A Game-Based Learning Environment Using the ARCS Model at a University Library

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***Abstract*—This study involves the development and evaluation of a game-based learning environment for library instruction that is based on the ARCS model and designed to run on mobile platforms such as iOS and Android. A questionnaire and performance test was administered to compare game-based and e-learning performance; no significant difference in performance was found between either groups, although three ARCS factors were significantly higher for the experimental group when compared to the control group. Furthermore, subjects in the experimental group were more likely to recognize the effects of the ARCS design when compared to those who used e-learning.**

Keywords—educational technology; mobile learning; gamification; ARCS model; university library

I. INTRODUCTION

A university library should be an environment in which students can learn and study effectively. Therefore, it is important for students to acquire the skills necessary to use library services. More than 90% of the libraries at Japanese universities offer an orientation program designed to familiarize students with library services [3]. Nevertheless, approximately 20% of the students surveyed by Hyodo [8] reported that such seminars were either useless or questionable benefit due to a lack of relevant information. Moreover, 80% of the participants indicated that the orientation did not motivate them to visit their institution's library. Following that investigation, the library integrated several instructional experiences into the orientation in an attempt to improve upon it [9]. Based on these experiences, we decided to focus on improving learning motivation, which led to the development of a game-based learning environment for library instruction.

This paper begins with a short literature review in Section II, followed by an overview of the model that formed the basis of our learning environment in Section III. Section IV describes the system environment from both the client and server side. In Section V an analysis of our results is presented. Lastly, the conclusion examines the study's ramifications and explores potential areas for future research.

II. LITERATURE REVIEW

In their examination of game-based library education in a university environment, Hori et al. [1] developed and evaluated a document retrieval game. Donald [6] suggested the use of alternate reality gaming, which transforms real world scenarios into a gaming platform, in order to familiarize students with library services. Gallegos, Allgood, and Grondin [4] also initiated a game development project designed to familiarize students with library services.

Gregory and Broussard [2] suggested using game-based learning materials, and highlighted the usefulness of integrating game design into library orientations. Marcus and Beck evaluated learning performance by comparing traditional and game-based approaches to library orientations [12]. Additionally, O'Hanlon, Diaz, and Roecker [11] proposed using multimedia such as games and video in library orientations.

Hsu, Shu-Chen, and Yueh-Min [5] examined learning performance in library instruction by developing a game-based learning system for PDAs. The adventure-styled game included actual scenery from the library, and prompted users to solve riddles related to library instruction. Although Hsu et al.'s concept resembles the present study, they did not base their design on the ARCS model.

Smale [10] conducted a survey examining the adoption of game-based learning in a library education context, which

highlighted the limitations of traditional one or two session lectures, such as limited time, difficulty in attracting learner interest, and a tendency to ignore the role of motivation in attracting learner interest. We also referred to Fujimoto and Yamada's [13] research concerning game-based learning in informal settings while developing the study's learning environment.

III. Instructional Design

The ARCS model functioned as a foundation for the game-based learning materials developed during this study. The following two sections describe how the materials were designed, and provide an overview of their content.

A. The ARCS Model and Library Education

In a study examining the attitudes of university students toward libraries, Hyodo [8] discovered three factors that contributed to students' avoidance of them: a notion that libraries are solely for reading books, not a place for study; a perception that there is no reason to visit them; and a belief that libraries themselves serve no purpose. These opinions indicate that many university students lack motivation to spend time at their campus libraries.

Hyodo also surveyed participants concerning their library's orientation program. Several students reported that they were unable to recollect the contents of the orientation, while others stated that they lacked opportunities to apply the knowledge that they acquired. Another series of interviews prompted senior-year students to recollect their first-year experiences in relation to their library orientation. Students frequently reported that they were unable to understand its importance, or that they completed assignments primarily by using the Internet.

In light of the aforementioned findings and the observations of several librarians, a persona model (Table 1) was created to profile the typical user of our educational materials. Based on concepts in the ARCS [7] and persona models, a formula was then devised for learning materials with the aim of motivating students to partake in library education.

The ARCS model is a motivational design model consisting of four components intended to evoke and sustain motivation throughout the learning process: attention, relevance, confidence, and satisfaction. Attention involves factors that users may consider attractive (e.g., role-playing or hands-on experiences); relevance concerns factors that a user may want (e.g., immediate or future usefulness); confidence entails factors that should increase one's likelihood to succeed (e.g., self-growth); satisfaction involves feedback factors that will likely secure success (e.g., rewards or benefits). The contents of the formula categorized according to each ARCS component are shown in Table 2.

TABLE I. A Persona Model of the Typical User of Our Educational Materials

Target	First-Year University Student
Background	Believes it is sufficient to search for information on-line in order to complete an assignment Rarely uses the university library and generally does not consider visiting it Possesses a smartphone
Situation	Preoccupied with studies, club activities, and a part-time job Plays games or uses social networking services during their free time

B. A Game-based Learning Environment Using the ARCS Model

Based on our formula, a game-based learning environment was created entitled "Library Adventures: Unveil the Hidden Mysteries!" (LA). The game was delivered in the form of a mobile application, thus allowing students to play LA during their free time. As shown in the far left screenshot provided in Fig. 1., LA includes 12 quizzes related to library services; students can obtain various items after successfully completing a quiz. These quizzes contain questions related to library services, and require students to physically explore the library premises or use its services in order to solve them.

The center image in Fig. 1 shows a quiz in which users are prompted to search for information by using a dictionary. During the process, players must learn to use the library's Bibliotheca search engine to locate a specific document containing information needed to solve the quiz. Following the search, players may go to the book's location in order to retrieve it.

TABLE II. Formula for the Study's Educational Materials

Attention	A game-based design that is attractive to students Cute characters that resonate with students A fieldwork-style educational design that concentrates on student learning
Relevance	Useful content that assists students in tackling their academic tasks
Confidence	Varying difficulty levels that enable students to play both easy and difficult games Several hints to assist students in reaching the correct answer Practical experience that leads students to actually using a technique in a library context
Satisfaction	Students feel a sense of accomplishment when a task is completed Students experience slight difficulty in completing the game in order to inspire learning Students gain knowledge of the library's services and come to apreeciate its usefulness, even without borrowing a book

Fig. 1. Screenshots from the library adventure game.

Other quizzes in the game are puzzle-styled, and include crossword activities or games that require users to locate QR codes found within the library. In the latter tasks, a game character navigates the student through the building while providing clues that will enable him or her to locate a given code, as shown in the far right image in Fig. 1. Upon finding the appropriate QR code, the player scans it to successfully complete the quiz. By completing each quiz, learners can obtain the basic skills required to use the library's services, which are outlined in Table 3.

IV. System Configuration

The client application runs on iOS and Android devices, and works in conjunction with the server application to collect user data, which is then stored in a relational database. The sections that follow discuss the logged data in greater detail, and also describe the server and database configuration.

TABLE III. Contents of the LibraryAdventure Game

Content	Details
Basic Information	Library's hours of operation Facilties inside the library Where books are located The arrangement of shelves
Library Services	How to borrow a book Procedure for reserving group learning rooms Using the automated archival system to locate a book
Search Techniques	Ways to search for a book Methods to locate a journal article How to locate a newspaper article How to find a referenced book
Other	Spending fun time with staff members in the library.

A. Client Application

During the conceptualization of LA consideration was given not only to instructional design, but also the game's technical aspects. In order to reduce development costs, it was decided that LA should be coded as a cross-platform application capable of running on both iOS and Android devices. Furthermore, we believed that the game should run as a native application on both platforms, not merely as a browser-based app. Accordingly, the cross-platform Unity 3D game engine was selected as our development environment. To facilitate data collection, it was deemed necessary for LA to adopt a client-server configuration, wherein user accounts are managed by a server application in order to log each user's respective activities. These logs, which are initially created by the client application, are uploaded to the server whenever a user saves his or her game data.

In conducting data analysis research, it is important to determine the kinds of information that should be collected. The librarians who participated in this study believed it would be beneficial to obtain data concerning (1) how users transitioned between activities, (2) the difficulty of quizzes that they selected, and (3) the times and places in which the app was used.

The first item's importance lies in its ability to reveal the types of questions that tended to appeal to users. As for the second item, this information can be obtained by examining the logs uploaded by the client application, which reveal when a user answered a question, in addition to his or her actual response. Moreover, the timestamps from these logs enable us to determine the amount of time taken by a user to complete a given task. The IP address associated with a particular action is also recorded, which assists us in obtaining data pertinent to the third item. A data format was created specifically to assist us in obtaining the aforementioned information; the user log shown in Fig. 2 is based on this format.

```
<?xml version="1.0" encoding="UTF-8"?>
<log>
  <enter scene="100" datetime="6/23/2014 6:16:41 PM" />
  <enter scene="101" datetime="6/23/2014 6:16:43 PM" />
  <enter scene="103" datetime="6/23/2014 6:16:45 PM" />
  <enter scene="102" datetime="6/23/2014 6:16:55 PM" />
  <enter scene="104" datetime="6/23/2014 6:16:57 PM" />
  <save scene="104" datetime="6/23/2014 6:16:58 PM" />
  <end scene="104" datetime="6/23/2014 6:16:58 PM" />
   .
   .
   .
  <save scene="102" datetime="2/24/2015 4:21:25 PM" />
  <continue scene="102" datetime="2/24/2015 4:21:25 PM" />
  <resume scene="100" datetime="2/24/2015 4:29:01 PM" />
  <enter scene="100" datetime="2/24/2015 4:29:01 PM" />
  <enter scene="102" datetime="2/24/2015 4:29:03 PM" />
  <enter scene="0" datetime="2/24/2015 4:29:05 PM" />
  <enter scene="102" datetime="2/24/2015 4:29:07 PM" />
  <enter scene="104" datetime="2/24/2015 4:29:10 PM" />
  <enter scene="102" datetime="2/24/2015 4:29:11 PM" />
  <enter scene="104" datetime="2/24/2015 4:29:13 PM" />
  <save scene="104" datetime="2/24/2015 4:29:14 PM" />
  <end scene="104" datetime="2/24/2015 4:29:14 PM" />
</log>
```

Fig. 2. A sample log file showing one user's activities.

Due to its high parsability, XML was used to log application data. The following seven XML elements were used to denote various user activities:

- *Enter*. The user has reached a page.
- *Pause*. The game has switched to a background process, such as when the user opens another application or receives a phone call.
- *Resume*. The application is no longer a background process.
- *Answer*. The user has answered a question.
- *Save*. The user has saved his or her game data.
- *Continue*. After saving a game, the user is asked whether or not they would like to continue using the application. This element indciates that the user decided to continue.
- *End*. The user has closed the application.

Each of these elements possesses two types of common attributes: *scene*, which is accompanied by a page ID, and *datetime*, which indicates the time when an action took place.

Consider the following example wherein the element is *enter*, with a *scene* attribute of 100, and a *datetime* attribute of 6/23/2014 6:16:41 PM. This indicates that the user accessed a page with the ID 100 at 6:16:41 PM on June 23, 2014. By comparing the *datetime* and *scene* attributes between various occurrences of the *enter* element, it is possible to establish the amount of time spent by a user on a given task. Furthermore, this information provides the data necessary to determine how users transition between various activities.

The *answer* element is unique in that a string of text entered by the user follows it. Based on the user's answer and when it was entered, it is possible to estimate the question's overall difficulty. When a user saves his or her game data, a log is sent to the server containing the individual's IP address and the time of submission, which can then be used to determine their location.

B. Server Application

Like with the client application, technical issues were taken into consideration during the development of its server-side counterpart. Since the server-side app needed to accommodate at least 50 users simultaneously, it was not feasible to use live streaming techniques for the transmission of log data from the client. Instead, we opted to send data using the HTTP protocol, but only during the save game process; a reverse proxy was implemented to distribute the server load across multiple machines. Log data was sent as POST parameters from the client-side application to the server.

The server-side application was developed using the Python programming language, which features many libraries geared toward academic purposes (e.g., the numerical operation and machine learning libraries), in addition to its robust web framework libraries. Hence, the server is highly capable of analyzing the supplied log data.

Fig. 3 provides an overview of the server configuration. For the purpose of receiving POST parameters from the client-side app, Nginx was configured to function as a reverse proxy, which relays data to the web application framework. Gunicorn, a web server gateway interface, was used to link the web server and web application framework. Gunicorn runs several workers to facilitate the web application process, which are managed as daemon processes by Supervisor, a Python-based process management tool.

The web application was built upon Bottle, a simple web framework featuring a model-view-controller (MVC) architecture. The web application communicates with a MySQL database, which depends on data-store and data-getting processes. Peewee was adopted as an object-relational mapping library to connect the web application and database, which contains the log data for each user. An entity-relationship diagram for the database is shown in Fig. 4. The database includes four tables:

- *Users*. Contains information such as the user's name and affiliation.
- *Logs*. Consists of data related to the user's activities, in which each schema represents one of the earlier discussed actions.
- *Status*. Includes game status data, such as whether a user has successfully answered a specific question.
- *Comments*. Contains user comments related to the educational materials.

The information contained in the *users* table facilitates comparisons between users' activities in relation to their affiliations and grades. The *option* schema in the *logs* table enables the system to supply additional details, such as the answers inputted by a user.

As mentioned above, the *status* table includes data concerning a user's game status, such as which quizzes he or she successfully completed. The aforementioned tables include strictly Boolean parameters. However, upon successfully completing all question users are prompted to comment on the learning materials; these comments are subsequently stored in the *comments* table. The *users* table has a one-to-many relationship with other tables.

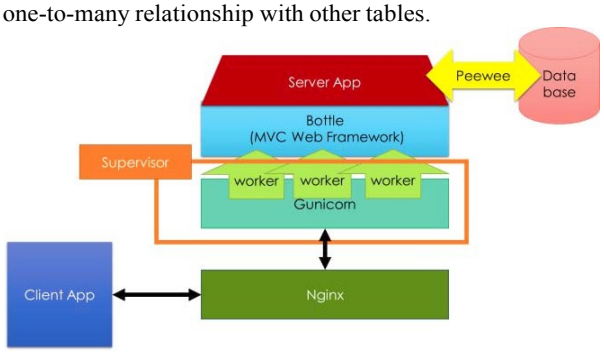

Fig. 3. Configuration of the server application.

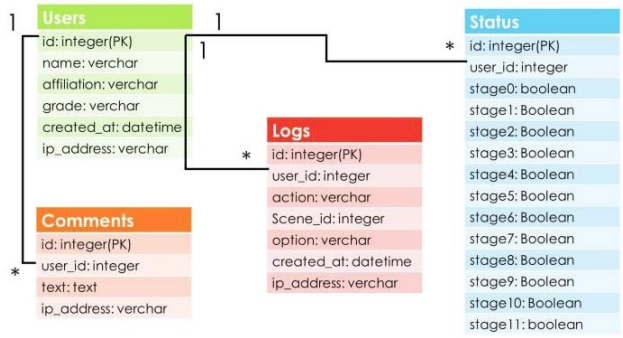

Fig. 4. Entity-relationship diagram for the server-side application database.

V. Analytical Results

The effectiveness of our game-based learning materials was determined by comparing them to traditional e-learning materials. E-learning materials are similar to game-based materials in that they are slide-based, and accompanied by voice narrations; users are able to skip or return to slides interactively as needed. Blackboard Learn, a learning management system, was used in our experiment. In the sections that follow, we discuss our approach to conducting this experiment, our data collection methods, the experimental results, and finally examine participants' learning performance.

A. Procedure

Thirty-six (11 male, 25 female) first-year university students were equally divided into game (experimental) and e-learning (control) groups. Following an explanation of the experiment, subjects in both groups were asked to complete a performance test, after which they engaged in learning activities using their respective game-based or e-learning systems.

Students in both groups were allotted up to three hours to complete the activity. Members of the game group attempted to successfully answer the questions for each quiz. On average, members of the game group took between two and three hours to complete the task, although some subjects were unable to finish the activity in the amount of time given. Members of the e-learning group were encouraged to review the provided materials until they reached a thorough understanding of the library's services and how to use them. Subjects in this group took one hour on average to review their materials. Participants from both groups later completed a performance test and responded to a questionnaire.

B. Data Collection

Data were collected by means of a questionnaire concerning game design, and also by using a performance test. The Instructional Material Motivational Survey (IMMS) [7] was used to evaluate the game design's effects, and contained 36 items distributed across 4 factors related to the ARCS model. Participants were asked to rate each item on a five-point Likert-scale, wherein 1 = negative and 5 = positive.

To assess learning performance, a 20-question performance test was compiled by university librarians, and conducted both before and after the experiment. Table 4 contains a list of these questions.

C. Results

In evaluating the ARCS design, the data of 32 subjects were analyzed (15 from the experimental group; 17 from the control group); four participants' responses were eliminated due to invalid data. The analysis was conducted using a Wilcoxon sign-ranked test. The results are provided in Table 5, along with mean and median scores.

The instructional design factors in the experimental group, with the exception of confidence, were significantly higher than for the control group. These results indicate that subjects who used the game could more easily recognize the effects of the ARCS design.

TABLE IV. Questions From the Pre and Posttest

No.	Question
1	For how long can one borrow a journal from the library?
2	How is a book in the automatic archival system accessed
3	What is the mascot name of the library staff?
4	Which of these choices does not reflect the role of a library staff member?
5	Which of these choices correctly describes the library's collection?
6	Which of these choices does not correctly reflect a feature of the library's collection?
7	What do you call the brochure gathering back-number of newspapers?
8	Which method is optimal for locating a newspaper article containing a specific theme during a given decade?
9	How many books and journals can a first-year student borrow simultaneously?
10	Which of these choices correctly depicts Vol. 3 No. 2 represntation?
11	Where are monthly cooking magazines located in the library?
12	Which of these choices is best for locating a reference book in corner 2F of the library?
13	Where would a general book be found in corner 2F of the library?
14	Which of these choices does not correctly describe the usage of a group learning room?
15	Where are the Blue Back series of books located in the library?
16	At what time does the library close?
17	Which of these choices correctly describes something that can be done in the library's computer lab?
18	How are biographies classified according to the Nippon Decimal Classification
19	How are titles involving language classified according to the Nippon Decimal Classification?
20	Which of these choices incorrectly describes the process a first-year student must follow in order to renew a borrowed item?

TABLE V. RESULTS OF THE IMMS SCORE ANALYSIS USING A WILCOXON SIGN-RANKED TEST

ARCS factor	Mean		Median		Z
	Game	*e-learning*	*Game*	*e-learning*	
Attention (12 items; min = 12; max = 60)	50.73 (6.80)	44.18 (5.28)	53.00	44.00	3.13[b]
Relevance (9 items; min = 9; max = 45)	37.13 (4.76)	34.82 (4.07)	38.00	35.00	2.14[c]
Confidence (8 items; min = 8; max = 40)	31.27 (3.81)	29.59 (2.90)	32.00	29.00	1.40
Satisfaction (5 items; min = 5; max = 25)	22.80 (2.54)	17.59 (3.20)	24.00	18.00	3.86[a]

[a] $p < 0.001$

[b] $p < 0.01$

[c] $p < 0.05$

D. Learning Performance

Thirty-six subjects completed the learning performance test both before and after the experiment. The results of a two-way ANOVA (time x group) revealed a significant difference between the pre and posttests ($F(3, 68) = 61.47$, $p < 0.001$, $R^2 = 0.73$), although there was no significant difference between groups, and no interaction effect (see Fig. 5). These results indicate that learning performance between both groups improved.

VI. CONCLUSION AND FUTURE STUDIES

A game-based learning environment for library education was proposed based on the ARCS model, and its effectiveness was compared to traditional e-learning materials. Thirty-six individuals were divided equally into two groups who utilized either game-based or e-learning materials. The results failed to reveal a significant difference in leaning performance between either groups, although instructional design factors in the experimental group were significantly higher than for the control group.

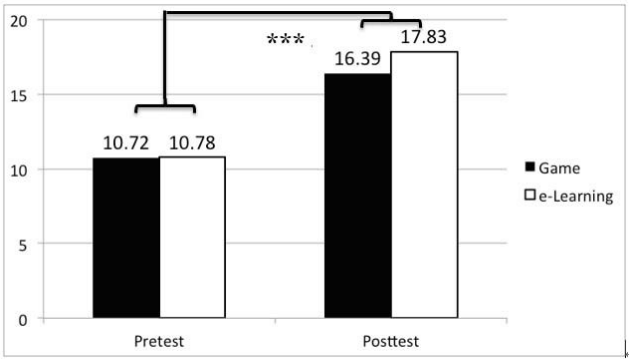

Fig. 5. ANOVA results for learning performance.

Furthermore, the results indicated that individuals in the experimental group more easily recognized the effects of the ARCS design when compared to the control group. Future studies may investigate the relationship between user test scores and data logs, and also examine delayed test results. Additionally, it would be beneficial to investigate possible correlations between the experimental group's duration of game use with each component of the ARCS motivation scale and learning performance. The results in this study should lead to new discoveries and, consequently, the development of improved game-based learning environments.

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