

Work-in-Progress Paper—Learners’ Interaction With Task Narratives for Math Problem-Solving in Game-Based Learning

Chih-Pu Dai

Department of Educational Psychology and Learning Systems
Florida State University
Tallahassee, USA
cd18m@my.fsu.edu

Fengfeng Ke

Department of Educational Psychology and Learning Systems
Florida State University
Tallahassee, USA
fke@fsu.edu

Yanjun Pan

Department of Educational Psychology and Learning Systems
Florida State University
Tallahassee, USA
yp10d@my.fsu.edu

Zhaihuan Dai

Department of Educational Psychology and Learning Systems
Florida State University
Tallahassee, USA
zd12@my.fsu.edu

Abstract—The purpose of this work-in-progress paper is to explore the learners’ interactions with task narratives in a Game-Based Learning (GBL) environment for math problem-solving. We present a qualitative case study to demonstrate how the learners interact with task narratives in a GBL environment for math problem-solving. Three preliminary patterns were identified: (1) narrative immersion mediated math problem-solving; (2) task narratives and the game world afforded cognitive connection for math problem-solving; (3) narrative structure influenced math problem-solving. Implications and future directions are discussed.

Index terms—narratives, game-based learning, math problem-solving

I. INTRODUCTION

Story, narrative, and fantasy have been used as an element in Game-Based Learning (GBL) environments for the purpose of enhancing learning and playability [1], [2]. However, studies continue to yield inconsistent research results of narratives’ effects on GBL [1], [3]. In other words, although there is a high popularity of implementing narratives in GBL, the evidence of the effects and phenomenon of such game features (i.e., narratives) are still elusive. To be more specific, previous studies revealed a mix result in the current state of GBL literature regarding the effects of narratives on cognition and learning achievements [1]. The complexity of designs on top of intricate interactions of the learners with the design in GBL could be the reasons. Thus, this study aims to bridge the gap in the literature by exploring the design of task narratives and the learners’ interactions with this design feature in GBL for math problem-solving. This study addresses the following research question (RQ): *what are the learners’ interactions with task narratives in a game-based math learning environment?*

II. STORIES AND NARRATIVES IN GAME-BASED LEARNING

The goal of utilizing stories and narratives in GBL environment is to make the design of such features personally meaningful so that the students can use it for problem-solving and tackling the learning tasks they are experiencing [1]. Developed from the learning theories of Bruner and Vygotsky,

prior research has conceptualized and discussed the role of narratives in GBL [3]. Plass *et al.* suggested that narrative can immerse the learners in a contextual environment and connect other elements such as rewards, characters, and rules together for learning. However, they also indicated that the role of narratives can be minimal in some GBL contexts [3]. Similarly, other scholars have examined narrative-based game environments for advancing our understanding about narrative in GBL [4]. For example, Barab *et al.* advocated that game narratives can frame cognitive structure [4]. Furthermore, using *Crystal Island*, Rowe *et al.* revealed that increased engagement in the narrative-centered learning game has a significantly positive correlation with in-game problem-solving and learning outcomes [5]. Along the same line, GBL researchers are also interested in the relations between game narratives, engagement, and immersion.

As described by Nilsson *et al.*, immersion can occur when an individual interacts with the narrative in media because narrative immersion is “a product of mediated content” [6, p. 114]. In their syntheses, narrative immersion is a disposition an individual experiences that demonstrates intensive and concentrated attention to the stories, narratives, and the impending events; it provides an absorption and presence in the story world [6]. Research in immersion and narratives in GBL concerns learners’ active participation and interactive discovery in the game world and narratives [1]. However, the unique designs and the learners’ interactions, specifically in math problem-solving, are lacking in the literature which is the focus of this paper.

III. NARRATIVES DESIGN IN *eRebuild*

Logical reasoning, symbolic representations, and problem-solving are some essential skills math educators are eager to engage the students in. Our team of instructional designers, math education professionals, and computer programmers built a GBL platform called *eRebuild*. We focused on narratives in *eRebuild* in this paper. Narratives are designed via several elements including task narratives, math annotations on the game objects, measuring instruments, and interactive feedback. As reading is a predominant cause of narrative immersion, the exploration of learner interactions in this study is centered around the symbolic representation: task narratives (see Fig. 1).

We thank National Science Foundation for funding this study (grant 1720533). Any opinions, findings and conclusions are those of the authors.



Fig. 1. Example of a task narrative in *eReBuild*. (in the upper-right grey box)

IV. METHOD

This study adopts an exploratory case study method. Each participant is bounded by time and gameplay session and thus serve as an individual case. The individual sessions allowed the researchers to closely observe the human-computer interactions, thinking processes, and playing trajectories. 5 participants (P1-P5; mean age = 20.4; SD = 3.2) were purposefully selected from a research pool in a large research university in the southeastern USA based on their gaming and academic background to gather balanced and diversified information. That is, two self-identified as gamers and three self-identified as non-gamers. Among them, three were from STEM majors, one liberal arts, and one business. They played *eReBuild* for about one and a half hours followed by a half hour semistructured interview. All sessions were audio- and screen-recorded. The researcher sat next to the participants for observations and technical-support. Based on the RQ, relevant literature was reviewed to form a protocol for data collection and analysis. Eight questions representing aspects of usefulness, experience, perceived engagement, and math problem thinking processes were formulated for the interview. For example, “take one level as an example, describe how you solved it.” The data were transformed into descriptive and reflexive journals for triangulation. Inductive open-coding technique was used to analyze the data guided by the RQ and the literature. Similar codes were aggregated for three patterns reported in this paper.

V. RESULTS

A. Narrative immersion mediated math problem-solving.

In *eReBuild*, students began math problem-solving from reading the task narratives [6]. After being asked “what was the first thing you do when you are in a new episode?”, all participants said: “read the direction/guidance/instruction (i.e., task narratives).” To be specific, all participants demonstrated the same interaction with the game at the beginning of each episode. They first read the task narrative; then they were directed to the game world by the task narrative for site-surveying and math problem exploration. These learner-game interactions mediated by task narratives increased learning engagement for *doing math*. In other words, the mediation afforded by the task narratives created immersion and absorption in the game world for the learners. “I feel like I am in the game...yeah...it’s like... a task, it tells you what to do...you just have to finish it...” (P5).

B. Task narratives and the game world afforded cognitive connection for math problem-solving

Learners’ interactions with the task narratives also relate to framing learners’ cognitive schema for math problem-solving.

For example, in an episode, learners have to “build a wall...blocks can be bought from the store.” As observed, after reading the task narrative out loud, P2 mentally organized information and then confirmed the resources she found in the game world to form a solution. She looked for the information of the size of the blocks and calculated the amount of blocks needed for the wall-building task. This connection suggests that narrative designs in games are architectural-based designs [2]. It was within the context of the game for the task narrative to facilitate math problem-solving.

C. Narrative structured math problem-solving

The data revealed that task narratives structure can influence learners’ interaction with the game. For example, in one episode, the task narrative provides structured information needed for assigning students to rebuild classrooms: “...31 students: 5 in computer class, 8 in math, 18 in writing. Each subject requires a different area: computer requires 6m², math requires 3m², writing requires 1m².” Being interviewed, P4 recalled her own experience of designing learning activities when discussing on the task narrative design: “we like to give them a few things to get used to...like...the environment...then start...actual problem-solving component of the game.” P4 suggested that the task narratives can be designed to adapt to students’ diverse abilities. Structured narratives would be within novices’ capabilities; ill-structured narratives will foster advanced students’ problem-solving skills.

VI. DISCUSSION AND CONCLUSION

This paper explored task narrative designs and learner interactions in a math problem-solving learning game. The results illuminate multiple design implications based on the learner-game interactions that revolved around task narratives. First, we found that task narratives support game immersion. Second, task narratives and game designs are an integral architecture to build cognitive frameworks for the learners. Third, narrative structure should adapt to learners’ capabilities. The results confirmed the conjecture in previous literature [3], and inform specific domain: math. Future research should further experimentally investigate the effects of task narratives on learning engagement, immersion, and learning outcomes.

REFERENCES

- [1] F. Ke, “Designing and integrating purposeful learning in game play: A systematic review,” *Educ. Technol. Res. & Develop.*, vol. 62, no. 2, 2016, pp. 219–224.
- [2] H. Jenkins, “Game design as narrative architecture,” In *First Person: New media as story, performance, game*, N. Wardrip-Fruin & P. Harrigan, Eds., Cambridge: MIT Press, 2004, pp. 118-130.
- [3] J. L. Plass, D. H. Bruce, and K. K. Charles, “Foundations of game-based learning,” *Educational Psychologist*, vol. 50, no. 4, 2015, pp. 258-283.
- [4] S. A. Barab, M. Gresalfi, and A. Ingram-Goble, “Transformational play: Using games to position person, content, and context,” *Educational researcher*, Vol. 39, no. 7, 2010, pp. 525-536.
- [5] J. P. Rowe, L. R. Shores, W. M. Bradford, and J. C. Lester. “Integrating learning, problem solving, and engagement in narrative-centered learning environments.” *Int. J. Artif. Intell. in Educ.* Vol. 21, no. 1-2, 2011, pp. 115-133.
- [6] N. C., Nilsson, R. Nordahl, and S. Serafin. “Immersion revisited: A review of existing definitions of immersion and their relation to different theories of presence.” *Human Technol.* vol. 12, no. 2, 2016, pp. 108-134.