Design and Development of a Serious Game for Medical Training in Cytopathology

Dan C. Rotaru  
Complutense University of Madrid  
C Profesor Garcia Santemasases 9,  
28040 Madrid, Spain  
+34 692 682 845  
drotaru@ucm.es

Baltasar Fernandez-Manjon  
Complutense University of Madrid  
C Profesor Garcia Santemasases 9,  
28040 Madrid, Spain  
+34 609 232 095  
balta@fdi.ucm.es

Avni Katri  
LCS Massachusetts General Hospital  
50 Staniford Street  
Boston, MA, 02114, USA  
+1 (617) 726-3909  
amkhatri@mgh.harvard.edu

Rosemary H. Tamboret  
MGH & Harvard Medical School  
Boston, MA, 02115, USA  
+1 (617) 726-3909  
rtamboret@mgh.harvard.edu

We are designing and developing a serious game for cytopathology medical training. This game has some challenging technical requirement as to be deployable both in PCs and in low-cost Android tablets (e.g., 50$ Kindle Fire 7 tablet) with a limited budget. We reviewed some of the existing games or gamified e-learning modules to create a shared understanding between medical experts and developers about possible game mechanics and to identify which of those approaches can be suitable for our case.

There are numerous examples of games and game-like approaches successfully used in education. Those games are called “serious games” as their main goal is not only entertainment. Serious games for health have been increasingly used in the past years and there are examples in very different areas as games targeted at HIV prevention education, cancer diagnosis, dental pain, etc. and both for training medical personnel or oriented to patients [2].

In our project we want to create an educational game that can be used as a supplement to content for an Introduction to Cytopathology course. But, the use of serious games to train medical personnel in cytopathology is still a relatively uncharted field. Our project has a limited budget and some challenging technical requirements as the game should be also aimed to train cytologists in resource-limited areas of the world. That means, for instance, that the game should run in low-cost Android tablets and be fully functional without requiring continuous Internet connection.

The educational approach is focused on training the medical personnel in medical microscopy. The ability to morphologically identify normal and abnormal cells and to locate rare abnormal cells among many normal-appearing cells is the most difficult for cytotecnology students and pathology residents to learn. The learning objectives are to be presented in a gamified way, offering exciting, innovative, and effective methods for increasing the knowledge of the learner. Knowing which story and game characteristics (e.g. game mechanics) appeal to specific types of people would help tailor game design and behaviour change procedures to maximize effectiveness.

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the Owner/Author.

Copyright is held by the owner/authors.

DH ’16, April 11-13, 2016, Montreal, QC, Canada  
ACM 978-1-4503-4224-7/16/04  
http://dx.doi.org/10.1145/2896338.2896371

Furthermore, implementing the gaming platform must be done taking in consideration different key technical project requirements such as the target resolution for Android tablets and PCs, code maintainability, applications design, etc.

A specific analysis of serious games for medical training was needed to obtain specific game mechanics that could be useful for our project. For instance, in our case all the assets of the game must be packed with the game and cannot be downloaded dynamically, which may imply size-related concerns for the Android version of the game. Most existing games use an Internet connection (not suitable for our project) and are executed on PCs where the size of the game and its assets did not pose a technical problem. We decided to review specific games and applications that have been used in medical education to train expert and non-expert personnel in domains relying on medical microscopy.

MalariaSpot is a game-like application oriented for crowd sourced collaboration in the diagnosis of malaria done by non-medical experts [1]. The objective of this game mechanic is to tag in a given amount of time as many intracellular parasites as possible in an image of a peripheral blood smear. There is an initial introductory mini-tutorial screen explaining what a parasite is and what is not and how to interact with the image. During the game, if the player finds all the parasites of an image in the allocated time, a new image will be loaded up. Each image should be considered as a level of the game, therefore, a player can analyze several images (levels) in a single game. There are several game mechanics to reinforce the player engagement. Firstly, the players receive continuous feedback. For instance, each click is represented with an icon that indicates a correct or incorrect selection. Furthermore, if a player misidentifies a target and clicks in the wrong one (e.g. on a leukocyte) the penalty is a reduction of the remaining time available and the final score of the level. The players’ score is tracked on a leader board.

In our case, image size may pose a technical problem for the tablets video memory, especially if the image is very large. A possible solution can be to slice the image in multiple tiles that are used to render the entire map. The tiles can be loaded and unloaded from the graphic memory dynamically as they are shown in the screen or hidden.

The Cytopathology virtual microscopy adaptive tutorials (VMATs) use an adaptive e-learning platform that includes whole slide images for pathology education and training of both students and specialists [6]. VMATs are designed to “adapt” to the user’s decision-making and aid with possible misconceptions through immediate feedback. The gameplay is composed of a text-based
question on one part of the screen and a related image (slide) on the
other side of the screen. There are several mechanics that provide a
game-like behavior enhancing the gamified interaction. Firstly, the
question format changes (e.g. multiple-choice, drop-down lists,
drag and drop type questions, fill-in-the-blank). Furthermore,
immmediate feedback is provided based on the learner’s responses
with more information about the quiz or about a specific area on
the slide.

The VMAT approach can be reused in our project as it is oriented
to cytopathology and it takes as a content starting point a set of
teaching slides. But VMATs are only for PC and rely on a
continuous Internet connection as data is continuously collected
from these interactions for adaptive purposes and to provide
evidence about the effectiveness of the quizzes. The size of the slide
image may also present technical problems for the tablet hardware.
A possible solution is to reduce the size of the slides to an
acceptable level. VMATs were created using an intelligent tutoring
system called AeLP (Adaptive eLearning Platform) that is
completely web-based and eases the development of adaptive
learning materials. Even though there are several applications and
simulations created using the AeLP (e.g. VMATs or the Western
Botting vLAB [4]), those applications do not meet the requirements
of our project, since they rely on a stable Internet connection and
are not optimized to be displayed on low cost Android tablets. But
of course there are some design choices that can be reused. For
instance, the way to integrate introductory information inside the
formative experience, how the tasks are associated with questions
and how different media is embedded within the user interface (e.g.
interactive images) to enhance the student learning.

BioGames is a training game that helps identify malaria infected
cells [3]. The game has an introductory tutorial and challenges the
player to identify infected and uninfected cells. For each level a set
of cells is displayed to the player. The player has to label the
available cells either as “positive”, “questionable” or “negative”.
Players receive a score depending on their performance labeling
cells. There is also a progress bar as a visual feedback and the
players’ top scores are integrated with a leaderboard system to
promote competition and to improve engagement. Furthermore,
this type of game mechanics can be easily integrated with an
analytics tracking system to collect useful interaction data.

To reuse a similar approach in our game we must consider the size
of the final game. Since all the images must be packed inside the
game (cannot be downloaded dynamically), the number of cell
images available to the player might increase the size of the game
different challenges (i.e. levels) that can be measured to assess the learner’s progression. A challenge, in its
simplest form, could be a multiple choice question about a concept,
an image or a specific region of an image where the user should
identify if there is any anomaly or special circumstance. There
could be a set of challenges, questions or puzzles from which a
randomized sample is taken every time the learner starts playing a
session. The challenges may also vary in difficulty as the learner
advances and could have a gamification metric associated
(allowing the creation of rankings between players) increasing the
content diversity for each gameplay session. This design presents
the content as a progression of events - initial story, basic concepts
description, progressive challenges - that can be easily understood
by the player. The initial story provides a supporting narrative
meant to address the learner’s motivation and interest. This initial
design should be aligned with the specificities of our project.

Some of the analyzed systems capture user interaction data with
different purposes (e.g. adaptation, leaderboard) and we consider
that this is the correct approach even if in our case the game
deployed in tablets cannot rely on a continuous Internet connection.

To conclude, we believe that the review done and the conclusions
obtained about designing serious games for medical training in
Cytopathology provide a solid ground for developing our
prototype, as part of the early stage of a PhD. Next steps in the
project are the completion of the initial prototype and the evaluation
with medical students at the Harvard Medical School.

1. ACKNOWLEDGEMENTS

The e-UCM research group has been partially funded by Regional
Government of Madrid (eMadrid S2013/ICE-2715), by the
Ministry of Education (TIN2013-46149-C2-1-R) and by the
European Commission (RAGE H2020-ICT-2014-1-644187,

2. REFERENCES

1. Miguel Angel Luengo-Oroz, Asier Arranz, and John
Frean. 2012. Crowdsourcing malaria parasite
quantification: An online game for analyzing images of
infected thick blood smears. Journal of Medical Internet

2. Elizabeth J. Lyons. 2014. Review of Games for Health:
Proceedings of the 3rd European Conference on Gaming
and Playful Interaction in Health Care. Games for Health
Journal 3, 1: 49–52.

3. Sam Mavandadi, Steve Feng, Frank Yu, Stoyan
BioGames: A Platform for Crowd-Sourced Biomedical
Image Analysis and Telediagnosis. Games for health
journal 1, 5: 373–376.

4. Patsie Polly, Nadine Marcus, Danni Maguire, Zack
Belinson, and Gary M Velan. 2014. Evaluation of an
adaptive virtual laboratory environment using Western
Blotting for diagnosis of disease. BMC medical
education 14, 1: 222.

5. Mark Schrope. 2013. Solving tough problems with

6. L. Van Es Simone, Wendy M. Pryor, Zack Belinson,
Elizabeth L. Salisbury, and Gary M. Velan. 2015.
Cytopathology whole slide images and virtual
microscopy adaptive tutorials: A software pilot.
Retrieved from
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4629310/