A Prototype Development of Mobile Game Contents for Mathematics based on ARCS Model

Sungho Kwon
Hanyang University, Korea
skwon@hanyang.ac.kr
Seunghee Jeong
Hanyang University, Korea
christfriend@hanmail.net

Abstract: As mathematics is a notional scholarship and presents many formulas, learners have difficulty compared to other studies of the specific nature. In particular, in order to study and learn the formulas presented in mathematics, practice is essential. Fortunately, the popularization of mobile devices such as smart phone, creates an environment in which the learners can study anytime and anywhere. Therefore, the purpose of this study is to develop a prototype of mobile game contents for mathematics which applies the motivation strategies of Keller's ARCS model. The content of the development is the 'set operation' in the first semester of middle school freshman. Detailed research substances in accordance with the research purpose are, first, to develop the education course for the prototype of mobile game contents for mathematics, second, to develop contents which applies the motivation strategies of ARCS model and third, to apply the education course and ARCS motivation strategies and develop the prototype of mobile game contents for mathematics. To verify this study, the pilot study targeting 20 first-grade students in S middle school was conducted through questionnaire. The developed prototype of math mobile game based on ARCS model was proven to be effective. This study is valuable in a way that it glimpsed the potentials of a pioneering learning method integrating the ubiquitous mobile technology with the educational aspects of learning motivation.

Keywords: *Mobile, Mobile game, ARCS Model, Mathematics, prototype*

1. Introduction

Recently, our educational culture has rapidly changed in the information age. The fast development of ICT has played a critical role for educational paradigm shifts from distance learning to e-learning, from e-learning to m-learning(Guy, 2009). These educational shifts now move towards a ubiquitous education that education take place anytime and anywhere, which is much accelerated by m-learning. Wireless network and mobile devices are essential parts of infrastructure for realizing m-learning. Wireless network technology enables ubiquitous education featured by portability, immediacy and connectivity. Furthermore, the technology enhances individuality and broad accessibility which leads to enrichment and variety to conventional courses or lessons(Abfalter, Mirski, & Hitz, 2004). Especially, m-learning utilizing a smart phone or tablet PC, which is usually cheaper than a desktop or laptop PC, has gained great attention as an alternative educational medium from instructors and learners for its capacity to enhance learners' accessibility to educational resources. According to a report published by SA(Strategy Analytics), an American market research organization, smart phone supply ratio has reached 67.6% in Korea in 2012, since 2009, and subsequently tons of studies have been made concerning educational value and effect of smart phone (Chen, Myers, & Yaron, 2002; Danielsson, Hedestig, Juslin, & Orre, 2004; Park, 2005; Pownell & Bailey, 2001; Roschelle, 2003; Roschelle & Pea, 2002; Sharples, Corlett, & Westmancott, 2002).

M-learning enables learners to learn anywhere and anytime overcoming physical constraints in accessibility with a variety of educational resources. However, there is a disadvantage in m-learning. For example, instructors might have difficulty regulating learners. Hence, learners' self-regulatory learning capacity in m-learning is much emphasized compared to that in other types of learning environment (Kim, 2010).

Keller(2001) emphasized the importance of motivation in terms of instruction-learning design and ARCS motivation strategies play a critical role in the formation of motivation. 49 educational studies published from 1996 to 2006 that had applied the strategies in Keller's ARCS model were reported to have 30% enhancement of educational effects compared to those without them(Kang, 2006). Also, Learners' engagement, attention and motivation toward learning can be reinforced by an educational game based on ARCS model (Cho, 2008). These results revealed that learning motivation has a positive impact on learning outcomes.

However, lots of students have troubles in developing and maintaining motivation especially in mathematics among various subjects. As its abstractness and abstruseness, many learners have difficulty and in learning mathematics. As it is imperative to understand terms, figures, symbols and graphs and interpret their meanings in mathematics, through conscious practices and exercises, learners' mathematical knowledge and applicability can be broadened(Kim, Park & Woo, 2002). M-learning can be conducive to math learning due to its ubiquitousness.

The primary purpose of the study is to develop a prototype of math-learning mobile game. The following steps are listed as a process of the development. First, a learning process of math in mobile game was designed. Second, ARCS model for motivation strategies that will be integrated with a math mobile game was designed. Third, tailored ARCS motivation strategies were applied to the math mobile game. Forth, the motivational effect of a prototype of math mobile game was investigated.

2. Background

2.1 Mobile learning

With the advent of mobile devices and wireless network, the concept of m-learning has been introduced. With a broad definition, m-learning can be defined as a class or course utilizing various educational medium. On the other hand, m-learning can be conceptualized as a learning method featured by mobility, immediacy, individuality and accessibility to information with technical supports of devices such as tablet PC, laptop and mobile devices (Kwon, 2011). The potential educational use of mobile is listed below according to characteristics of mobile learning contents[Table. 2.1].

Table 2.1. Potential uses and features of mobile contents(Kwon, 2011)

Features of m-learning	Potential uses of mobile contents
Mobility	Utilizing learners' location information for tailored learning •On-the-spot experience study •Applications of GPS •Situated learning
Portability	Portability in learning materials •Easy-to-use player control •Learning-assisted materials while portable

Immediacy	Immediate feedback • Provision of learning information of expertise • Time-efficient learning according to educational goals
Individuality	SRM(Student Relationship Management) • Accessibility to LMS for individual learners • Self-diagnostic test • Synchronous learning information exchange through SNS
Accessibility	Anywhere, anytime • Self-regulated learning • Problem–based learning • Assistance-based learning

2.2 Keller`s ARCS model

Many studies of human learning have shown that motivation is a key to learning (Crookes & Schmidt, 1991). Psychologists also consider motivation as one of the major determinants of academic achievement and work productivity (Keller, 1987). Motivation is the most frequently used explanation for success or failure in completing any complex task and has been considered a pivotal concept in most theories of learning. Keller pointed out that learners' motivation is a frequently ignored aspect when it comes to instructional design (Keller, 1979). Keller was intrigued by theoretical concerns about motivation and investigated whether motivation can be systematically classified. With Keller's through and systematic approaches, the concept of motivation encapsulated in four categories; attention, relevance, confidence and satisfaction. Keller(2001) believed that external conditions could be successfully constructed to facilitate and increase learner motivation.

Based on this notion, Keller(1984, 1987) integrated several learning theories and developed the ARCS(Attention, Relevance, Confidence, and Satisfaction) model. Attention refers to the extent to which learners' curiosity is aroused and sustained over time. Relevance refers to learners' perception that the instruction is related to personal needs or goals. Confidence describes learners' perceived likelihood of achieving success through personal control. Satisfaction refers to the combination of extrinsic rewards and intrinsic motivation and the consistency of expectations with outcomes (Keller, 1983; Keller, 1987, Mei-Mei & James, 2002 to re-quotation). Keller(2001) emphasized that four factors of motivation are not actually components of it, but rather they are requisite to trigger motivation. Therefore, four factors of motivation should be above the minimum level respectively in order to maintain the appropriate level of motivation of learners. ARCS motivation model covers the broad aspect of motivation and focus on external strategies instructors should take in an overall course. Briefly, ARCS model provides the specific guidance to design and develop a course. Keller defined four factors and three sub-elements of each factor of ARCS model and introduced specific tactics to develop and maintain them[Table2.2].

Table 2.2. Four factors of Keller's' ARCS model (2002)

Attention	**A1**	**Capture Interest (Perceptual Arousal)** What can I do to capture their interest?
	A2	**Stimulate Inquiry (Inquiry Arousal)** How can I stimulate an attitude of inquiry?
	A3	**Maintain Attention (Variability)** How can I use a variety of tactics to maintain their attention?
Relevance	**R1**	**Relate to Goals (Goal Orientation)** How can I best meet my learner`s needs?
	R2	**Match Interests (Motive Matching)** How and when can I provide my learners with appropriate choices, responsibilities, and influences?
	R3	**Tie to Experiences (Familiarity)** How can I tie the instruction to the learners` experiences?
Confidence	**C1**	**Success Expectations (Learning Requirements)** How can I assist in building a positive expectation for success?
	C2	**Success Opportunities (Learning Activities)** How will the learning experience support or enhance the students` beliefs in their competence?
	C3	**Personal Responsibility (Success Attributions)** How will the learners clearly know their success is based upon their efforts and abilities?

Satisfaction	**S1**	**Intrinsic Satisfaction (Self-Reinforcement)** How can I provide meaningful opportunities for learners to use their newly acquired knowledge/skill?
	S2	**Rewarding Outcomes (Extrinsic Rewards)** what will provide reinforcement to the learners` successes?
	S3	**Fair Treatment (Equity)** How can I assist the students in anchoring a positive feeling about their accomplishments?

2.3 Game based learning

Game based learning is a learning process that learners are independently able to pursue their educational goal with an interaction with a computer game integrated with educational contents. Engagement and interaction are major drives for people to play a game. Likewise, two reasons for integrating game into education can be discussed(Baek, 2006). First, learners' engagement can be enhanced by integrating game into education. Subjects or contents that learners are reluctant to take can be intriguing if they are mixed with game, which in turn, leads to keeping learners' motivation through the learning process (Prensky, 2001). Second, as a game has an interactional element in nature, the process of game is made not merely by 'to see' but by 'to do'. This makes possible for learners not to passively accept and memorize knowledge but rather actively participate in learning process through physical involvement and realistic experiences (Baek, 2006).

Yun (2001) classified the genre of games appropriate for educational purposes and instruction-learning types. He classified 10 types of educational games as lecture, individual, train, discussion, collaboration, self-study, problem-solving, project and simulation according to instruction-learning styles.

Table 2.3 Classifications of the genre of games appropriate for 10 types of instruction-learning types(Yun, 2001).

Types of Instruction-Learning / Genre of game	Lecture	Individualized	Training	Discussion	Collaboration	Self-study	Exploration	Problem solving	Project	Simulation
Action/ Arcade			○							
Adventure		○	○	○			○	○		
Board/ Puzzle	○		○			○				
Role-playing				○	○		○	○	○	
Simulation/ Strategy						○	○	○		○

In action/arcade game, players are expected to reach a goal with a simple key control. Once the mission is completed, players are able to challenge the next level. With a simple game scenario and fast speed, action/arcade can be appropriate for a train type of learning that is oriented to learn skills and concepts. In adventure game, players are required to follow a certain plot of game and encounter and cope with events. Finally, players are heading toward a final destination solving problems faced with. Adventure game takes amount of time to complete it and learners are also expected to be patient during game. Adventure game can be proper for individualized learning and training learning. Since board and puzzle game requires for learners high level of cognitive capacity and involvement, they can be appropriate for time-intensive learning such as lecture-oriented or training learning. In role-playing game, players play a character with certain role in a game and raise their character. Discourse and interactions are requisite for playing this type of game. Therefore, role-play game can be suitable for discussion, collaboration, exploration, problem-solving and project learning. In simulation/strategy game, scientific or realistic data can be experimentally manipulated and represented with singularity and variation according to players. Since these types of games are characterized by verisimilitude and dynamics of real life, they are adequate for self-study, exploration, problem-solving and simulation learning (Yun, 2001).

There is educationally appropriate game genre according to instruction-learning types. With the proper applications of types of games, educational effects can be enhanced. This study aims to develop a prototype of math mobile learning contents that encompasses lots of abstract ideas and formula to be memorized by learners. In pursuit of the aim, lectures and trainings were provided and learners' self-study was recommended. Board/Puzzle game can be regarded as appropriate for this

type of instruction-learning style [refer to Table 2.3]. In this study, board/puzzle game was utilized as a suitable genre of game for math learning.

3. Method

3.1 Participants

20 participants who are all first-grade students carrying their own smartphones in S middle school located in Seoul are sampled for the pilot test.

3.2 Procedure

In order to develop a prototype of math mobile game based on ARCS mode, five steps are enlisted below. First, an analysis of learners and math textbooks was conducted. And then, based on the previous analysis, math learning contents were selected for the pilot test. Second, a math learning course that is applied to a mobile setting was designed. Third, specific ARCS motivation strategies were designed for the math mobile game. Fourth, math mobile-game contents were developed on the basis of motivation strategies and learning course previously established. Fifth, a pilot test was conducted to test a prototype.

Table 2.4 Five developmental phases of a prototype of a math mobile game

Phase		Details
1	Analysis	Analysis of learners and math textbooks and selection of math learning contents.
2	Design	Designing math learning course that is applied to a mobile setting was designed
3		Designing specific ARCS motivation strategies for the math mobile game
4	Development	Developing math mobile-game contents on the basis of previous motivation strategies and learning course.
5	Pilot test	Conducting a pilot test for a prototype

4. Material

Prototype of math mobile game learning based on ARCE model

4.1 Analysis of learners & learning contents

This pilot study targeted first-grade middle school students and the learning contents of the pilot test were composed based on the official middle school curriculum at first grade level. Specifically, the learning contents of the prototype were about ‘set operation’ which is a part of ‘unit no.1; set & operation’ under the ‘chapter. I; set & natural number’ in textbook.

4.2 A learning flow chart of learning process of the prototype

Initial menus including ‘School Information’, ’School Life’, ‘Learning Shop’ and ‘Bulletin Board’ are exhibited on the first page. Once a learner clicks on a ‘Learning Shop’ button, a ‘Login’ page will pop up. With a learner logged in, a ‘Grade Selection’ page, which includes separate links to each grade level in middle school, is displayed. If a leaner choose a first grade level, ‘Semester Selection’ tab is shown in a sequence. Subjects in the first semester for the first grade students are listed. Leaners are able to select ‘Math’ among them and then proceed into a ‘Chapter Selection’ phase followed by ‘Lesson Selection’. Through the process, Math leaners are expected to choose the first chapter called ‘set & natural number’ and then go into the respective unit. Once ‘set’ unit chosen, a following menu page pops up with options of ‘Concept Acquisitions’, ‘Cross-word Puzzle’, ‘OX quizzes’ and ‘Help’. A system was manipulated in a way that, after a leaner passed ‘Concept Acquisitions’, he/she can challenge ‘Cross-word Puzzle’ and then go into ‘OX quizzes’ corner.

Learners are expected to learn basic concepts of units through the ‘Concept Acquisitions’ phase. As soon as learners mastered all basics in every unit, they can jump into the ‘Cross-word Puzzle’ section whose problems are reflections and reviews of previous learning contents. After finishing the ‘Cross-word Puzzle’, a learner’s rank is recorded and the program is terminated. Contents that learners have learnt previously can be reviewed through the ‘OX Quizzes’ step. Once ‘OX Quizzes’ is completed, a learner’s score is ranked and stored in the program repeatedly [Figure 4.1].

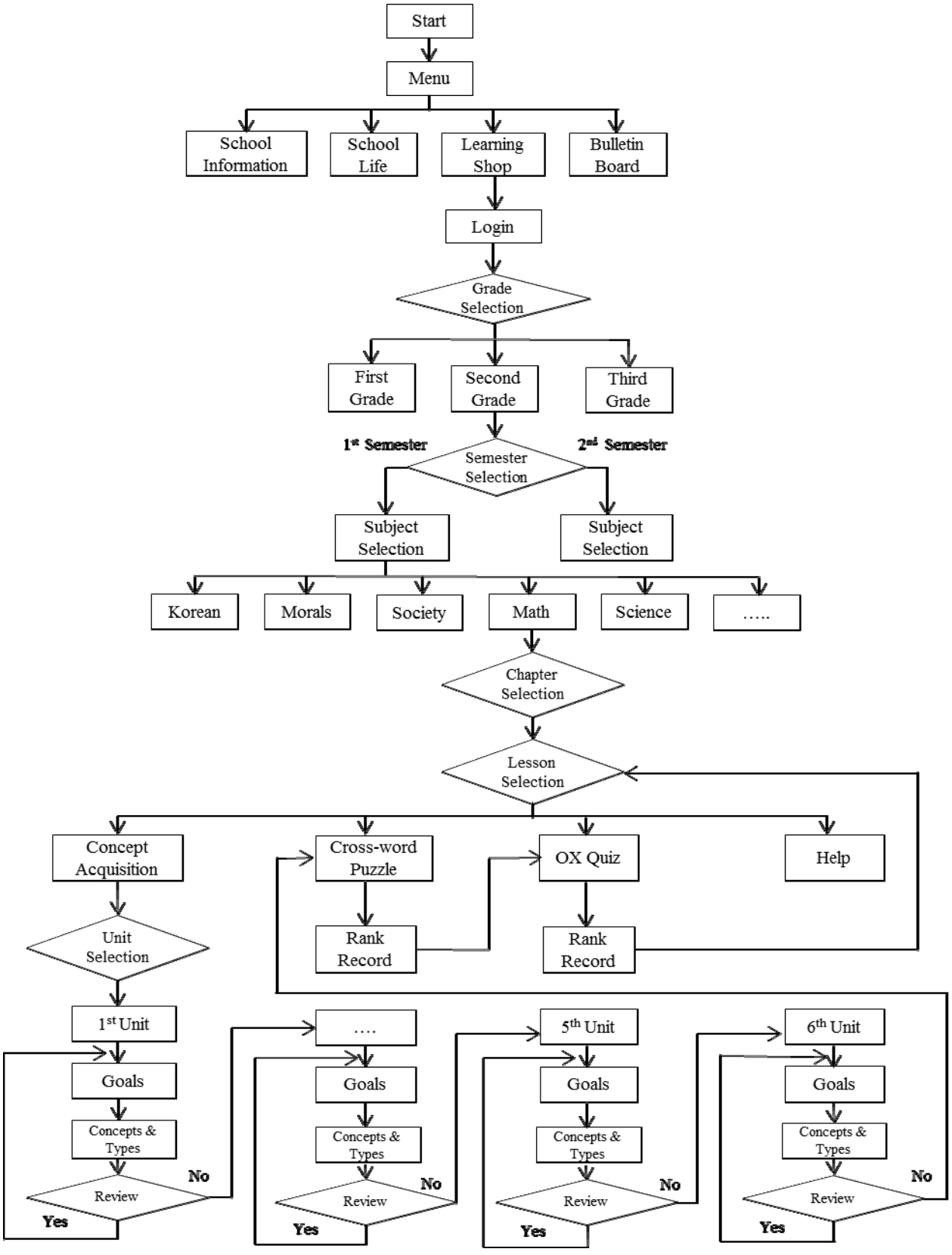


Figure. 4.1. A learning flow chart of math mobile game learning

4.3 ARCS motivation strategies applied to a prototype

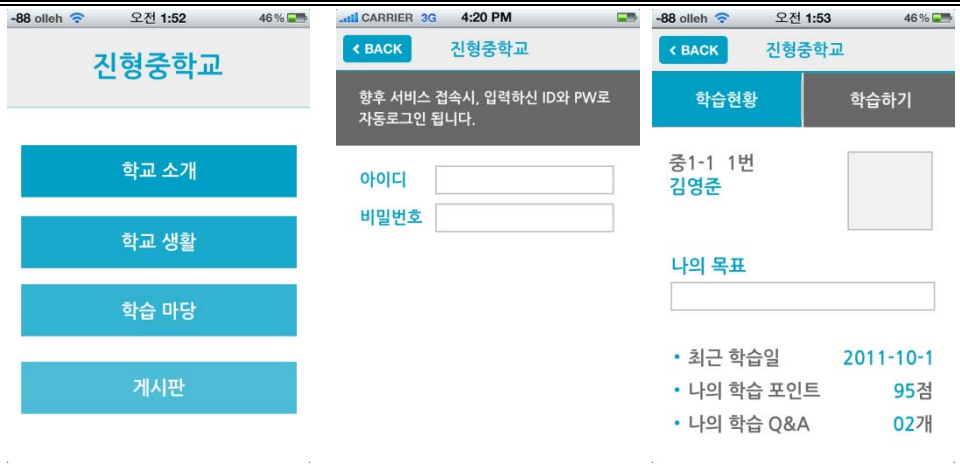
Table.4.1 ARCS motivation strategies applied to a prototype

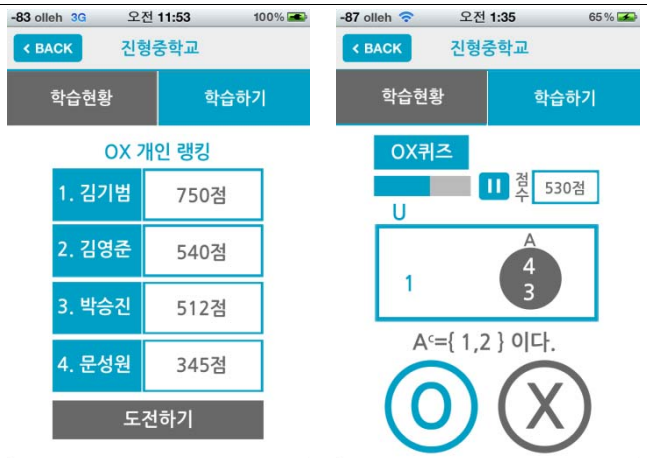
Phase		ARCS model areas	Learning Motivation Strategies
Introduction	Login & Learning Status	A1 A2	Blinking when new post is registered in Learning Q&A section. Teachers and Students exchange questions, answers and feedbacks through Learning Q&A section.
		R1 R2	Learners' learning goals and learning statues are informed. Learning incentive points are given.
		S2	Deposited points can be used to decorate learners' avatars.
	Learning	A1 A1	Sound effects when selecting a menu button. A unit that learners should study through 'Concept Acquisition' is blinking.
		R1,C1	Learning goals of each individual unit are displayed.
		C2 C3 C3 C3	With system control, learners are able to learn from easy to difficult level. Learners have choice in the menu: grade, semester and subjects. Learners can move back in the menu through 'Back' button Learners have choice whether to learn back from the first level or continue the current learning.
Development	Main Learning (Concept Acquisitions)	A1 A2 A3 A3 A3	Audio-visual effects with false and true responses. Learners' active engagement and responses during the learning process. Various types of quizzes and problems are shown under the same learning goal. Each unit is composed briefly in order for learners to learning for about 10 minutes. In the middle of learning, 'Surprise quizzes' pops up with audio-visual effects.
		R1 R2 R3 R3	Utilizing a proper game(e.g., word quizzes, cross-out game) in accordance with learning goals. Feedbacks whether answers are true or false. Audio-visual effects making use of figures and graphics. In the first and last stage, real-world examples are used.
		C2 C2 C3	Problems and quizzes are displayed from easy to difficult level. If all unit-level problems are solved, a locked 'Cross-word Puzzle' is activated. After 'Concept Acquisition' is finished, the performance is evaluated. And then, a learner decides whether to continue learning or not.
		S1 S2 S2 S3	A variety of exercises are provided for learners to increase chances of application of learnt concepts. Learning point incentives are provided when a correct answer is registered. Learning point incentives are given as learners' reviews repeat. Types of game and quizzes are tailored to the learning goals.
Wrap up	Reviewing (Cross-word Puzzle)	A1 A2	Audio-visual effects with false or true responses. Encouraging learners' active responses with questions, answers and feedbacks.
		R1 R2 R2 R2	The use of goal-oriented games. Feedbacks provided in each exercise and problem. Learners' rank and top 100 rank scores are displayed in the first page of 'Cross-word Puzzles'. With the number of left items and won scores displayed on the top of the page, learners are encouraged to be motivated.
		C1 C2 C3 C3	With a 'Help' menu, tutorials and evaluating criteria of 'Cross-word Puzzle' game are provided. Once all quizzes in 'Cross-word Puzzle' are solved, 'OX quiz' is activated. On the top of the page, 'Pause' button is available in order for learners to control their pace of learning. Learners can solve problems by pressing the empty part of a puzzle or blank.
		S1 S2 S3	Reviewing concepts learnt from 'Concept Acquisition' with 'Cross-word Puzzle'. Learning incentive points are given when learners answered correctly. Organizing 'Cross-word Puzzle' in accordance with learning goals.

Evaluation	Formative evaluation (OX quiz)	A1 A2	Audio-visual effects with false or true responses. Encouraging learners' active responses with questions, answers and feedbacks.
		R1 R2 R2 R2	The use of goal-oriented games. Feedbacks provided in each exercise and problem. Learners' rank and top 100 rank scores are displayed in the first page of 'Cross-word Puzzles'. With the number of left items and won scores displayed on the top of the page, learners are encouraged to be academically motivated.
		C1 C2	With a 'Help' menu, tutorials and evaluating criteria of 'OX quiz' game are provided. Once all quizzes in 'Cross-word Puzzle' are solved, 'OX quiz' is activated.
		S1 S2 S3	Contents learnt from 'Concept Acquisition' and 'Cross-word Puzzle' are reviewed through the 'OX quiz'. Learning point incentives are provided when a correct answer is registered. Organizing 'OX quiz' in accordance with learning goals.

4.4 A prototype development of a math mobile game based on ARCS model

Table.4.2 A prototype development of a math mobile game based on ARCS model

Phases		Prototype display
Introduction	Login & Learning Status	
	Learning	

Development	Main Learning (Concept Acquisitions)	
Wrap-up	Review (Cross-word Puzzle)	
Evaluation	Formative evaluation (OX quiz)	

5. Measure

5.1 Instrument

The effects of a prototype of math mobile learning were evaluated based on learners' motivation response consisting of 36 items rooted in Keller(1993)`s IMMS(Instructional Materials Motivation Survey) with Cronbach α .97(Keller, 2001).

5.2 Data Analyses

For survey responses, a 5 point-Likert scale was adopted. A reverse coding was processed with item number 3, 7, 12, 15, 19, 22, 26, 29, 31. A descriptive statistics was analyzed with statistical software SPSS 12.0.

6. Result

As a result of survey and analyzing IMMS questionnaire, all the scores of sub-factors of ARCS model are significantly above the average 3,specifically, with 3.78 in attention, 3.69 in relevance, 3.92 in confidence and 3.81 in satisfaction[Table 6.1].

Table 6.1 Development of math mobile game based on ARCS model

Categories	Sample (*N*)	Items	The average of motivation response
Attention	20	12 items	**M=3.78, SD=±.82**
Relevance	20	9 items	**M=3.69, SD=±.79**
Confidence	20	9 items	**M=3.92, SD=±.82**
Satisfaction	20	6 items	**M=3.81, SD=±.86**

7. Discussion

M-learning, the fastest growing educational paradigm, is characterized by learning that can take place anywhere and anytime. In this study, considering the difficulties regulating learners by instructors in m-learning environment, strategies for increasing learners' motivation were drawn based on ARCS model and subsequently applied to math mobile game. 20 first-grade middle school students located in Seoul were participants to test the prototype with Keller's Instructional Materials Motivation Survey. The pilot test indicated that the prototype was effective. As a consequence, a math mobile game based on ARCS model was proven to be successful for enhancing learners' motivation during m-learning.

This study concluded with limitations and suggestions for follow-up studies in the future. First, participants might not randomly be assigned mainly because a small number of students have smartphones. Second, novelty effect might affect the result since the pilot test was conducted only after 1 unit of lesson with a narrowed scope of contents. Follow-up studies should be conducted with a more broad range of contents and course duration.

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