001; Kim & Kim, 2002; Kumar & Zahn, 2003; Quinn,

2009). Among the characteristics, mobility is the origin where all other characteristics are derived from.

Learning in these mobile environments can be viewed in the following aspects, self-directedness, ubiquity, instant connectivity, formation of learning community and personalization. First, self-directedness refers to the progress of learning where learners select individual learning objectives, contents, and methods, and lead learning to check its results by mobile device. Second, ubiquity means learning is able wherever in real time. Learners are always granted with learnable environment because the learning is through portable device that guarantees mobility. Third, instant connectivity refers to the learning characteristics where learners can login real time without any preparation through mobile device. Fourth, in the process of learners attaining knowledge voluntarily, knowledge sharing members can form learning community when interaction continues. Fifth, personalization means that learners can be provided with user specific content since learning is processed with each individual's own device.

Design Strategies for Promoting Self-regulated Learning Behaviors

Concepts of self-regulated learning

Definitions and areas of self-regulated learning are varyingly presented depending on the perspectives and emphasis of scholars. However, there is a common agreement to define self-directed learning that learners voluntarily use effective strategies to continue their learning. The following is the summary of the characteristics of self-regulated learning expressed by many researches: First, the scholars who assert self-regulated learning say that learners do not passively accept information but they are assumed to actively participate and contribute in learning. Second, learners have an ability to control and regulate cognitive, behavioral, motivational, and contextual aspects. Therefore, areas for self-regulated learning, they can be categorized into the following four regulation areas: Cognition,

motivation, behavior, and context. Third, self-regulation is a process where they decide on whether to continue or change their learning progress. Fourth, self-regulation of individual cognition, motivation and behavior act as a mediator among learners, environment and the level of achievement.

Design strategies to promote self-regulated learning behaviors through media

Design strategies which promote learners' self-regulated learning through media are important learning strategies in e-learning environment. As many advanced researches show positive effects of self-regulated learning ability in e-learning, many researches on design strategies which supports self-regulated learning have been conducted (Chang, 2005; Lee, 2003; Lim, 2005; Niemi *et al*., 2003; Wang & Lin, 2007). The following is the design strategies by areas for self-regulated learning. This implies the promotion of self-regulated learning behaviors through media.

Design strategies to promote cognitive behaviors. Design strategies that promote cognitive behaviors for self-regulated learning through media share the design strategies which are suggested as cognitive, meta-cognitive strategies in general self-regulated learning. As cognitive strategies, there are rehearsal and organization. For meta-cognitive strategies, there are planning, reviewing and regulating. Cognitive strategies utilize media to promote mental activity which understands stores and withdraws information. Meta-cognitive strategies use media to promote controlling and monitoring of cognitive process. These strategies can be provided through media to control learners' cognition in Learning Management System (LMS) or e-learning contents. Specific design strategies are described in Table 1.

Table 1. Design strategies which promote cognitive behaviors for self-regulated learning

Strategy	Design Strategies	Reference
rehearsal	∘ Let learners read aloud the learning materials. ∘ Let learners underline, highlight, color and so on. ∘ Enable learners to take notes related to learning materials.	Yang (2000), Jung (2008), Hofer, Yu & Pintrich (1998) Cennamo & Ross (2000)
elaboration	∘ Ask learners to paraphrase what they have learnt into their own words. ∘ Make learners summarize and establish relationships between concepts. ∘ Let learners raise questions. ∘ Let learners use electronic note or utilize an exemplary learner's electronic note.	Yang (2000), Lim(2005), Hofer, Yu & Pintrich (1998)
organization	∘ Help learners to systemize and group information properly. ∘ Make learners to visualize information and idea into tables or other forms. ∘ Let learners express their ideas in network structure	Eom (1999), Lim (2005), Cennamo & Ross(2000) Hofer, Yu & Pintrich (1998)
planning	∘ Let learners scan through the index and overall learning materials before starting the lesson. ∘ Provide learning outline. ∘ Set learning objective. ∘ Make learners guess what they are going to be asked before solve problems. ∘ Provide bookmark function so that they could mark important parts or parts where they need to review.	Kim (2008), Park (2001), Yang (2000), Hofer, Yu & Pintrich (1998), Ley & Young (2001)
reviewing	∘ Let learners ask themselves and self-evaluate their comprehension level. ∘ Check learners' progress time when they take a test. ∘ Give learners' opportunity to self-evaluate and review their learning progress through quiz. ∘ Provide learners to revisit learning guide, online lecture, quiz. ∘ Provide immediate feedback on quiz. ∘ Provide printed page on quiz.	Park (2001), Yang (2000), Lim (2005), Hofer, Yu & Pintrich (1998) Cennamo & Ross (2000)
regulation	∘ Let learners go back and study after monitoring. ∘ Let learners regulate their learning speed. ∘ Make learners review their answer sheets and check for reasons why they got answers wrong or right. ∘ Ask learners to create a note of wrong answers they got on a test.	Kim (2008), Yang (2000), Park (2001), Hofer, Yu & Pintrich (1998) Ley & Young (2001)

Design strategies to promote motivational behaviors. Design strategies which promote motivational behaviors for self-regulated learning explain learners' willingness and confidence in learning. Strategies to promote motivational behaviors can be viewed as strategies that promote behaviors in learners' motivation aspects through media. Related design strategies are as follows; goal setting, self-efficacy, and achievement value. The specifics are stated in Table 2.

Table 2. Design strategies which promote motivational behaviors for self-regulated learning

Strategy	Design strategies	Reference
goal setting	∘ Set goals after going through learning materials and learning objectives. ∘ Guide with specific learning planning configuration to achieve goals. ∘ Engage superiors in setting process of learning objective. ∘ Provide examples of setting achievement and performance objective.	Cennamo & Ross (2000), Kim (2008), Yang (2000), Lim (2005)
self-efficacy	∘ Give advices on confidence in learning, self-efficacy, regulation on endeavor strategy, internal & external motivations, test anxiety, task value through self-regulation board ∘ Make learns realize their ability accurately. ∘ Confirm useful motivational strategies that suits individual learner. ∘ Inspire learners with positive self-awareness. ∘ Provide complimentary feedback on learning results.	Cennamo & Ross (2000), Hofer, Yu & Pintrich (1998) Kim (2008)
achievement value	∘ Let learners put value on learning itself in importance and application aspects. ∘ Assign importance in grades and external acknowledgement. .	Hofer, Yu & Pintrich (1998) Yang (2000)

Design strategies to promote executive behaviors. Design strategies which promote executive behaviors for self-regulated learning are to enable learners to achieve learning objectives autonomously by controlling and regulating their learning behaviors. These behavior controlling strategies are to provide a learning alarm function or time management function by using various electronic media such as computer, mobile devices and so on. Specific design strategies are behavior control, asking for help and time management which are listed in Table 3.

Table 3. Design strategies which promote executive behaviors for self-regulated learning

Strategy	Design strategies	Reference
behavior control	◦ Enable learners to write down several factors that hinder learning and to self-check whether they have overcome the hindrance. ◦ Let learners set their own learning rules. ◦ Let learners check whether they have implemented learning plan.	Kim (2008), Ley & Young (2001), Yang (2000)
help-seeking	◦ Give learner options to request help from peers or instructors through self-regulation board. ◦ Provide search engines where they can use to search on issues they are unfamiliar. ◦ Let learners exchange information and opinions through email.	Cennamo & Ross(2000), Kim (2008), Young (2001)
time management	◦ Let learners are able to view their learning plan by day and month and enter their objectives. ◦ Ask learners to write down learning duration on each session. ◦ Provide the number of login. ◦ Provide the exemplary learning activities along with the learner have and suggest a result of pattern analysis. ◦ Show learner's learning progress result.	Cennamo & Ross(2000), Hofer, Yu & Pintrich (1998) Kim (2008), Lee (2003), Ley & Young (2001), Lim (2005)

Design strategies to promote context control behaviors. Design strategies which promote contextual control behaviors for self-regulated learning are to enable learners to configure learning environments autonomously. The strategies providing communication tools by media or managing learning resources such as tasks are included in environmental strategies. Related design strategies are learning task management, learning environment management and human resource management delineated specifically in Table 4.

Table 4. Design strategies which promote context control behaviors for self-regulated learning

Strategy	Design Strategy	Reference
task management	∘ Provide results of the completed tasks and feedback to learners. ∘ Enable learners to review peers' task and provide feedback to peers. ∘ Provide statistical information on the frequency of task submission and scores.	Pintrich(2004)
learning context management	∘ Show learners their current status through self-regulated learning ability test and give advice. ∘ Provide definition and cases of effective self-regulated learning. ∘ Let learners configure learning environment according to their preference.	Lim (2005), Jung (2008), Wang & Lin (2007)
human resource management	∘ Give a list of experts. ∘ Make colleagues and teachers interact.	Hofer, Yu & Pintrich (1998)

Sound design in mobile environments

Concepts and characteristics of sound

Sound, according to dictionary, is mechanical radiant energy that is transmitted by longitudinal pressure waves in a material medium and is the objective cause of

hearing. Perception of sound is due to objects' vibration, therefore what human hears is the effect that objects make to air, water or other surrounding medium (Goldstein, 1999). In other words, the source of sound shakes air and the generated waves are transferred to human ears through air as medium (Kim *et. al.,* 2000).

The type of sound design being utilized based on computer can be categorized into language message, auditory icon, earcon and much. Each can be explained as follows.

Language message consists of human voice message. Language message can express learning contents or system situation through human audio language. E-learning, in general, provides visual resources along with audio resources. Also system connection status, location and so on can be alerted by audio. Language message is the most exact mean to tell system situation and provide feedback however, it requires high technology when voice recognition and voice output are used. For voice output to be successfully generated, natural voice, grammar structure, appropriate voice for the context, tone of voice, pronunciation and natural change in intonation should be considered.

Auditory icons were developed by Gaver (1997) and they express actions and objects in interface with natural routine sound. The sound that we hear everyday is generated due to interaction between objects. We can assume that glass is broken when we hear a shattered sound. Because when human hears sound human do not focus on pitch or timre but the origin where the sound is coming from (Mountford & Gaver, 1990).

Earcorn can be expressed in imitative or mimetic words and they are sound produced with instrument so that it has rhythm, tone, range, dynamic and so on. Earcorn is a non-colloquial message that is used to transfer information such as object, operation, interaction and so on within computer or user interface (Blattner *et al*, 1998). Earcorn, unlike other auditory icons, has no intuitive links between sound and its representation, therefore learning is required to related the object with sound (Brewster, 1994).

Music means song or a repertoire that express emotions or thoughts through

voice or instrument by harmonizing and combining in various forms with beat, melody, voice and so one. Background music is the sound provided as a background for something (Ki, 2005). Music has a property that attracts attention and retains it (Lee, 2003). Therefore, music sometimes can change gloomy feeling to joyful or triumphant. Also for long time music has been perceived as an efficient and effective tool to cause non-verbal emotional reaction over a long period of time in mood and communication. Human assign emotional meaning into music, experience emotional reaction by music and contribute behavior or emotional reaction through music. If these properties of music are applied in learning, learning motivation can be expected to be induced.

Research related to sound design

Despite the fact that applying the design principles and methods used in desktop system design to mobile device is a stretch, graphic interface design method has been directly applied to mobile device (Brewster, 2002). As a result, tasks that were performed in mobile environment were very limited due to illegible text, undistinguishable graphic, and lack of context information. Also since mobile device is not utilized in static place such as desk but is used while moving such as walking or driving, therefore visual information presented in a small screen makes it hard to pay attention to (Brewster, 1997). To overcome mobile device's limitations with small screen and mobility, utilization of visual feedback or utilization of sound as information providing auxiliary is one of solutions. On one hand, due to the external exposure the effect of sound may sound restricted however, as personalization (Kim, 2005) is emphasized, earphone can be used therefore surrounding noises as a disturbing factor can be minimized. Hereupon, the researches exploring the sound application's possibility in mobile environment were summarized as follows; Sound provide spatial clue to help navigation activity (Kim, 2005; Leplatre & Breswter, 2000; Park, 2007), providing auditory clue to current ongoing task situation by copying file or downloading music (Walker & Brewster, 2000), and designing button using sound in touch screen display (Breswter, 2002).

Each research is summarized briefly in the following manner.

Providing spatial information using sound. Users in mobile phone environment have hard time in fulfilling task and the main reason is navigation (Yankelovich *et al.*, 1995). The reason is because all information is provided consecutively, and input method is very limited so interaction with user is prominently restrictive (Schumacher *et al.*, 1995). Leplatre and Breswter (2000) integrated sound with menu to help navigation activity in mobile phone environment and verified effectiveness. The result of the experiment shows that sound was effective in reducing the error rate and the number of menu selection related to task performance, however, it shows no significant differences in task performance time.

A classic method of providing spatial clue using sound is providing auditory feedback. This is when auditory information is provided when the menu is selected to relate the sound and the menu selection. In the research of Kim (2005), providing a short sound as an auditory feedback incurred higher task performance level. As such, the research of Park (2007) also indicated that the group that auditory icon was applied showed faster performance time. Likewise, providing spatial information using sound can be seen as a positive factor by reducing selection time and selection error.

Providing auditory clue to current ongoing task situation. Walker and Brewster (2000) designed the audio process bar that tells status and monitor on-going task using sound and verified its effectiveness. When adopting the visual process bar that is generally presented when copying files in the desktop computer in mobile device, it requires user's persistent attention and also covers the whole screen. To resolve this matter, audio process bar was designed and the effectiveness was investigated. Toward 16 people, test group was provided with audio process bar whereas control group was provided with visual process bar. There was no significant difference in task performance duration, however, standard deviation of

the control group using visual process bar was significantly high. In the typing task while downloading file, the test group typed more than the test group and task load was less in test group than control group.

Designing button using sound. Frequent mishap is occurred when trying to press the precise location of the touch screen in PDA or similar sized touch screen. Therefore Brewster (2002) investigated the effects of button size and sound types in usability and task load. Toward 12 graduate students, at the experiment 1, the effect of button size (16x16 pixel, 4x4 pixel) and sound types (mute, short, reinforcing) on usability and task load was tested. Reinforcing sound is the added sound that is played when short sounded button is pressed. The task was to enter generated 5 digit number using keypad on the screen. Regardless of the button size, two groups with sound treatment had lower task load compared to control group and participants prefer reinforcing sound however there was no significant difference in usability comparison with standard sized button without sound with small button with reinforcing sound. The researcher expects the cause of the result is due to the status location where the experiment was performed; therefore the experiment 2 was conducted while PDA is carried around and the task was performed. In experiment 2, toward 16 graduate students, the effect of button size (16x16 pixel, 8x8 pixel) and sound types (mute, reinforcing) on usability and task load was verified. The result was same with experiment 1. To summarize, sound utilization in PDA devices in both static and dynamic location significantly reduces task load. Therefore when designing button in a small screen based device, to reduce user's task load, sound should be utilized.

Research Methods

The sound design strategies to promote self-regulated learning behaviors in mobile learning environments were developed and verified by the developmental

research methodology (Seels & Richey, 1994). This study was conducted in the following procedures as Richey and Klein (2007) had suggested.

Table 5. Research procedures and results

Step	Purpose	Participants	Research procedures	Research results
Step 1	Development of sound design strategies for promoting self-regulated learning behaviors	5 PhDs in Educational Technology	① Select related previous literature ② Investigate the concept and design strategies for self-regulated learning behaviors ③ Investigate the cognitive characteristics of auditory sense and sound design strategies ④ Develop the sound design strategies for promoting self-regulated learning behaviors ⑤ Conduct the first expert review ⑥ Revise the sound design strategies ⑦ Conduct the second expert review	. Sound design strategies . Results of the first and second expert review on validity
Step 2	Revision of the sound design strategies	2 SMEs, 3 IDs, 5 Ph.Ds In Educational technology	① Select subject matter experts (English education) and instructional designers ② Design storyboards without sound elements ③ Observe and record the sound design process of instructional designers ④ Conduct interview and organize suggestions for sound design strategies ⑤ Conduct third expert review	. Revised sound design strategies . Result of third expert review on validity
Step 3	Usability tests for the sound design strategies	3 IDs, 10 College students	① Develop the storyboard related to sound design ② Develop the mobile learning contents with sound ③ Conduct fourth expert review on proper implementation ④ Conduct instructional designers' usability test ⑤ Conduct learners' usability test	. Mobile learning contents . Results of usability tests . Final sound design strategies

Development of sound design strategies for promoting self-regulated learning behaviors

Literature review

Literature review was conducted as follows. First, to select studies related to self-regulated learning and sound design strategy, we searched for journal articles using 1) keywords on databases and search engines and 2) snowball method. We searched using such keywords as 'self-regulated learning' and 'self-regulated learning and design strategy' on Research Information Sharing Service (RISS: http://www.riss4u.net), Google Scholar (http://scholar.google.co.kr), Educational Resources Information Center (ERIC: http://www.eric.ed .gov). Other keywords used include 'cognitive characteristics of auditory sense', 'sound design', 'earcorn', 'auditory icons', 'background music'. Additionally, snowball method suggested by Travaglia and Debono (2009) was used to investigate the lists of references from selected articles.

Secondly, from the literature review the features of design strategy for self-regulated learning in e-learning or mobile learning environments were examined. Research results on design strategies that promote the elements of self-regulated learning, such as cognitive, motivated, behavioral, and environmental regulation were put together.

Thirdly, general design strategies of mobile learning contents based on the concept and characteristics of mobile learning were organized. More specifically, we investigated information and interaction design strategies concerned with self-regulation and mobility affected by learning environment and small screen size affected by physical aspects of mobile electronics. And it was then examined to find which of the design strategies would be enhanced if supported with sound.

Fourthly, literature on cognitive characteristics of auditory sense and sound design were reviewed to specify the types and effects of sound used in mobile learning or e-learning environment. From the results of literature review, general

procedure of sound design strategy was obtained.

Finally, sound design strategies for self-regulated learning behaviors in mobile learning environment were devised from the results of literature review. General sound design strategies and sound strategies for the components of self-regulated learning were synthesized to provide a more specific design strategy for instructional designers.

Measure and analysis method

To establish validity of the sound design strategy, content validity tests were conducted by experts. The validity test measure for expert review was consisted of questions on validity of each design strategy for promoting self-regulated learning behaviors in mobile learning environments and questions on improvements to be made. Five education experts were recruited as the expert group for validity test, as suggested by the previous research (Jin, 2009; Rubio *et al.*, 2003). For each question on validity of the sound design strategies, evaluation was completed on a 4 point Likert scale. Moreover, to establish validity of the responses of the experts, inter-rater agreement (IRA) and content validity index (CVI) were calculated for each of their responses.

IRA gives a score of how trustworthy the evaluation of the experts is. On a 4 point Likert scale, rating scores 1 (strongly disagree) and 2 (disagree) were paired up, and scores 3 (agree) and 4 (strongly agree) were paired to calculate IRA to determine how homogeneous the ratings given by experts are (Grant & Davis, 1997; Lynn, 1986; Rubio *et al.*, 2003). IRA is computed by dividing the number of items that are equally evaluated by the total number of items. IRA over .80 is considered valid (Rubio *et al.*, 2003).

Content validity index (CVI) is the number of experts who evaluated each survey item as valid divided by the total number of experts (Lynn, 1986; Rubio *et al.*, 2003). Similar to IRA, when CVI is measured on a 4 point scale, it is calculated by looking at how homogeneous the experts rated for the rating scores 1 and 2 versus 3 and 4.

CVI provides a ratio of experts who evaluated the items to be valid and CVI over .80 is considered valid.

Revision of sound design strategies

After the first validity test by experts, the sound design strategies for promoting self-regulated learning behaviors were revised. The revised sound design strategies were again tested in the process to secure the validity of design strategies.

Revision of design strategies from formative research

This step of the process is to revise the sound design strategies produced from literature review by conducting the formative research of instructional designers. To do so, the process of how instructional designers design and incorporate sound into mobile learning contents should be observed. Follow up interviews are also conducted to further develop better sound design strategies. If additional sound design strategies were deduced, they are reviewed by the experts for validity test.

Visual information design

Mobile learning contents were developed to perform formative research of instructional designers. For formative research, storyboards exclusively involving visual information without sound design were developed. In developing the design process, we referred to the typical systematic design of instruction involving analysis, design and development stages (Dick, Carey, & Carey, 2005).

Selection of learning content and learners. Since this research involves the design strategy of sound, English subject which can effectively utilize sound was selected for the content of learning. Specifically, after considering the level of college students, lesson on present verb tense present progressive tense was chosen for the lesson unit. The selected unit on verb tenses is fundamental grammar which

is necessary for basic English skills in college students. The college student participants were selected based on their ability to use mobile devices ad their knowledge of basic English grammar as the English lesson will take place in mobile learning environment.

Learner and context analysis. Because the study subjects were college students, the learning contents were named as 'College English'. The learning objective was to understand the features of present tense and present progressive tense and to accurately use verbs. To achieve the learning objective, the learning contents were organized with grammar rules and examples based on "Basic English Grammar" (Choi, 2004), and were reviewed by the college English instructors.

Design. The main features of information design area are as follows. Metaphors similar to notes or diaries are used as layout. Menu and function buttons are presented in a consistent matter on the left side. Learning contents are presented in a large area on the right. For text, gothic font was used. The same font type was presented at a certain size, and overall the default text color was black except for the main keywords.

Interaction design mainly involved designing feedback, button and navigation. The design of feedback involved instantly providing corrective feedback to learner's response in the review part. Another form of feedback was provided when a learner clicks on a button. To navigate through pages, one can use the menu button or a button which flips one page at a time for successive movement. On each page, the location of current page was also represented.

Development. iPhone SDK and Xcord were used to produce for Mac iOS system. The product was created in iPhone 4 setting, but the test of product was done with mobile devices like iPhone4 and iPad2.

Formative research

To supplement the sound design strategy for self-regulated learning, three instructional designers with instructional design experiences of three years or more carried out the formative research. As sound design was not a familiar field even to these instructional designers, they were given enough time to understand the process and conceive of sound design strategies for promoting self-regulated learning behaviors.

The three instructional designers selected were informed about necessary information about the research though email and phone. The information given to the instructional designers included research purpose, research problem, content and methods. It was also requested that the final product should based on the sound design strategy obtained from the literature review, but they could add to the sound design strategy with their expertise in instructional design, or provide feedbacks on how to improve the current strategy if they found a problem in the process. After three days of reviewing the sound design strategy, the research team gathered to exchange opinions. The discussion evolved around the strengths of the sound design strategy developed, possible improvements to be made, and additional suggestions. Finally, the sound design strategy was revised based on the suggestions by the instructional designers.

Measure and analysis method

To establish the validity of the revised sound design strategy after the formative research, another content validity test was conducted.

Usability tests

Evaluations were carried out twice for the sound design strategy developed from formative research of instructional designers and literature review. The first evaluation of design strategy was completed by instructional designers. The second evaluation of mobile learning contents was completely by learners.

Implementation of sound design strategies

Based on the sound design strategy developed from the literature review and formative research of instructional designers, storyboards were constructed to implement mobile learning contents. As shown in Figure 1 below, the mobile learning contents for iPad were developed.

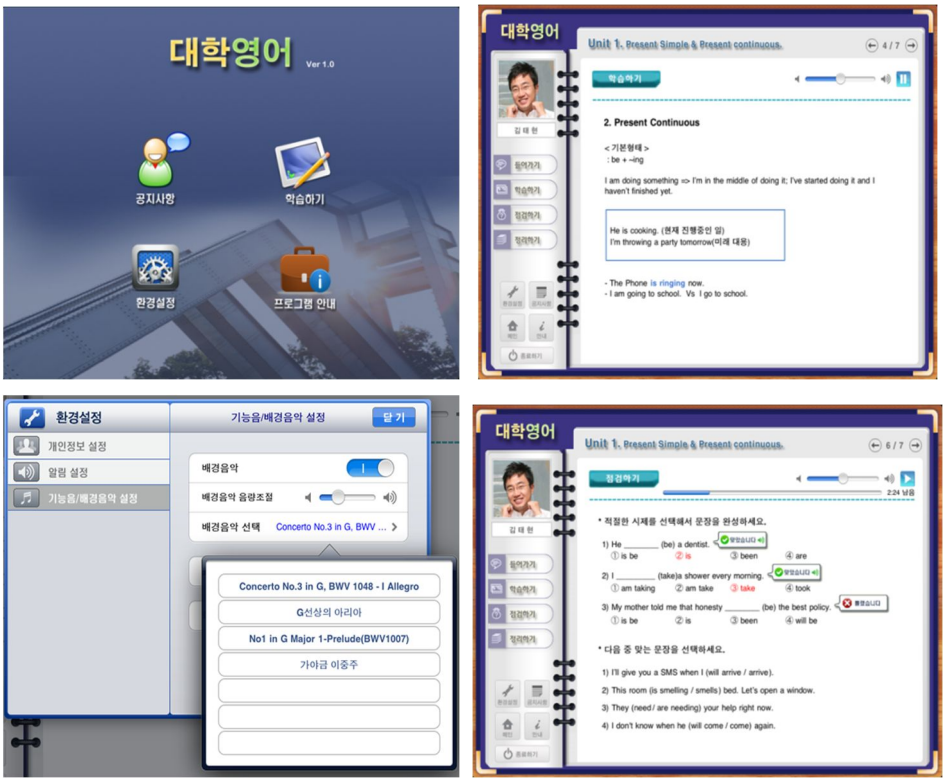

Figure 1. Implementation

Expert evaluation of the proper implementation

To review if the sound design strategy was properly implemented, fourth content validity test was conducted. Two experts who also participated in all of the previous evaluations and two new education experts, the total of four experts participated in this procedure. IRA came out to be 1, which suggests the general consensus among

experts. Overall, it can be interpreted that sound design strategy for mobile learning environment is appropriately implemented.

Usability tests

Usability evaluation was conducted with instructional designers and learners to explore the possible generalization of sound design strategy for promoting self-regulated behaviors

User's response evaluation of sound design strategy. Usability test was carried out to evaluate the validity of design strategy when it was actually applied to instruction design process. Those who participated in the evaluation process were three instructional designers with three years or more experience in the field. The usability test procedure is described as follows.

First, instructional designers designed a first draft of instruction that promotes self-regulated learning behaviors with visually constructed mobile learning contents and using sound design strategy. Secondly, they reviewed the sound design strategy for self-regulated learning behaviors and revised their draft. Thirdly, they evaluated the draft in terms of its effectiveness to promote self-regulated learning behaviors and its readiness to be implemented in instructional design process. To quickly grasp the process, they were also told to use blue color code while drafting the instruction and red for revision. Follow up interviews were carried out to collect qualitative information.

Learners' response evaluation of mobile learning contents. The learners' evaluation was conducted to test the effectiveness of mobile learning contents facilitated by the sound design strategy for regulating and reviewing their own learning procedure. Ten students from a university participated in the user response evaluation. They were junior and senior students in Humanities who either had no previous experience of taking TOEIC or had a score below 600.

The evaluation was done individually. The purpose of research and the general

process of evaluation were explained to the students. After the brief introduction, they studied mobile learning contents without implementation of sound design strategy. Secondly, they then studied mobile learning contents with implementation of sound design strategy. Thirdly, comparing the two learning experiences, they answered the evaluation items. Finally, to collect qualitative data, interviews were carried out.

Evaluation tool of user response test. User response test for sound design strategy was developed in consideration of the research purpose and based on the previous research studies (Jin, 2009; Han, 2006; Sung, 2009).

User response test for instructional designers included items measuring the ease of use, effectiveness of learning, and satisfaction of use. Items on ease of use measure how easily an instructional designer can understand and apply the given sound design strategy in instructional design activity. Effectiveness of learning assess how helpful an instructional designer thinks the given sound design strategy is to promote leaner's self-regulated learning behaviors. Finally, satisfaction of use looks at how satisfied an instructional designer is. The question items were reviewed and revised by two educational technology doctoral students, and the reliability of question items was proven with Cronbach α value of 0.73.

Research Results

The sound design strategy for self-regulating learning behaviors included six general design strategies and sixteen detailed design strategies that served six purposes. The six purposes are regulation of learner's attention, regulation of learning strategy, regulation of emotion, regulation of time management strategy, regulation of operation, and regulation of setting. Taking the first letters of each six objectives, we have named it ASETOS strategy. Table 6 below presents the design strategies.

Table 6. Sound design strategy for self-regulated learning in mobile learning environment (ASETOS strategy)

Purpose	General strategies	Detailed design strategies
Regulation of learner's attention	1. Design to focus learner's attention while learning	1-1. If a learner does not show reaction after certain period of time, voice sound is provided to encourage learning and stimulate attention (e.g. please pay attention).
		1-2. A sound is played to increase attention before presenting the essential information while learning.
		1-3. Provide a sound option to play when the content changes, or when learning begins or ends (e.g. a short xylophone sound, Windows starting and ending sound).
Regulation of learning strategy	2. Design to guide effective learning strategies before, during and after each learning session.	2-1. Provide a sound notification to review the outline of contents to be learned or to set learner's own learning objectives prior to the learning session.
		2-2. Provide a sound notification to listen again to the parts that are either difficult to understand or important. Provide sound notification to facilitate visualization of the information.
		2-3. After the learning session, provide a sound notification to summarize the learning content or to self-assess by creating and answering questions.
Regulation of learner's emotion	3. Design to increase learner's presence and emotional stability in mobile learning environment.	The system calls the name of the learner to increase the presence.
		3-2. Provide a sound option to listen to music while studying.
Regulation of time management strategy	4. Design to promote better time management	4-1. Provide an alarm function to ring on the time set by the learner. .
		4-2. Inform learners of required time, remaining time and current time.
Regulation of operation	5. Design the operation system to be easily used by learners.	5-1. Provide a sound feedback when the learner correctly clicked on a menu or a button.
		5-2. Provide a sound warning notice if there is any technological error that may interrupt the learning process, such as low batteries, internet connection or OS system errors.
		5-3. Provide sound feedbacks for correct and incorrect responses in the evaluation step.
Regulation of setting	6. Design to promote learner's self-regulation of sound.	6-1. Considering the individual differences, allow the learner to control the on/off option of sound, the volume, and the sound speed.
		6-2. Provide a control option for sequential playback, playback at a specific location, and continual playback.
		6-3. Provide a preference option to choose from a variety of sounds (e.g. music, attention sound, screen transition sound, alarm, feedback sound).

Regulation of learner's attention

Sound provision for calling attention during the learning session

As the mobile learning is based on mobility and thus more difficult to concentrate on learning, it requires learner's self-regulation ability more than e-learning environment does. Considering such environmental feature, it is important to provide sound to help arousal when the learner does not respond to the instruction after certain period of time. For instance, it is possible to increase the attention of learner by providing an arousal sound when the learner remains inactive for a certain period of time in the physical interaction with the contents.

Emphasis of the important content

Due to the limited capacity of working memory, the learner cannot remember everything presented to them in the lesson. Therefore, the learner will selectively remember the information that they decide to be important (Glynn, Britton, & Tillmen, 1985). In order to ensure that a learner pay close attention to the important information, clues about the key information should be provided. In visual design strategy, important phrases or nouns are emphasized visually or highlighted. In sound design strategy, sound notification can be provided before the delivery of important content. Important contents can also be played with louder volume or be repeated two to three times to inform the learners of the significance of information presented. Such emphasis methods as these can help to improve a learner's memory by increasing learner's attention and facilitating encoding process (Dyson & Gregory, 2002; Hartley, 2004).

Sound notification in case of switch of learning content

In mobile learning environment, learners cannot continually look at the screen presenting the learning contents. Neither is it easy for them to pay attention as there are many distractions (Lee, Song, & Lee, 2006; Kukulska-Hulme, 2008). By

providing appropriate sound when there is a switch of content or when the learning activity starts or ends, it is possible to draw the learner's attention.

For instance, in an English listening comprehension test which plays the problems without a pause, a learner will have difficulty distinguishing the start and end of each question items without sound notification. It will effective to present such type of sound notification in a consistent manner, so that learners will clearly understand the meaning of sound.

Regulation of learning strategy

Learning strategy before a learning session

Setting goals before the learning session is a critical factor in determining the success of self-regulated learning process (Artelt *et al.*, 2000; Cennamo & Ross, 2000; Kim, 2008; Lim, 2005; Printrich, 2000; Yang, 2000; Zimmerman, 1989, 2000; Zimmerman & Martinez-Pons, 1986). In fact, setting goals is the basic and fundamental activity in any type of learning performance, not just for self-regulated learning.

The learning strategy before the learning session refers to strategies that will guide and support the goal setting activity of learner prior to the learning session. For instance, a learning map of visual design strategy helps to understand the overall structure, but does not provide specific guidance regarding what learning activities to carry out. Using speech narration, however, it is possible to give detailed instructions to carefully read the learning map and to perform specific activities. Therefore, sound design strategy can facilitate learner's self-regulation learning behaviors better. Furthermore, some e-leaning contents present text-based information without speech sound; however, to regulate learning strategies, it is necessary to guide and suggest more specific information using sound notifications.

Learning strategy during a learning session

It is not easy for learners to establish or inspect their own learning strategy during a learning session. Rehearsing and memorizing are efforts to remember information and practice both externally and internally and are viewed by Zimmerman and Martinez-Pons as one of the fourteen essential activities that learners should perform to self-regulate (Zimmerman & Martinez-Pons, 1986). Thus, this strategy is to offer guidance about repeating and elaboration strategies during a learning session. For example, an instructor or an instructional designer can present a speech notification to repeat information which a learner thinks is important or parts which a learner had difficulty understanding. The sound notification will induce repetition or visualization of learning content. Learners should be able to select whether speech notification will play and what type of speech notification will pay for their self-regulated learning.

Learning strategy after a learning session

For self-regulated learning, learners need strategy to summarize and organize learning contents. Printrich(2000) insists that organization strategy, as cognitive component, is the main mechanism of self-regulated learning. Therefore, it is possible to increase learner's capacity to perform self-regulated learning by directing a learner to summarize and organize the learning content on their own. Usually in visual design, they suggest these strategies under the names of 'summary' and 'organization'. Along with these visual cues, it will be more useful if sound instructions are provided to learners.

Regulation of learners' emotion

Calling student's name

Learners' presence awareness in virtual learning space like in mobile e-learning is an influencing factor that positively affects learning (Wang & Kang, 2006). Presence can be defined as an idea that learners recognize their existence in mobile learning

environment. This can be increased when the names of learners are called or if sound contents that applies learner's name are provided. Feeling of presence can be increased when names of learners are being called or sound contents that apply learner's name are used because learners will see themselves as main learning hosts not as observers. It has been found that there is positive self-regulation effect when learners' feeling of presence is increased in online learning environment because their motivation is increased.

Providing background music for emotional stability

It has been reported that if musical components are effectively used there is a positive result in learning because music as typical sound type acts as an emotional factor that closely relates to learner's motivation (Jung, 2002; Lee, 2003; Song, 2002). Therefore, if musical component such as background music is used for learner's emotional stability, this can not only provide emotional stability but also influences learning positively. From prior researches that analyze the effects of background music on cognitive task performance, soothing music affects positively on fulfilling tasks compared to simulative music and regular tempo music increases attention span better (Borling, 1981; Jo, 2000; Jung, 2002; Richman, 1976; Stratton & Zalznowski, 1984). Especially, Lozanov method which is music application method shows that baroque music among classical music is more effective in increasing (Schuster, Benitez-Bordon, & Gritton, 1976). However, performance results differ depending on familiarity, preference of background music therefore background music should be designed so that learners can select it instead of providing the music.

Time management regulation

Learning time guidance

Learners' time management during learning is a main considerable component in self-regulation learning (Lee, 2003; Loomis, 2000). Learners who involve in regular

learning in daily life have superior learners who have self-regulation ability. However, there are many intrinsic and extrinsic difficulties for learners to manage time by themselves to be involved in learning. This sound application strategy uses the advantage of mobile devices that they are potable anytime in daily life to provide information related to learning time to learners. One of the important strategies in time management is planning activity which can be planned by learners in mobile learning environment and through alarm function, learners can be notified that it is time for learning.

Providing time information during learning activity

If learners are presented with lapse time, remaining time and current time while learning, they can manage learning time better which can enhance behavior regulation ability (Lee, 2003; Loomis, 2000; Nonis & Hudson, 2006; Zimmerman & Martinez-Pons, 1986). Particularly, when visual resource focused evaluation is conducted; presenting time limit through voice message can control learners' behavior more effectively. Also if learning progress information is provided through voice message, learners can plan on their behavior prior to learning which equip them to control their behavior continuously.

Operation activity regulation

Providing feedback on learners' response

There is higher error rates in clicking menu or buttons designed for mobile contents by touching method in a small screen environment such as in mobile devices compared to desktop environment (Brewster, 2002). Due to the characteristics of mobile environment, high task error rate is inevitable when conducting tasks, so when providing sound telling whether learners choose the menu correctly or not, learners' activities can be supported. It can be expected to provide useful information guiding learners' behavior when instant sound feedback

on an incorrect click or selection is given. Brewster (2002)'s research also reported the usability effectiveness of providing sound feedback on button in mobile devices. Auxiliary strategy of navigation helps learning progress by working as an assistant to manage learners' behavior in small screened mobile learning environment.

Provide alert sound

The most effective function of auditory sound is alert sound (Stanton & Edworthy, 1999). In a product like a mobile device, the types of sound feedback can be divided into two, product maneuver behavior and product status alert (Kim, Lee, & Jung, 2008). In a learning environment through mobile device, utilizing sound feedback to tell the status of mobile device is expected to provide useful information to learners. Mobile learning is affected by the physical environmental features of mobile devices such as battery life or internet connection status. Informing learners that learning needs to be ceased due to mechanical defects is an important factor for self-regulated learning. Therefore when battery life is below a certain level or when internet is disconnected, the sound works as an agent to help learners' learning activity to be controlled.

Providing correct/incorrect feedback in evaluation activity

Providing feedback during conducting evaluation activity assigns learning motivation (Dempsey, 1993; Kang, 2000; Kim, 2011). If feedback is provided according to the evaluation result, learners can engage in self-reflective opportunity and sense the evaluation result immediately. This also reduces the intervention of evaluation contents that are provided in visual format. Learners can immediately recognize their answers as correct or incorrect and take a next step such as selecting a different answer, moving on to a next question. Correct/incorrect feedback usually has lively sound for correct answer and heavy short type sound for incorrect answer.

Learning environment regulation

Providing sound manipulative function

Supporting learners to control their environment in e-learning envrionment indicates a promotion of self-regulated learning behavior, chich is an important design strategy (Lim, 2001; Zimmerman & Martinez-Pons, 1986). Sound in mobile learning contents is an influencing factor on learners' cognitive and affective activities and its effects can vary by each individual learner. Therefore, individual differences can be reflected by enabling learners to manipulate volume, play, stop, mute and other function selectively. Especially providing a function to control the playing speed is equal to controlling learning speed, which resulted positively on satisfaction level when sound is provided according to learners' intelligent ability or learning speed (Kim, 2010).

Providing various play method

Progression in learning by one's own learning speed in e-learning is a very basic component in self-regulated learning. Sound is transferred consequentially in general however when utilizing technology, various ways of playing methods can be provided. Returning to the spot where learners left off listening or enabling learners to move to specific spot by simple touch can control learning speed. This factor enable learners to control their learning speed and be involved in self-regulation.

Providing sound type configuration

Musical component reacts emotionally, therefore how much learners accept can differ by individuals (Lee, 1994). One identical music can act as a positive factor which continue learnes' learning whereas this same music can be recognized as a disturbing factor. However, there are too much trouble for instructional designers to meet all these learner's needs to cover individual differences. Therefore learners are provided a function where they can configure their sound of preference. Providing an on-off option for incorrect/corrent or alert sound that learners can configure is an

example. Particularly, inappropriately provided background much can disturb learning therefore, music selection, mute, volume control should reflect learners' autonomous choice.

Discussion and Conclusion

This research draws sound design strategy that promotes self-regulated learning behavior in mobile learning environment and verify the process, which is an ultimate objective of this research. Prior researches were delved to come up with sound design strategies that promotes self-regulated learning behavior and the revised strategies through experts' validity to generalize the drawn strategies. Also to feedback from instructional desingers and learners on drawn sound design strategies, instructional design was implemented by the instructional desingers and after mobile learning contents are applied to the sound design strategies, usability tests were performed by learners. Both of the results showed positive effects on self-regulated learning behavior.

Implication for sound design strategy that promotes self-regulated learning behavior

As a result of this research, 6 aspects of sound general design strategies of self-regulated learning behavior (Learners' attention regulation, learning strategy regulation, learning strategy regulation, learners' emotion regulation, time management strategy regulation, manipulative regulation, sound environment regulation) were drawn and 16 specific detailed design strategies were drawn. There were positive effects in reliability, satisfaction and effectivveness. This results shows that sound design strategy that promotes self-regulated learning behavior pomotes self-regulated learning behavior and furthuremore, give positive results to learning.

Generally self-regulated learning process contains forethought, performance or

volitional control, self-reflection cyclically (Schunk & Zimmerman, 1998). Forethoughts contain subcatecories of as follows; setting objective, setting strategic planning, belif of self-efficacy, objective directivity and internal motivation. Before learning activity, learning steps configuration process and belief process are included as well. Process of performance and will power control consists of the following sub categories: attention focusing, self-instruction, self-check up. They are generated during learning is performed and process that affects attention and performance is included. Self reflection occurrs after learning activity which is consisted of self-evalutation, attribution, self reaction, accomodation, which affects thoughts before learning. If this cyclical process is understood correctly, when designing instructions to promote self-regulated learning behavior, instructional design for one part of the process shouldn't be conducted. Also since mobile learning environment along with e-learning environment is based on multimedia resrouces, therefore, design should be performed when both visual and auditory parts are considered. To summarize, instructional design based on audio-visual should be performed in the self-regulation process depicted as Figure 2.

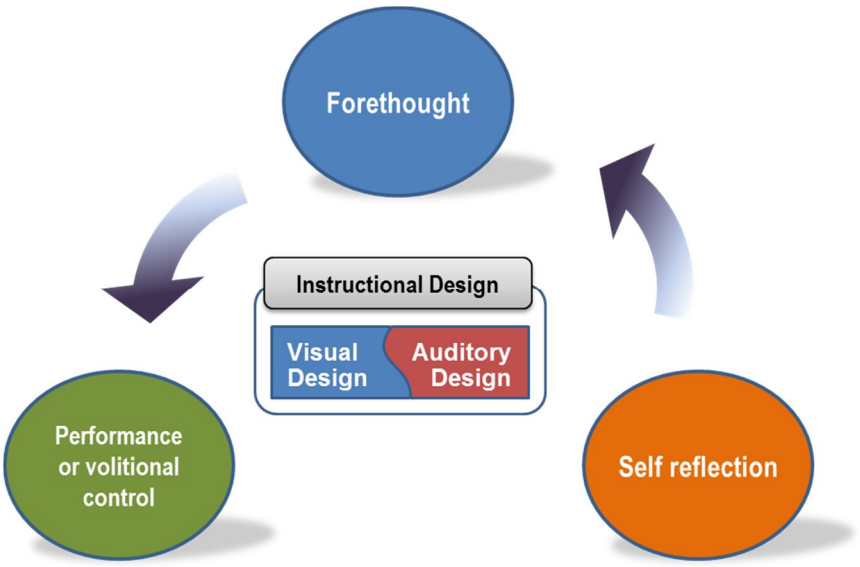

Figure 2. Theortical significance of sound design strategies in self-regulated learning

Conclusion and suggestion

Conclusion

The conclusions based on research results and discussions are as follows. First, six general design principles and subsequent specific design principles were suggested through this research. Six strategies (learners attention regulation strategy, learning strategy regulation strategy, control activity regulation strategy and sound environment regulation trategy) can be designed and applied independtly, however if various strategies are interactively designed and applied, the effect of self-regulation support will be increased.

Second, this is expected to contribute in instructional design diversity which utilizes multiple sensory organs whereas most of design was visual focused in e-learning and mobile learning environment. Sound design strategies to promote self-regulated learning behavior suggested in this research are anticipated to be applied generally. This can be used as a foundational research that shows another possibility in visual design focused instructional design researches.

Third, in mobile learning environment, the existing instructional design principles and strategies needed to be specialized. In this research, sound applied strategy was suggested and applied to overcome the screen limitation and meet the feature of mobile learning which is learners' self-regulation. Mobile learning environment is a new educational environment that has various limitations and considerations. Therefore, there need to be instructional design principles and strategies to resolve and to be suggested. In this perspective, this research is significant as a case study that suggests and applies strategies to be used in mobile learning environment, indicating the necessity of mobile environment specialized instructional design.

Suggestion on future researches

Research limitation. There are following limitations using the results of

research as a foundational work. First, this research came up with sound design strategy to promote self-regulated behavior in mobile learning environment. However, including visual design strategy, omnidirectional instructional design implementation is necessary to promote self-regulated behavior in mobile environment. There is a self-regulated leaning behavior promotion area that cannot be supported by only sound design strategy. Self-regulated learning behavior in mobile learning environment can be more promoted if the sound design strategy suggested in this research is used as a basis to design visual design strategy of mobile learning environment.

Second, self-regulation ability was not measured for a long time for this research. As an alternative solution, instructional designers along with education experts were involved in verification process to gain validity of strategies that support self-regulation. Despite the fact, self-regulation ability is learned and measured in long term according to the prior literature review. Therefore it can be anticipated to have more practical and useful sound design strategy that promotes self-regulated learning behavior if this research is applied for long term.

Third, there were strategies that did not reflect the design strategy faithfully in the contents that were developed through this research results. These strategies were suggested however could not be implemented due to technical and budget limitation. For example the strategy which provides learners presence by calling learners' name could have used Text to Speech technology, however the voice recorded file was provided. This factor was pointed out as a negative factor in user convenience, however due to technical limitation; it was not able to be implemented. Likewise, the strategy that was suggested to regulate sound environment such as paying speed control function, listening where learners have left off could not be implemented due to technical and budget limitation.

Fourth, the study subjects for sound design strategy that promotes self-regulated behavior were university students in English major. Therefore, when applied to different age or major learners, there would be hardship in generalization.

Suggestions on future researches. Sound design strategy that promotes self-regulated learning behavior developed in this research and the contents that apply the strategies are characterized as prototype. Therefore sound design strategy should consider educational objective, learning objective, usage environment, learners' age, instructional designers' competence in development. Also this research has comprehensive research characteristics of sound design in self-regulated learning behavior promotion, therefore validity and effects of each design strategy in real context should be proven and elaborated. Accordingly, the follow up researches are suggested as follows.

First, through long term research, sound design strategy that promotes self-regulated learning behavior should verify the change in learner's self-regulations ability. The course should be designed as a regular course longer than a semester to compare the effectiveness of self-regulated learning behavior promotion to revise, supplement design strategies for elaboration

Second, comprehensive strategy development is needed for self-regulated learning behavior promotion in mobile learning environment. Based on the sound strategy mentioned in this research, if microscopic design strategy that promotes self-regulated learning behavior including visual design strategy is provided, learners can be provided with more meaningful strategy.

Third, provided sound based on in depth research on sound types should be individualized and diversified. In this research three types (language message, earcon, and auditory icon) were combined to be used in design and application. When transferring an identical message, depending on the sound type, learning effects can differ. If sound type and features are analyzed and applied, maximized effects can be expected.

Fourth, mixed application of the strategies in various e-learning environments can indicate revision and supplement area. In recent e-learning trend, one program is designed for various e-learning devices however, this research was designed for one mobile device. Therefore if design strategy were derived for multiple

application purposes in different mobile devices or computer environment, universal design strategies can be established.

Through follow up researches, useful self-regulated strategy in mobile learning environment, practical sound design strategy in e-learning environment can be derived. Furthermore, this research can work as a foundational research needed instructional design in mobile learning environment which has been lacking compared to persistent development in technology. It will act as an agent to expand instructional design theory in sound design which has been minimal.

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Taehyun KIM

Professor, Dept. of Early Childhood Education, Chungkang College of Cultural Industries. Interests: Educational Technology, Audio instructional Design, Mobile Learning

E-mail: thkim@ck.ac.kr

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