THE IMPACT OF NARRATIVE-BASED GOALS IN A GAME-BASED LEARNING ENVIRONMENT

J. Nietfeld[1], A. Sperling[2]

[1]North Carolina State University (UNITED STATES)
[2]The Pennsylvania State University (UNITED STATES)

Abstract

Effective self-regulated learning (SRL) relies upon the selection, monitoring, and regulation of goals. Yet, surprisingly the impact of goals has been understudied in game-based learning environments (GBLEs). In more complex GBLEs a sustained goal-driven focus is critical for learners to attain improved learning outcomes. Therefore, the current study focused on the selection of in-game narrative-based goals presented in MISSIONS WITH MONTY, a GBLE targeting science literacy skills for Grade 5 students (*N* = 154) using informational science texts. Results revealed that a mastery based in-game goal was a significant predictor of posttest science knowledge even after accounting for mastery goal orientation, science self-efficacy, and prior knowledge. Alternatively, an in-game game goal focused on obtaining badges was a significant negative predictor of performance on an in-game multiple source comprehension measure after accounting for mastery goal orientation, science self-efficacy, and prior knowledge. Implications for goal selection and the inclusion of goal tracking in GBLEs are discussed.

Keywords: Game-based learning, achievement goals, science, reading.

1 INTRODUCTION

Digital game-based learning is being increasingly employed in educational learning environments and has been shown to have a positive effect on learning outcomes [1]. Educators are turning to game-based learning environments (GBLEs) not only in the hope of improving learner motivation but also to provide customized practice, immediate and timely feedback, and scaffolded strategy use [2]. Importantly, as research on GBLEs advances, there is a need to examine process-related data as learners interact with GBLEs. This would allow for the improved development of GBLEs particularly when considering real-time scaffolds that could be integrated in the program.

One of the most comprehensive theoretical approaches for this perspective is self-regulated learning (SRL). SRL is a complex process that considers learners' strategies, metacognition, motivation, and affect in the learning process [3] [4]. It involves the effective regulation of one's own learning in the pursuit of personal goals [5]. One critical component within the study of SRL is to allow for a degree of autonomy within the learning process in order to give the learner opportunities to practice their regulation [4]. In addition, in order to be able to understand and subsequently track the ability of learners to self-regulate, it is important to know the goals that learners have chosen as a focus of their regulation. Interestingly, very little is known about how learners select and then regulate their goals in GBLEs at this time [6].

Goals can be examined in a number of different ways in GBLEs. They can be measured via general self-report inventories before, during, and after gameplay, assessed via self-report for specific game goals before or during gameplay, or be assigned to the players within the game narrative or game instructions before or during gameplay. Chen et al. [7] included a goal setting version and a negotiated goal setting version of a game to teach programming with adults. The negotiated version involved the system intervening for goal selection and strategy selection when there were discrepancies with learning performance. The authors found the negotiated version produced better learning traces and regulation. Yang et al. [8] explored the impact of performance goals within an English learning game and found that university students with higher performance approach goals outperformed those with higher performance avoid goals. However, both groups had similar gain scores after playing the game. In an immersive classroom-based GBLE for Grade 8 students, Nietfeld and Hoffmann [6] found that assigned mastery goals led to greater enjoyment and higher monitoring ratings than assigned performance goals while also finding that pre-existing self-report mastery goals led to greater game enjoyment. Syal and Nietfeld [9] found trace measures to be better predictors of game performance and science knowledge than self-report achievement goals for Grade 5 students in an immersive classroom-based GBLE.

The current study attempted to fill in some gaps in the existing literature by examining the specific goals that children, in this case in Grade 5, chose while playing a GBLE and how these goals then predicted learning and performance outcomes. The GBLE that was employed, *MISSIONS WITH MONTY* (see Fig. 1), has been found to have a significant impact on reading comprehension, science learning, and metacognitive calibration for Grade 5 students after approximately six weeks of interaction [10] [11]. In MISSIONS WITH MONTY the player fills the role of a promising young science professor traveling to work with Monty, a monitor lizard and world-renowned scientist known for his ability to solve real-life problems. Monty has created Wildlife University (WU) in a remote rainforest where students and professors (all animal characters) conduct research on saving their natural habitats. Unfortunately, upon arrival at WU the player realizes that 1) WU has been recently closed due to animals getting sick and 2) Monty has gone missing and is tasked with solving these two dilemmas. MISSIONS WITH MONTY includes three key curricular units (ecosystems, Earth and human activity, from molecules to organisms) that align with state and national standards.

Once the player is clear on the overall game narrative and problems they visit research sites with animal scientists that are composed of mini-games clustered by content-related texts. The texts within each site vary both in length and structure, as some are topical and informative, and others will require interpretation of data, charts, and graphs. At each site players independently read texts before undergoing challenges to check for understanding. Responses from summarization, knowledge, and multiple-source comprehension challenges are assessed and translated into categorical game-based scores as badges and be presented in Mission Progress screens as feedback.

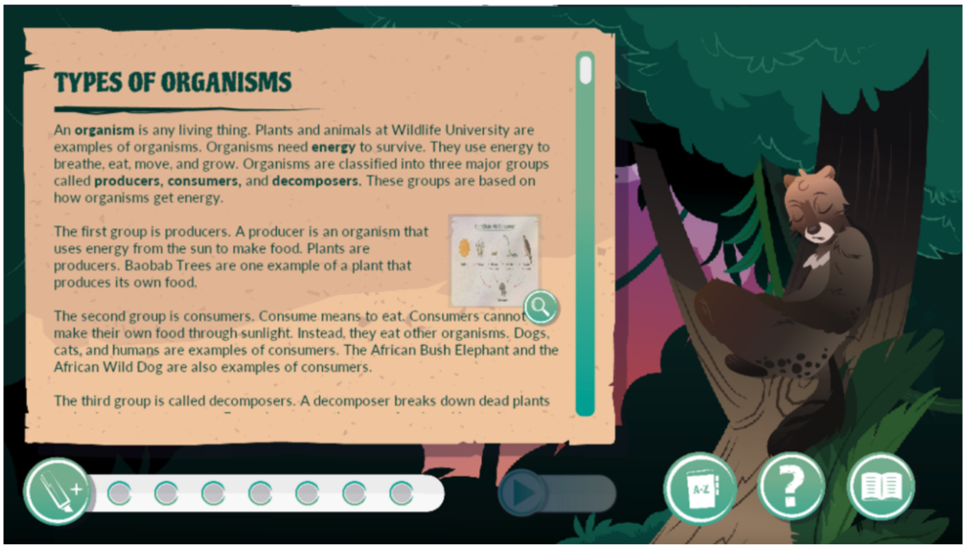

Figure 1. Missions with Monty text interface.

The primary research question in the current study was *how do in-game goals impact science learning*? To answer this question we decided to use a stringent test of the potential contribution of goals by also controlling for prior knowledge, offline science-self-efficacy, and offline mastery-approach goals. Given the rigor of this approach to observe unique variance contributions coupled with the lack of related research in the existing literature it was difficult to make firm hypotheses. Literature supports contributions of both performance-approach [8] and mastery-approach goals [6] however this has been understudied within the context of games and also while parcelling out other key knowledge and motivational variables. Secondary analysis examined the impact of in-game goals on in-game performance metrics including knowledge challenges, summary challenges, and multiple-source challenges.

2 METHODOLOGY

2.1 Participants

Fifth-grade students (ages 10-11) from two schools in North Carolina, USA participated in the study. Demographic totals at these two schools were: 48% White, 14% Black or African American, 28 % Hispanic or Latin American, <1% Native American/Pacific Islander/Alaskan Native, 8% two or more races, and <1% Asian backgrounds.

2.2 Materials

Before gameplay participants completed a set of instruments including a science knowledge test, a measure of science self-efficacy, and a measure of achievement goals. The science knowledge test consisted of 20 items and was derived from released test items from national and international tests related to the curriculum in the game. It was administered before gameplay as a measure of prior knowledge and again after gameplay as a measure of posttest knowledge. The content was aligned with the passages in the GBLE along with the state curriculum and included both declarative and conceptual level items. A sample knowledge item included: A lizard's tail breaks very easily. How does this help to protect the lizard? a) The lizard can leave pieces of its tail to mark its territory; b) During a food shortage, the lizard can break off its tail and eat it; c) The lizard can leave broken pieces of tail to fool predators; or d) The lizard's tail can break off if a predator attacks. Items were included at both the declarative and conceptual levels.

The Patterns of Adaptive Learning Scales (PALS) [12] were administered to measure achievement goals and, more specifically, we focused on the mastery goal orientation subscale. Five mastery goal items (α = .85) were included with responses provided on a five-point Likert scale. A sample item was "I like school work that I'll learn from, even if I make a lot of mistakes."

The science self-efficacy measure consisted of 10 seven-point Likert scale items (α = .91) and was created by the research team. The measure was specific to the curriculum in the GBLE and students answered with their judgment to "learn about . . . " each topic (e.g., ecosystems, energy in living things, how plants grow, etc.).

In addition to these offline measures students were asked to select how important each of six different goals (see Fig. 2) were while they were playing the GBLE. After students had the opportunity to read an initial text and engage in the subsequent challenges, a character posing as a local reporter asked for the students' goals as they navigated through their game missions. The items were created to represent both approach and avoidance goal orientations as well as non-task related goals. Mastery approach items were represented by "Discovering what's making the animals sick", "Getting all the important information to solve the problem", and "Finding Monty." Performance-approach goals were represented by "Earning more badges." Performance-avoidance goals were represented by "Avoiding performing poorly" while "Meeting new characters" represented a non task-focused goal.

Figure 2. Missions with Monty in-game goal selection.

Three in-game metrics were used as performance measures and included game challenges focused on knowledge, selection of summaries, and multiple source understanding. As students navigated through the GBLE they encountered various animal researcher characters who would present them with their research in the form of informational text passages. The passages ranged from 250 to 350 words with

Flesch-Kincaid levels ranging from 4 to 7. Following each text passage, students engaged in a series of challenges related to knowledge and summarization. Periodically, they were also challenged to display their multiple-source understanding within the game context. Students received badges depending upon their performance levels for the in-game challenges. As the game progressed students attempted to determine the source of the illness at WU by saving critical information and understanding gained from the text passages to a detective board that they could submit when putting forth a solution hypothesis. The knowledge challenge consisted of multiple-choice items written at two levels: declarative and conceptual. The summary challenge required students to select the best summary from three options. Finally, the multiple source challenges were created with a drag and drop format and required students to apply knowledge gained across multiple texts encountered in the game. For instance, one asks the student to: *Select the food web that correctly represents the trophic levels. Identify the trophic level that has the most energy. Suppose the grasshopper dies. Select all the organisms that will need to find a new source of energy and food*. All passages and assessment items were created by the research team, reviewed by participating teachers, and then subjected to a validation study with students (*N* = 330) from four schools. Given that students varied in the number of challenges that they were able to complete, mean scores were used in the analysis.

2.3 Procedure

Students played MISSIONS WITH MONTY within the context of their normal classroom instruction. Teachers were instructed to aim for having students play for approximately 45 minutes two times per week across six weeks. However, due to scheduling constraints this varied to some extent across classrooms.

3 RESULTS

Descriptive statistics for the major study variables are included in Table 1. As a whole students made a significant improvement in their science knowledge from pretest to posttest ($t_{(89)} = -9.72$, $p < .001$; Cohen's $d = 1.02$). Bivariate correlations of study variables are presented in Table 2. In order to determine predictors to be used in regression analysis variables showing significant correlations with the posttest science measure were selected.

Table 1. Means and standard deviations for key study variables.

Variable	*M*	*SD*
Science content pretest	10.30	3.74
Science content posttest	13.21	3.94
Goal: Avoiding performing poorly	4.09	1.38
Goal: Discovering cause of sickness	4.56	.89
Goal: Earning more badges	4.32	1.12
Goal: Finding Monty	4.71	.71
Goal: Get science information to solve problem	4.49	.85
Goal: Meeting new characters	3.93	1.32
Science self-efficacy	44.01	16.73
Mastery goal orientation	19.47	6.79

Table 2

Bivariate Correlations Among Observed Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Science content pretest	-												
2. Science content posttest	.68**	-											
3. G: Avoid perform poorly	-.16	-.12	-										
4. G: Cause of sickness	.22*	.35**	.02	-									
5. G: Earn more badges	.12	.18	.26*	.08	-								
6. G: Finding Monty	.02	-.02	.04	-.01	.08	-							
7. G: Important information	.14	.19	.00	.08	.23*	.41**	-						
8. G: Meeting new characters	-.17	-.10	.59**	.17	.32**	.26*	.17	-					
9. Mastery approach	.35**	.26*	-.09	-.04	-.03	.01	.25*	-.12	-				
10. Science self-efficacy	.41**	.34**	-27*	.14	.01	-.02	.08	-.18	.61**	-			
11. Knowledge Challenge	.74**	.73**	-.18	.19	.00	-.09	.09	-.23*	.20	.34**	-		
12. Summary Challenge	.26*	.18	.06	.06	.03	-.06	.04	-.02	.17	.23*	.24*	-	
13. Multiple Source Challenge	.32*	.30*	-.16	-.05	-.27*	-.04	.14	-.15	.18	.10	.32*	.05	-

* $p < .05$, ** $p < .01$

In order to answer the primary research question a multiple regression with performance on the posttest science measure as the outcome measure was conducted (see Table 3). Predictor variables included the science pretest as a measure of prior knowledge, the PALS mastery goal orientation scale, science self-efficacy, and finally the in-game goal "discovering what's making the animals sick." Results indicated that the in-game goal related to determining the cause of the sickness was a significant predictor of posttest science knowledge even after accounting for prior knowledge, mastery goal orientation, and science self-efficacy. As would be expected, prior knowledge was the strongest predictor overall.

Table 3. Multiple regression predicting post science knowledge.

	(N = 90)		
Predictors	*B*	*SE*	β
Science prior knowledge	.65	.09	.61***
Goal: Discovering cause of sickness	.94	.35	.21**
Mastery goal orientation	.03	.07	.04
Science self-efficacy	.01	.03	.04
R^2		.51	

Note. ** < .01, *** < .001.

In order to examine the predictive power of the in-game goals on in-game performance measures the bivariate correlations were examined. With regard to predicting performance on the knowledge challenges a significant negative correlation (r = -.23) was found with the goal "meeting new characters." However, when entered into a multiple regression as a predictor it did not produce significant variance over and above science prior knowledge, mastery goal orientation, and science self-efficacy. None of the in-game goals were significantly correlated with summarization challenge performance. Finally, the in-game goal "earning more badges" showed a significant negative correlation (r = -.27) with performance on multiple source challenges. This goal was then entered as a predictor in a multiple regression analysis to predict multiple source challenge performance while also simultaneously considering science prior knowledge, the PALS mastery goal orientation scale, and. science self-efficacy (see Table 4). Results revealed that the in-game goal related to earning more badges was a significant negative predictor of posttest science knowledge even after accounting for prior knowledge, mastery goal orientation, and science self-efficacy.

Table 4. Multiple regression predicting post multiple source challenge performance.

	(N = 90)		
Predictors	*B*	*SE*	β
Science prior knowledge	.12	.04	.37**
Goal: Earning more badges	-.34	.12	-.33**
Mastery goal orientation	.03	.03	.11
Science self-efficacy	-.01	.01	-.09
R^2		.22	

Note. ** < .01.

4 CONCLUSIONS

The examination of student real-time goal selection in GBLEs has been understudied but may have important implications for understanding student self-regulation and performance outcomes. The current study examined the predictive power of in-game goals in the MISSIONS WITH MONTY GBLE to impact science learning and in-game performance. Findings revealed that the choice of specific goals lead to varying predictive patterns. For instance, selection of the mastery-based goal of discovering the cause of the sickness occurring in the game narrative predicted higher performance on the posttest of science knowledge. Alternatively, selection of the in-game goal of earning more badges predicted lower performance on challenges leading to multiple source integration.

These findings have important implications for the development of GBLEs and also potential real-time scaffolds that might be incorporated into such GBLEs. The current study is simply an initial step that has determined that in-game goals might influence learning and performance outcomes. Variations of the types of goals assessed in the current study should be replicated and customized to fit other GBLEs to determine how the findings generalize. A corpus of findings might then inform designers of GBLEs of the types of goals that should be encouraged through game scaffolds. Findings may also impact the narratives behind games and the roles that players assume when they play games. Further research is needed to examine if the impact of specific goals is consistent across different types of learners (e.g., high and low prior knowledge, varied motivational profiles, etc.). In addition, multiple goal adoption and goal shifting should be examined over time within extended gameplay. The current study was limited by a single measure of in-game goals and should lead to follow-up examinations with multiple measures over extended periods of time.

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