Learning Mathematics From History: A Case Study on Learning Support Design With History of Mathematics in GBL

Yanjun Pan, Fengfeng Ke, Seyda Uysal, Kathleen M. Clark, and Chih-Pu Dai
yp10d@my.fsu.edu, fke@fsu.edu, su17b@my.fsu.edu, kclark@fsu.edu, cd18m@my.fsu.edu
Florida State University

Abstract: Game-based learning environments with content-specific learning support have been shown to be an effective platform for mathematics education. Integrating the history of mathematics in mathematics learning is another long-advocated approach. However, learning support with the history of mathematics in game-based learning environment is largely unstudied. This descriptive, in-situ case study explores the perceptions and experiences of middle school students when using mathematics history-oriented learning support in a game-based learning environment. The current study should inform the heuristics governing the design and implementation of mathematics history-oriented learning support in a game-based learning environment.

Keywords: Game-based learning, learning support, history of mathematics

Introduction

Researchers sought the application of new and innovative techniques, tools, or platforms for mathematics education (Twigg, 2011). Game-based learning (GBL) environments were then proposed to address challenges encountered in mathematics learning and teaching. Providing content-specific learning support embedded in the GBL is regarded as a key component that influences the effectiveness of learning in GBL.

Integrating the history of mathematics (HM) is another advocated approach in mathematics teaching since researchers believe that the use of history makes mathematics lessons not only interesting but also meaningful to the students who are eager to know *hows* and *whys* about the origin of rules, theorems, formulas they use. Siu (2006) underlined the positive results on affective outcomes of the use of history in teaching mathematics, which may function as a bridge toward the cognitive processes by stimulating the affective dimensions. Additionally, the use of history as-a-tool through a module approach illustrates the intrinsic and extrinsic nature of mathematics (Jankvist, 2009). HM contributes to the contextualization of knowledge and thus potentially facilitates conceptual understanding. Demonstrating the evolutionary aspects of mathematics through history by using interactive tools such as GBL seems promising to support students' conceptual understanding (Swetz, 2000).

Despite the relatively large number of studies about the use of learning support in GBL for mathematics learning or using HM to teach mathematics, studies combining these two variables are limited. Therefore, the current study aims to explore what features can motivate middle school students to use the learning support with HM embedded in a mathematics game and how such a learning support scaffolds students in learning mathematics conceptually in a GBL environment. Specifically, we intend to address the following research questions:

1. How do middle school students perceive their experiences when interacting with the mathematics history-oriented learning support in a GBL environment?
2. What are the features of the mathematics history-oriented learning support that engage and scaffold middle school students in conceptual knowledge of ratio and proportion for problem solving in a GBL environment?

Design learning support with history of mathematics

The current study uses a multi-level, 3D architecture game E-rebuild, aiming to improve mathematical conceptual understanding and problem-solving skills for students in grades 6 through 8 by making them plan, design, and rebuild a disaster-damaged space (Ke, 2016). The participants are requested to complete each level of the design quest through the application of relevant mathematical knowledge, including ratio and proportional relationships, angle measure, surface area, volume, numerical and algebraic expressions. Therefore, the topics selected for the learning support with HM comprise geometry, numeral systems (e.g., Babylonian, Egyptians, Mayan, Ancient Chinese, and Roman), ratio and proportion, and the Pythagorean Theorem. All learning support with HM are under a "Tips" tab, which allows students to click at any time when they want such assistance. Each level of the design quest links to a specific element of learning support with HM in terms of the relevancy of the mathematical content that students are required to apply to complete the game quest. The ways in which relevant knowledge of

 © ISLS

HM are presented include text, image, animation, and video.

We used four strategies to integrate HM in the game during the development of the learning support. The first strategy is to learn history by directly presenting historical information, such as life stories, birth and death dates, and studies of famous mathematicians. This strategy emphasizes historical knowledge by familiarizing students with the context functioning as background knowledge. The second strategy focuses on the use of historical content to implicitly or explicitly teach a mathematical topic or concept by engaging students in maneuvering an illustrative artifact. An example is introducing Fibonacci's sequence by representing numbers with rabbit reproduction. The next strategy gives students an awareness that the developments of mathematical concepts are impacted by different social and cultural perspectives. This idea helps students to perceive that mathematics is developed based on discovery process in human history as opposed to invention in a single moment. For instance, examining the concept of ratio by starting from the ratio as a *magnitude* notion of ancient Greeks to the ratio as a quantity notion in modern-practical era with Hindu-Arabic roots will be supportive for students' conceptual understanding. The emphasis on the epistemological differences of the same concept is promising to help students' meaning-making of abstract mathematical concepts. The fourth strategy is to compare modern mathematical solution methods with historical ones. An example of such a learning support is the ancient Egyptians' use of hieroglyphics to represent numerals and the method of summing two or more non-repeating unit fractions to represent fractions. When students are confronted with meaningful examples and perspectives situated in the history of mathematics and GBL, a deeper understanding of unfamiliar mathematical terms should be fostered.

Methodology

We adopt a descriptive, holistic case study approach (Yin, 2003) to investigate how middle school students and teachers perceive the mathematics history-oriented learning support in a 3D game-based learning environment. The descriptive case study is used to describe an intervention or phenomenon in which it occurred (Yin, 2003). This in-situ case study enables the researchers to explore differences of a purposeful sample of middle school students. In this study, the experiences of each student will be a case. To obtain a deep understanding of students' perceptions and experiences of interaction with the mathematics history-oriented learning support in a GBL environment, we will collect data via (a) gameplay logs, (b) screen recording videos, (c) semi-structured interviews, and (d) in-field observations. Each student will play the game for 45 minutes and then participate in a 30-minute semi-structured interview. We are conducting systematic coding followed by thematic analysis of the collected data. The current study should inform the heuristics governing the design and implementation of mathematics history-oriented learning support in a GBL environment, by understanding students' perceptions of and experiences with the HM learning support.

The study is an ongoing research project, with active data collection at the time of this proposal. Thus, we will report the results at the conference.

References

Bai, H., Pan, W., Hirumi, A., & Kebritchi, M. (2012). Assessing the effectiveness of a 3-D instructional game on improving mathematics achievement and motivation of middle school students. *British Journal of Educational Technology, 43*(6), 993–1003.

Jankvist, U. T. (2009). A categorization of the "whys" and "hows" of using history in mathematics education. *Educational Studies in Mathematics, 71*(3), 235–261.

Ke, F. (2016). Designing Intrinsic Integration of Learning and Gaming Actions in a 3D Architecture Game. *Handbook of Research on Serious Games for Educational Applications*, 234-251.

Siu, M. K. (2006). No, I don't use history of mathematics in my class. Why? In F. Furinghetti, S. Kaisjer, & C. Tzanakis (Eds.), *Proceedings of HPM 2004 & ESU 4* (pp. 268–277). Iraklion, Crete: University of Crete.

Swetz, F. (2000). Mathematical pedagogy: A historical perspective. In V. Katz (Ed.), *Using history to teach mathematics: An international perspective* (pp. 11–16). Washington, DC: The Mathematical Association of America.

Twigg, C. A. (2011). The math emporium: A silver bullet for higher education. Change: *The magazine of higher learning, 43*(3), 25–34.

Acknowledgments

Research reported in this article is funded by the National Science Foundation, grant 1720533. Any opinions, findings, and conclusions or recommendations expressed in these materials are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.