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Herbopolis – A mobile serious game to educate players on herbal medicines

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ABSTRACT

Background: Use of herbal medicines is common. There is a need for education in this area. Mobile games are useful educational tools for motivating learning. A mobile game on herbal medicines can potentially enhance players' herb-related knowledge. Our objective was to develop a mobile game to motivate players to learn more about herbal medicines.

Methods: Game development comprised of storyboarding, user interface design, database development, server development and distribution. A pilot usability study was conducted for the game prototype. Data was gathered through user registration, background data collection and a post-game survey containing a quiz on herbs encountered in the game. Mann-Whitney *U* test, chi-squared test and Spearman's correlation coefficient were used for data analysis.

Results: "Herbopolis" is an in-house developed mobile game of the simulation genre. Players are tasked to manage a city specializing in the production and sale of herbal products. Nineteen out of 24 participants downloaded and played the game, and completed the post-game survey. Heuristic evaluations for usability, playability and educability were generally positive. Strong positive associations were observed between player level ($r = 0.810$, $p < 0.001$) and gameplay time ($r = 0.757$, $p < 0.001$) with quiz scores. Female players scored higher in the quiz ($p = .044$), played for more days ($p = .010$) and attained higher levels ($p = .010$) than male players.

Conclusion: Players are motivated to learn about herb-related information through playing "Herbopolis". Our results support its use for improving knowledge on herbal medicines. Future game iterations to improve robustness and performance will likely to improve its reception and effectiveness in learning.

1. Introduction

Complementary and alternative medicines (CAMs) use is a commonly seen phenomenon. Approximately 33.2% of adults in the USA use CAMs,[1] among which 17.7% are from the use of non-vitamin and non-mineral dietary supplements, while 29.4% are from herbal medicines.[1] CAM use in Singapore is higher. About 76% of people use CAMs in Singapore, of which 36.8% are from the use of herbal medicines.[2] This high prevalence still occurs despite insufficient evidence for safety and effectiveness with some CAMs.[3] Furthermore, safety concerns are exacerbated since high proportions of Singaporeans (74%)[2] and US citizens (57%)[4] do not report their CAM use to their doctors. The attractiveness of CAM use by the layman is from more than just scientific evidence alone.[5–7] As such, the public needs to be educated about the appropriate use of CAMs. Current sources of information on CAMs and supplements include offline and online textual media, anecdotes, and professionals in the industry,[8] but the variety of sources can potentially lead to varied information. This study focuses on one of the largest subsets of CAMs[1,2] – herbal medicines.

Games are potentially useful tools for health education.[9–11] They provide the necessary motivation to change an individual's actions,[12,13] and can reach a large population at a relatively low cost.[14] In fact, games have been employed as educational tools in various healthcare fields, such as diet and nutrition,[12,15] health promotion,[16] smoking cessation,[14,17] diabetes management,[18] managing anxiety,[19] cognitive decline[20] and cardiopulmonary resuscitation.[21] One particular subset of games – mobile games, may be especially applicable for this purpose. Mobile games are one of the top three popular applications among smartphone users in Southeast Asia,[22] and a recent Global Mobile Consumer Survey showed that ~47% of the Southeast Asian population play games on their smartphones.[22] The smartphone platform provides high accessibility and connectivity[15,23] and its relevance is likely to increase with the eventual aging of the "digitally-savvy" generations.[24,25] There is evidence for the educational and motivational

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capabilities of mobile games.[18,19] With games like "Pokémon Go", lifestyle modifications can be achieved in players without actively delivering lifestyle advice.[26]

We postulated that a mobile game that allowed players to learn about herbal medicines could potentially enhance their knowledge on herbal medicines, but such a game does not currently exist. Therefore, this study aimed to investigate whether a mobile game would motivate users to learn more about herbal medicines. Our hypothesis was that a mobile game would improve the players' knowledge on herbal medicines. Hence, an in-house mobile game on herbal medicines was developed and usability and effectiveness data on the game was obtained from a pilot group of players.

2. Methodology

2.1. Game development

2.1.1. Storyboard

The game was set in a small city specialized in herbal product manufacture. The name of the game (Herbopolis) was derived from "herb-city", representing the game's setting. The in-game goal of the player was to manage the city, expand the product line-up and maximize revenue from trading of herbs. The storyboard was conceived with seven main game elements – Main map, Farm, Warehouse, Factory, Company, Shop and International Headquarters (HQ) (Appendix A). This was created using Photoshop CS5 (Adobe Systems, San Jose, CA) at Quad HD (2560 × 1440) resolution. Illustrator CS6 (Adobe Systems, San Jose, CA) was used for vector-based graphics elements. Game content was prepared for 50 levels of gameplay.

The game elements were modelled after the production process of herbal medicines. The "Main map" would offer an overview of all game elements in herbopolis. The "Farm" would allow herbs to be grown. The "Warehouse" would provide information on each herb and herbal product. The "Factory" would allow the processing of herbs into different herbal products. The "Company" would provide options for marketing, research and development, and manufacturing improvements. The "Shop" would allow the player to sell herbs and herbal products to virtual customers, who would then rate the Company through a "Product Review System". The "International HQ" would provide social gaming elements, such as rankings and interaction with other players. Each game element was developed with an associated in-game purpose, educational goal and game design consideration (Appendix B).

2.1.2. User interfaces

Graphic design was done from scratch for all herbs and herbal products in the game. Each herb had designs for its regular, growing, and fully grown form, as well as for each of its possible products (Appendix C). Sketches were done using Illustrator CS6 and coloured using Photoshop CS5. All game graphics assets were prepared for use at Quad HD (2560 × 1440) resolution, with the ability to scale to 4 K (3840 × 2160) resolution. Stock vector graphics licensed from Shutterstock (https://www.shutterstock.com/) were used as a base for the creation of graphics for the map, characters and user-interface elements.

The code for the game was written in-house using the Lua programming language and compiled using Corona software development kit (SDK) (Corona Labs, Palo Alto, CA) to produce the Android application package (APK) for android-based mobile phones and the iOS App Store Package for iPhones.

The in-game music was an original composition using ScoreCloud (DoReMIR, Stockholm, SE) for music notation and Musical Instrument Digital Interface (MIDI) output. The MIDI output was recorded using Audacity (Audacity, Pittsburgh, PA). Five instrument tracks (marimba, woodblock, cello, pan flute and ocarina) and two percussion tracks were mixed. Balance, equalisation, normalisation, tempo and reverb audio enhancement were performed on the audio tracks.

2.1.3. Database development

A list of commonly used herbs was compiled from the US,[1,3] Australia,[27] Singapore,[2] Europe and China.[28] The Natural Medicines Comprehensive Database (NMCD) effectiveness rating was used to check the effectiveness of each herb. Herbs that scored "possibly effective" or higher on the effectiveness rating were selected for the game. A total of 15 herbs covering 9 indications were selected for the game. Data on the herbs' indications and adverse reactions was obtained from NMCD and the National Center for Complementary and Integrative Health (NCCIH).

2.1.4. Server development

A server was set up to manage player registration, user authentication and multiplayer functions of the game, as well as data for a post-game survey. User credentials, demographic data, survey data and background gameplay data was collected and stored in the server. A website containing the registration page, post-game survey, user support and privacy policy pages was set-up using HTML (HyperText Markup Language), CSS (Cascading Style Sheets), Javascript, PHP (Hypertext Preprocessor) and MySQL (My Structured Query Language). The server communicated with the game using Hypertext Transfer Protocol (HTTP) requests for game functions, user accounts, and administration of the game. Secure Hash Algorithm (SHA-512) was employed for encryption.

2.1.5. Distribution

The file size of the mobile game was reduced from 151 megabytes (MB) to 22.8MB through compression. Lossy compression was performed on the graphics data using pngquant (https://pngquant.org/, OR8 format), followed by lossless compression using opting 0.7.6 (http://optipng.sourceforge.net/). Audio was compressed using LAME (http://lame.sourceforge.net/) using variable bit rate (VBR) quality 7 (80–120 kbps), fast variable speed and joint stereo settings.

Data communications between smartphone and server were optimized for minimal data usage. Data uploads were grouped and scheduled to reduce data usage and avoid data point loss if networking issues occurred on the smartphone. The game and server were built to automate data uploads during gameplay without the user manually sending data or uploading log files.

A web domain was registered for the game. The Android and iOS files were hosted on Google Play and Apple TestFlight platforms. Distribution of the game during the pilot usability study was done using a private link to control participation. Fig. 1 shows a flowchart summary of the game development process.

2.2. Pilot usability study

A registration form was sent out to a convenience sample of 70 students (Fig. 2). The form collected registration information (username, password, e-mail), demographic data (ethnicity, age, gender, country, city/state, educational background, phone operating system), gaming parameters (frequency, characteristics, preferences) and prior use of, knowledge and interest in herbal medications.

The Android version of the game was used for the pilot usability study. Android phone owners who completed the registration form were provided with a hyperlink to Google Play to download "Herbopolis" on their smartphones. A unique hyperlink to the post-game survey was made available to each player through a notification on their smartphone one week after they first installed the game. The post-game survey collected bug reports, suggestions for improvement, respondents' answers to evaluation heuristics and quiz questions.

A set of 17 true/false evaluation heuristics questions spanning 4 categories (usability, educability, mobility, playability) were used to evaluate the "Herbopolis" game.[18,29–36] In addition, 5-point Likert-