Chapter 21
Emotional Agents in Educational Game Design:
Heroes of Math Island

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ABSTRACT

Evaluating the subjective playing experience and engagement in learning is important in the design of advanced learning technologies (ALTs) that respond to the learners' cognitive and emotional states. This article addresses students' attitudes toward an educational game, Heroes of Math Island, and their responses to the emotional agent, an animated monkey. Fifteen students (seven boys and eight girls) from grades six and seven participated in this quasi-experimental study (pretest, intervention, post-test, followed by post-questionnaire and interview). This research presents a detailed analysis of students' subjective reactions with respect to Heroes of Math Island and to the underlying mathematics content, their learning gains and emotions triggered during gameplay, and design issues resulting from the evaluation of the game and of its emotional agent. The findings from this study inform how ALTs and educational games can be designed in order to be effective and provide emotional engagement, enjoyment, and learning.

1. OBJECTIVES

Educational games have a range of cognitive, emotional, motivational, and social benefits (Carvalho et al., 2015; Crookall, 2010; Ge & Ifenthaler, 2018). Video games designed to enhance or simulate educational experience are, in other words, advanced learning technologies (ATLs) (Conati, Jaques, & Muir, 2013; Rodrigo, et al., 2012). According to Aleven, Beal, and Graesser (2013), ALTs "provide a high degree of interactivity, reflecting a view of learning as a complex, constructive activity on the part of

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learners that can be enhanced with detailed, adaptive guidance" and are capable of assessing or tracking learners' experiences, including learning strategies and affective states (pp. 929-930).

In "Why Games Don't Teach," Clark (2013) argued that "advocating games as a main or even frequent instructional strategy is misleading" and encouraged the development of a "taxonomy of games or game features that link to desired instructional outcomes" (p. 10). She noted the "insufficient well-designed experimental research on which to base many conclusions" (Clark, 2013, p. 1). Downsides are reported in literature, such as the appeal of video games as entertainment (Persico, et al., 2018) and the lack of correlation between playing video games as leisure activities and school cognitive tests, i.e., comprehension, math, school knowledge, and reasoning tests (Lieury, Lorant, Trosseille, Champault, & Vourc'h, 2016). Although Clark's argument for better alignment of game design with learning outcomes is valid and downsides should be considered, the educational literature presents evidence of the effectiveness of game-based learning (GBL) (de Freitas, 2013; Ge & Ifenthaler, 2018; Kiili, Ketamo, Koivisto, & Finn, 2014; Hosseini & Mostafapour, 2020; Partovi & Razavi, 2019; Spires, Rowe, Mott, & Lester, 2011). In a study that explored primary school children's technology acceptance, Camilleri and Camilleri (2019) reported that students recognized the usefulness and relevance of educational games played at school. However, important shortcomings result from design focused on content, as designers of educational games often "develop products that miss the most essential mechanism of engagement in games— the fun" (Granic, Lobel, & Engels, 2014, p. 74).

This article is derived from a larger study that involved the design and implementation of an educational game titled *Heroes of Math Island* (Gutica, 2014). Using design-based research (DBR), the larger study explored students' emotions during gameplay, learning gains, as well as their subjective attitudes towards the game and learning. We address in this article the following research questions:

- What are the students' subjective reactions to *Heroes of Math Island*?
- What are their emotional responses to the game and emotional agent?
- What are their levels of interest and achievement in the mathematics content after gameplay?

2. THEORETICAL FRAMEWORK

In this article, "affect," "affective state," and "emotion" are used interchangeably. Many contemporary scientists and theorists define emotion in a context of cognition and motivation (LeDoux, 1995; Ortony & Turner, 1990; Plutchik, 1984; Rolls, 1995). According to LeDoux (1996), "once emotions occur they become powerful motivators of future behaviors. They chart the course of moment-to-moment action as well as set the sails toward long-term achievements" (p. 20). The relationships between emotion and learning are varied and complex (Petrina, 2007, pp. 53-90). Astleitner (2000) empirically validated his theoretical instructional design approach employing five emotions— fear, envy, anger, sympathy, pleasure (FEASP)— and demonstrated the existence of a significant correlation between sympathy-related and pleasure-related instructional strategies and corresponding emotions in learners. Hascher (2010) stated that a positive environment is an "optimal precondition for holistic and creative thinking as it does not force the learner to cope with the situation but enables open-mindedness" (p. 15). However, this is a simplistic approach and the "valence of a mood or an emotion (being positive or negative) is only one aspect of its quality" (Hascher, 2010, p. 16). Educational research is well served by empirical and theoretical studies of emotion and learning (Astleitner, 2000; Ingleton, 2000; Hascher, 2010; Pekrun & Linnenbrink-Garcia, 2014).

Several researchers in the affective computing field argue that the only way to respond users' needs is to prompt them to sense and respond to cognition and emotion (Norman, 2005; Picard, 1997; Picard & Klein, 2002; Scherer, 2009). Past research on intelligent tutoring systems (ITSs) tended to privilege cognitive over affective needs by emphasizing cognition and "marginalizing affect" (Woolf, et al., 2009, p. 129). However, attention to emotion has been increasing (Baker, D'Mello, Rodrigo, & Graesser, 2010; Derbali, Ghali, & Frasson, 2013; Rodrigo, et al., 2012; Jaques, Conati, Harley, & Azevedo, 2014; Azevedo, Taub, Mudrick, Farnsworth, & Martin, 2016) (Schuller & Schuller, 2018; Tettegah & Gartmeier, 2016). Emotional agents (Scheutz, 2002) respond to learners' affective states, for example a child animation showing emotional facial expressions to provide motivational adaptive scaffolding in Ecolab (Rodrigo, et al., 2008) and "Scooter the Tutor" a dog animation designed to reduce "gaming the system" in Scatterplot Tutor (Rodrigo, et al., 2012, p. 226). Schuller and Schuller (2018) note that these agents are typically designed for "emotional recognition, augmentation, and generation" (p. 41). As several evaluations of pedagogical agents produced ambiguous results, attention should be shifted to "socio-emotional and relational variables" by complementing measures of learning outcomes with process measures, which are sensitive to the "situational demands" of interaction (Krämer & Bente, 2010, p. 71).

The design of affect-sensitive ALTs or emotional agents is complex as designers need to understand "cognition, emotions, motivation, aesthetics, communication, social interactions, sociology and technology" (Graesser, D'Mello, & Strain, 2014, p. 473). Although there is a large number of affect recognition and response studies, these studies tend to overlook learners' attitudes and subjective reactions during interaction with the learning environment. Designing for the appraisal and augmentation of emotions is quite challenging, as we explain.

3. DESIGN CONSIDERATIONS, METHODOLOGY AND PROCEDURE

This study consisted of three stages: (1) design of the game; (2) quasi-experimental study (pretest, intervention, post-test, followed by post-questionnaire and interview), and (3) affect analysis (emotion-labeling process and video annotations) performed by two trained judges (Gutica, 2014). The affect analysis and framework used to define the emotions analyzed in this study are described in details elsewhere (Conati & Gutica, 2016; Gutica & Conati, 2013). This article focuses on the quasi-experimental, post-questionnaire, and interview data. We also triangulate our results with affect analysis.

3.1. Game Design

Heroes of Math Island was designed on a gaming platform (Microsoft XNA) in consultation with two game designers. This allowed the implementation of rich game mechanics comparable to that of commercial video games. As we wanted to target an age group that enjoys playing games and is developmentally in a process of learning complex mathematics concepts, we designed the game for grades 5-7 students. Additionally, several other studies targeted the same age group (Conati & Maclaren, 2009; Conati & Manske, 2009; Rodrigo, et al., 2008; Rodrigo, et al., 2012). The math content (number factorization) was based on the curriculum taught in British Columbia (BC), Canada (BC, Ministry of Education [MoE], 2007). The game design uses a narrative (set on an island with a castle as the central site where students get challenges or "quests" from a king or queen). We drew on a range of design principles (Salen & Zimmerman, 2004), including avatars, non-player characters (queen and king), content design (a narrative accompanying each task), levels of difficulty, metaphors and semiotics (e.g., prime numbers are rocks that cannot be broken), and repeatability (a player will repeat a set of actions to gain mastery of a task). The idea of an island is popular in fantasy literature and educational adventure games or serious games (e.g., *Crystal Island*, McQuiggan, Robison, & Lester, 2008; Valenza, Gasparini, & Hounsell, 2019). *Heroes of Math Island*, like a range of mathematics educational games, provides a rich digital game-based environment (Broza & Kolikant, 2020; Chu & Fowler, 2020; Conati, 2002; Conati & Maclaren, 2009; Conati & Manske, 2009).

There are five possible challenges or quests in *Heroes of Math Island*: forest, mine, mountain, seashore, and swamp (Figure 1). Each quest is intended to include a set of activities. The mine quest is based on learning outcomes involving divisibility, prime numbers, and factorization in accordance with the provincial curriculum (BC MoE, 2007). Three activities — divisibility, prime numbers, and decomposition — each consisting of 25 exercises organized into five levels of difficulty containing five items, are included in the mine quest. The game progresses to the next level only if the student correctly solves all five exercises. The exercises are generated by the system based on the student's previous performance. In order to design this game, we conducted four usability studies involving a grade 6 student, a mathematics teacher for grade 6 (two studies), and two instructional designers. For the mine quest theme, the miners are sick and need help. Rocks represent numbers: prime numbers are represented by hard rocks that cannot be "decomposed." Composite numbers can be broken with picks. When decomposed correctly, the composite numbers transform into gold (Figure 2).

Figure 1. Heroes of Math Island

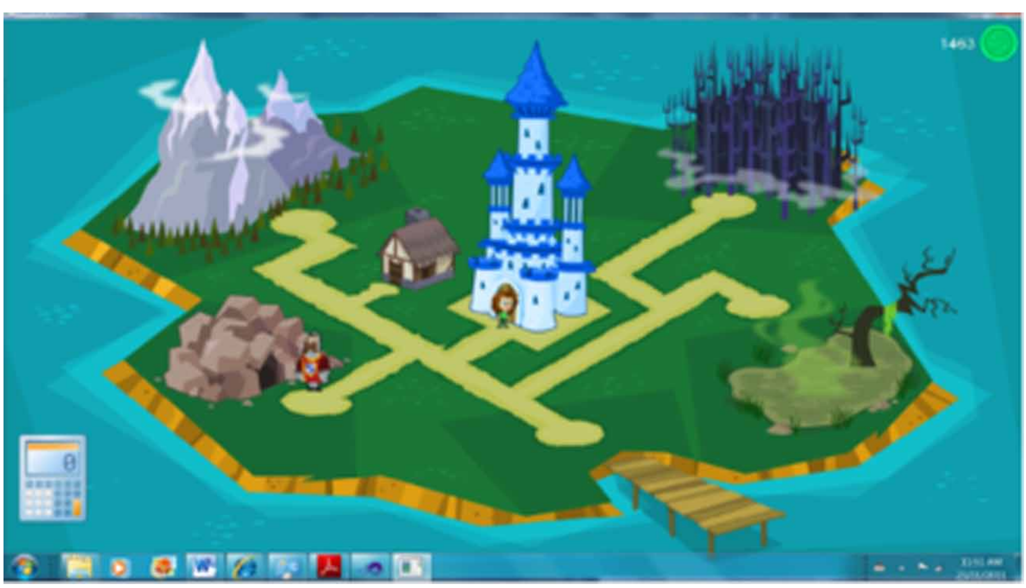


Figure 2. The Mine showing completed quest and happy monkey

On the island there is a library (the Wiseman's library) where students are sent when making mistakes. When students make mistakes, the game generates three levels of hints (a general hint acknowledging the error, a specific hint, and an example). The game design employs negative reinforcement for poor performance: on the fourth error, the player is sent to the library and the activity restarted. The Wiseman is not offering help in this version of the game (it will be expanded in the future). The game includes an emotional agent, represented by a monkey, presented in the next section.

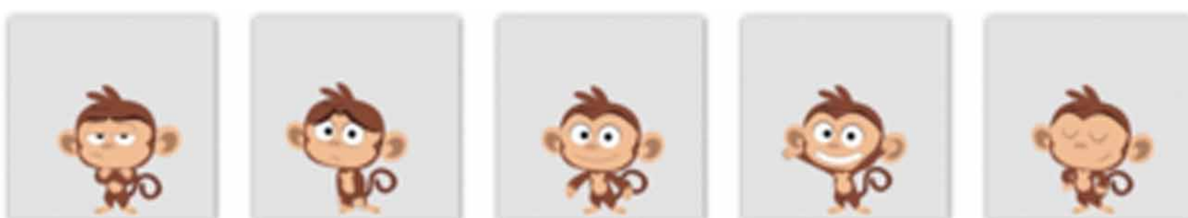
3.2. Emotion Framework

The emotions considered in this study were selected based on emotion models found: (1) in the affective computing literature, i.e., the affect framework proposed by Graesser et al. (2006), which considers the following emotions: boredom, confusion, delight, engaged concentration (also known as flow), frustration, and surprise; (2) appraisal theories of emotions (i.e., OCC cognitive theory of emotion) (Ortony, Clore, & Collins, 1988) which consists of 22 emotion types emotions occurring during interactions as a consequence of events; and (3) emotion models found in the education literature: (a) Astleitner's (2000) model of emotions in the context of instruction (i.e., anger, envy, fear, pleasure, and sympathy) and (b) Ingleton's (2000) emotion model in learning (confidence, distance, fear, pride, shame and solidarity). Our final model included 12 emotions (plus neutral): boredom, confidence, confusion/hesitancy, curiosity, delight/pleasure, disappointment/displeasure, engaged concentration, excitement, frustration, pride, shame and surprise. The 12 emotions were used for emotion labeling by video annotations by two judges (the first author of this paper, and a student research assistant trained to perform the task). The study participants' emotions were labeled with a video annotation technique, using a 20-second granularity and reporting all emotions that occurred in each time interval. It is important to note that in open-ended questions and interviews, our participants did not describe their feelings with the set of emotions used by judges for affect analysis. We did not provide participants with descriptions of these emotions (Gutica, 2014; Gutica & Conati, 2013; Conati & Gutica, 2016).

The game includes an emotional agent, represented by a monkey (Figure 3). We designed the monkey to be continuously present on the bottom-right corner of the screen and play animations that express emotional states according to the student's score calculated as an average between an absolute score (number of mistakes minus number of correct responses) and the trend of the most recent actions performed by the student (i.e., 20 correct answers in a row will cause the level of difficulty to increase two times faster).

We wanted to explore if the monkey's presence and emotional reactions can encourage the student by mirroring what is happening in the game. The monkey displays a neutral state, two positive (happy and confident), and two negative (sad and frustrated) emotional states. All four emotions were carefully selected as being considered relevant to learning in the context of an educational game. The emotions happy and sad were selected from the OCC model of emotion as they are representative of emotions focused on consequence of events and are used in game interactions (Ortony, Clore, & Collins, 1988). The other two emotions were selected as being important for learning: confidence (Ingleton, 2000) the very positive emotion occurring as a consequence of concept achievement, and frustration (Graesser et al., 2006) the negative emotion that can often occur during problem solving. The monkey's expressions were designed by a graphic artist based on standard portrayals of emotions used in psychological tests and therapy (Creative Therapy Associates). These expressions are longstanding in the history of caricatures and comics, most definitively dating to Töpffer's (1845) illustrations in physiognomy. Emotional agents in the form of avatars also commonly adopt these facial expressions (e.g., Chen et al., 2012; Rodrigo et al., 2008).

Figure 3. Emotional States: Frustrated, Sad, Neutral, Happy, and Confident



3.3. Participants, Methods and Techniques

Fifteen students (seven boys and eight girls) from grades 6-7 participated in this quasi-experimental study. Participants for research were recruited with flyers posted in several locations (schools, daycares, and the post-secondary institutions where the authors are affiliated) and randomly selected. The mean age of participants (seven boys and eight girls) was 11.4 and the median age was 11. Quantitative and qualitative data were collected from the quasi-experimental study and videos of the participants.

The protocol used for experiments included a short tutorial. The tutorial was needed to bring participating students to the same level of mathematical knowledge regarding divisibility, prime numbers, and decomposition in prime factors. Total time for an experiment was 1 to 2-½ hours, and the time used for gameplay was 15 to 48 min (M = 32.3 min; SD = 10.3 min). The game interaction was videotaped (one video camera recorded the student's face and one recorded the computer screen). The pre- and post-tests were similar but not identical and contained 23 questions (12 divisibility, 5 prime numbers, and 6 number decompositions). The post-questionnaire was adapted to this study from one used in *Prime Climb* studies (Conati & Maclaren, 2009; Conati & Manske, 2009). The primary author conducted the experiments together with three student research assistants enrolled in an undergraduate computing program at the British Columbia Institute of Technology (BCIT), who were also involved in the design and implementation of the game.

The post-questionnaire blueprint is presented in Table 1. The rows correspond to the students' subjective attitude towards the game, mathematics and the monkey (emotional agent in this game): (a) affective domain, (b) cognitive domain, and (c) learning. Columns indicate the following domains: attitude towards (1) the game, (2) content (mathematics), and (3) the emotional agent. Intersection of rows and columns correspond to the themes of this study.

The post-questionnaire (see Appendix A) was composed of 48 Likert scale items: statements regarding the general game experience (14); statements regarding the enjoyment of the game experience (13); statements regarding learning mathematics in this game (7); statements regarding interest in video and math games and willingness to play the game again (10); reports of mastery of the three topics (divisibility, prime numbers and decomposition) before playing the game (3) and the attitude towards mathematics (1); and 5 open-ended questions.

Table 1. Questionnaire Blueprint (see Appendix)

	Affective	**Cognitive**	**Learning**
Attitude toward the game	1.1; 1.10; 2.1; 2.7; 2.11; 2.12; 2.16; 4.5; 4.6; 4.8; 4.10	1.5; 1.11; 4.12	1.6; 1.13; 3.1; 3.9; 4:11
Attitude toward math	1.7; 1.8; 2.8; 2.9; 2.13; 2.14;	1.8; 1.16	1.13; 3.1; 3.2; 3.3; 3.4; 3.6; 3.9; 3.10; 4.11
Attitude toward the monkey	1.3; 1.9; 1.12; 1.15; 1.17; 2.2; 2.3; 2.4; 2.5		

Some post-questionnaire statements were used to characterize more than one category. For example, the statement "I believe that I can learn math better by playing this game" is about learning and attitudes toward both the game and mathematics. However, for simplicity we analyzed each statement in only the most appropriate category, giving priority to the affective domain and learning.

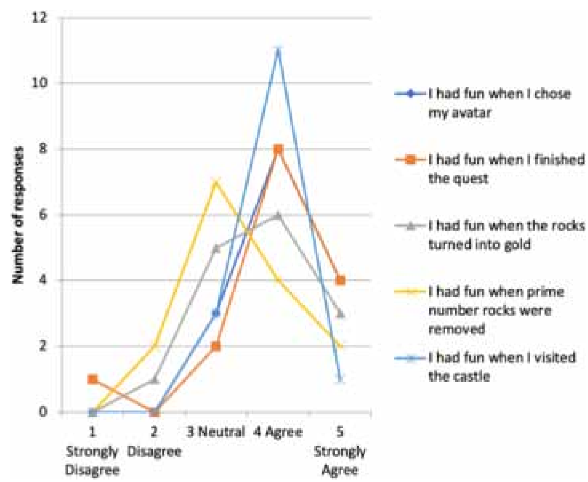
Interviews were semi-structured for allowing for free discussion. The interview guide included a set of questions related to emotions, game design and learning. Issues noted during game interaction were clarified in interviews. Data collected from interviews were used to better describe, clarify and understand the findings resulting from questionnaires. After interviews, observers had a discussion and collaboratively wrote a report based on notes taken during experiments which provided a starting point for data analysis. We used descriptive statistics to analyze the data extracted from pre- and post-tests and questionnaires. We analyzed the open-ended and interview data using a deductive approach based on these themes of this study.

4. FINDINGS

4.1. Attitude Toward the Game

In order to evaluate the students' emotional reaction to the design of the game, we computed a summative histogram, with results from five questions related to game mechanics (e.g., aspects of the game related to the avatar, finishing the quest, the rocks' animations, and visiting the castle). The analysis concluded that only a small percentage of responses were not favorable: generally students found the game design enjoyable. Figure 4 presents the results.

Figure 4. Game design: Detailed histogram



This finding is very important as many educational games lack the "fun" aspect of interaction (Granic, Lobel, & Engels, 2014). Students were asked during interviews to provide suggestions for improvement. They suggested adding more content to the game (quests), and including awards, leaderboards and game mechanics that are characteristics of video games targeting this age group (i.e., collecting items and "dressing their avatar").

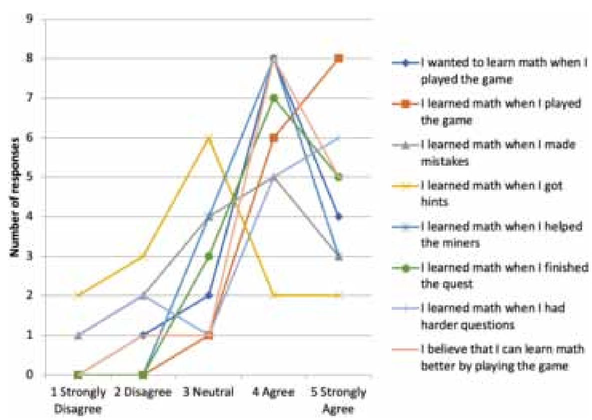
4.2. Attitude Toward Learning

Students reported different levels of previous knowledge with respect to the three mathematics topics. More students reported a better grasp of divisibility than of prime numbers and decomposition. The null hypothesis of no difference between the pretest and post-test was rejected. One student did not write the post-test because he was too tired; therefore we computed the pre- and post-test scores for 14 students only. For these 14 students, there was a significant improvement from pretest (M = 77.7%; SD = 9.26%) to post-test (M = 83.6%; SD = 8.74%), t (13) = 3.17; two-tailed p = .007, d = 0.647). The Cohen's effect size value (d= 0.647) indicates a moderate to high practical significance.

Eight statements in the post-questionnaire addressed the students' perception of learning. One post-questionnaire item addressed the students' attitude towards learning prior to the gameplay ("I wanted to learn when I played the game") and six items addressed learning gains during and after gameplay, the overall impression ("I learned math when I played the game"), task accomplished ("I learned math when I finished the quest"), game design aspects related to learning ("I learned math when I got hints/examples/harder question"), making mistakes ("I learned math when I made mistakes"), and social norms ("I learned math when I helped the miners"). One item addressed the students' belief that the game affords improved learning: "I believe that I can learn math better by playing this game." Figure 5 presents the computed histogram. We consider very promising that in the histogram, for all but one item ("I learned math when I got hints"), frequencies are concentrated towards "agree" and "strongly agree." Frequencies for the statement related to learning from hints are concentrated towards neutral, a finding that will be investigated in future research and will be taken into consideration in future revisions of the game.

From the group of 15 students, only one (Student 13) responded neutral to the overall statement related to learning "I learned math when I played the game," and 93.3% of students agree or strongly agreed: of the 14 students, 6 agreed and 8 strongly agreed. This was the same student who disagreed with the statement "I believe that I can learn math better by playing this game"; one other student was neutral, eight agreed, and five strongly disagreed. When Student 13 was asked how she would feel about the game if it would be improved, she responded that the game would not interest her unless the mathematical content were removed and replaced with "more fun learning material."

Figure 5. Learning: Detailed histogram



During the game, when experimenters observed that students were tired or struggled too much, they advised them to stop or replay the easier divisibility activity. It was interesting to notice that students were determined to finish the quest. None of the students in this group stopped before finishing the quest. Experimenters agreed that two students in particular were very tired during the gameplay, but did not want to stop, and managed to finish.

Interviews revealed the students' positive attitudes about the game: all but Student 13 agreed that they would like to study mathematics by playing the game. For example, Students 2 and 9 reported that the game is better than studying from textbooks. Student 6 believed that other students would also prefer this type of learning "because it is a game." Student 7 indicated that he would like to play the game to study for tests while Students 8 and 21 wanted to use the game to practice mathematics at school and home.

Student 18 reported that if each student would have a dedicated computer at school "then I would definitely say, we could use games like this one." Student 9 explained why she had fun: "Because I learned and I learned though a game and I like learning through games instead of just text book stuff." Even Student 13 (who disliked mathematics) agreed in interviews that she learned to some extent from the game: "Yes, I learned a little bit." It is important to note that Student 13 appeared to learn with the game as she improved her score by 4.3%, from 78.3% on the pretest to 82.6% on the post-test. She also was engaged during game play as engaged concentration was reported for her 48.5% by Judge 1 and 65.2% by Judge 2. She was observed only in few occasions expressing negative emotions: Judge 1 found her frustrated in few instances (6.1%) and Judge 2 found her confused but not frustrated (Gutica & Conati, 2013; Conati & Gutica, 2016).

Enjoyment and learning were generally reported together. Student 11 reflected on how gameplay enjoyment blended with learning: "I wanted to have [fun] and to learn more. And I like the game because it gave an opportunity to, like, do both." Student 15, who was neutral, clarified that she "didn't really care" if she had fun; however she learned "a lot."

4.3. Emotion and Learning

When asked what emotions they experienced during the game, participants generally responded happiness or having fun, and to a lesser extent confidence, confusion, frustration, and pride. We argue that the "happiness" state that students reported could represent the spectrum of positive emotions of confidence, curiosity, engaged concentration, excitement, delight/pleasure, and pride. One of the students reported "a sense of accomplishment" (Student 2), and another student described her experience with words like "interesting" and "effective" (Student 1).

Figure 4 included in a previous section of this paper indicates that the post-questionnaire responses are indicative of positive emotions felt during gameplay. In interviews, participants reported high engagement. Student 18 gave a response that encompasses the definition of engaged concentration "I felt like… it wasn't really a feeling, I felt like my mind was thinking a lot." He felt engaged with this game even though he generally has difficulties concentrating: "I felt at some points I felt a bit frustrated, and at some points I felt like I was really, I guess you could say, determined and my head was almost in it, when normally, when I'm doing stuff I can't keep concentrated, I can't pay attention to it."

Experimenters noted that engaged concentration was the main emotional state that students experienced. This observation is consistent with the results of the affect analysis, as engaged concentration was reported the majority of the time. It is important to note that these findings are in-line with the learning gains (the improvement from pre- to post-test), and the positive responses students gave to the post-questionnaire and during interviews.

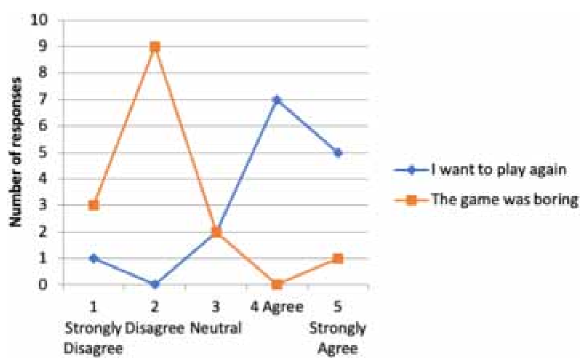
The second most important affective state reported by judges was confidence, indicating that this emotion should be considered in future studies (Gutica & Conati, 2013; Conati & Gutica, 2016). The third most frequently reported state by judges (confusion/hesitancy, reported during emotion labeling 26% of the time) was also reported by some students. However, confusion is not considered an emotion that prevents learning (Craig, Graesser, Sullins, & Gholson, 2004; D'Mello, Taylor, & Graesser, 2007; Graesser, et al., 2006; Rodrigo, & Graesser, 2010).

Frustration is a negative emotion; however, during a learning process it may be "less persistent, less associated with poorer learning" (Baker, D'Mello, Rodrigo, & Graesser, 2010, p. 223). Frustration was observed to a lesser extent (only 5% of the time) during emotion labeling (Gutica & Conati, 2013; Conati

& Gutica, 2016). Some students reported frustration; however to a lesser extent: Student 7 responded that he felt “somewhat” frustrated; Student 9: “A few times I was a little frustrated, when I didn’t get some of the rock things”; and Student 21: “It was fun, sometimes [I was] a bit frustrated, but it was a good game”. Student 11 reported frustration with respect to the emotional agent’s animations, which we will discuss in the next section. Frustration was reported in interviews in relationship to challenges encountered during learning (e.g., harder questions and making mistakes) and especially with regard to the negative reinforcement: when students made the fourth error and were sent to the Wiseman’s library and the activity was restarted from the beginning. Our study demonstrates that negative reinforcement, a design element frequently used in video game design and ABA (Linehan, Kirman, Lawson, & Chan, 2011), is not an effective pedagogical technique as it can lead to frustration as we found from our participants. We did not ask the students how frequently they were frustrated. However, based on the overall positive responses given by students when asked if they learned during gameplay (Figure 5) and if they want to play the game again (Figure 6), and based on judges’ observations, frustration seemed infrequent.

Another positive outcome of this study is that boredom, an emotion that is considered detrimental to learning (D’Mello, Taylor, & Graesser, 2007; Graesser, et al., 2006), was rarely observed; it was reported only 1.5% of the time in affect analysis. Only one student (Student 13) agreed with the post-questionnaire statement “This game was boring.” In interviews, students did not report or complain of boredom, except for Student 13.

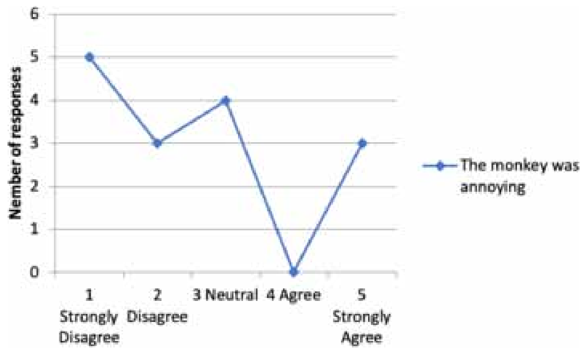
Figure 6. Boredom. Detailed histogram



4.4. Emotional Agent

Mixed results were obtained with regard to the emotional agent: the monkey. We started from an assumption that the monkey (even displaying a simplistic and rudimental behavior in this version of the game) would be appealing and appreciated by students (Rodrigo et al., 2012). The usability studies conducted during the game design gave us confidence that the monkey would be liked by students. However, not all students liked the monkey: 53.3% of students disagreed or strongly disagreed to the post-questionnaire statement “The monkey was annoying,” 26.6% of students were neutral, and 20% of students strongly agreed. Figure 7 presents the results.

Figure 7. The monkey was annoying. Detailed histogram.



Interviews revealed two main issues related to the monkey: the agent's presence was either not observed or too distracting. For example, Students 2, 9, 10, 12, and 18 indicated that they did not notice the monkey during the gameplay. When asked if he noticed the monkey, Student 2 responded: "I noticed the monkey in the beginning, but when he was here, [I] less noticed [it] because I was thinking about the questions and I really didn't see it." Student 18 also did not notice the monkey: he reported in the open-ended item of the post-questionnaire: "I did not see the monkey react." In interviews he elaborated: "it did not bother me…I am not very observant." Similarly, Student 12 liked the monkey but did notice it less during the game: "Well I thought he was cute. Didn't see him very much though." Other students felt distracted (Students 4, 5, 6 and 13). Based on their responses, it appears that the money's animations and continuous presence interfered with mental focus. Student 4 observed and enjoyed the agent's animations; however she repeatedly said she was distracted by the blinking animation. To the statement "Please tell us what emotions did you experience when you played the game," she responded "Happy (because of the monkey); Annoyed (monkey blinking)." She elaborated during the interview: "I like the monkey just not the blinking, the monkey was cute but the blinking was annoying…. I was happy because the monkey kept making these really… he looked really happy, he was like confident. So I was happy and I was sort of annoyed at the monkey's blinking." Student 5 strongly disagreed with the statement "The monkey was annoying"; however he also mentioned during the interview being distracted by the monkey. He suggested: "Just do it one time [the animation], then, yeah, just smiling it'd work better. Like every five minutes, he'd jump up, so you have more of a chance to think." Student 13, also reported being distracted. She suggested: "Well, I think that, maybe, if the monkey got too annoying, there should be a stop button." She also agreed that having a monkey that participates in a different way in the game was more attractive to her; however, she was very clear that mathematics content would not motivate her to play the game.

Only three students agreed or strongly agreed to the statement "The monkey reacted correctly to my emotions": Student 8, Student 15 and Student 21. These students also strongly disagreed that the monkey was annoying. Student 8 elaborated in the interview:

Interviewer: Did [the monkey] respond well to what you were feeling?

Student 8: It did, it kinda was doing what I felt like. When I was failing I felt mad and the monkey felt sad, so it kinda made sense.

Student 6, who responded neutral, was supportive of the idea of an emotional agent responsive to student's performance bur criticized the animation design:" I kind of like the idea of him being sad or happy whether you get it wrong or right, but, it was a bit… normally his actions were really big, like, he could just make a little face." Student 11 liked the monkey without being able to give a reason. However, he did not consider that the monkey responded to his feelings and the way the agent was implemented created more frustration than good: "I felt frustrated when I was supposed to catch prime numbers from the last one but I got a little mixed up there and the monkey kept being sad and I was more frustrated." Student 21 in her interview reported the she did not notice the monkey "that much," except for confidence animation (she even made a face imitating the monkey's animation). The video confirms that Student 21, a strong mathematics student, avoided making mistakes and the monkey was in a happy or confident state all the time.

Students had mixed feelings regarding the inclusion of the monkey. Student 2 considered that having an emotional agent is beneficial and offered advice for future design: "I think the emotions are good and maybe even a voice too, like if you are doing good when he feels those emotions he could say like good job or keep trying, keep it up." Student 9 suggested that the monkey can participate in the game by offering hints: "If you are making too many mistakes then I would want to go to the Wiseman but if I got one wrong then instead of that thing popping up then maybe the monkey can give the hint." Student 7 suggested a fairly passive role for the monkey:

Interviewer: What would you like the monkey to do?

Student 7: Well, the monkey doesn't really do anything so just, maybe, just sit, and sitting there and watches I think.

Other students offered ideas of improvement of the monkey not necessarily related to emotions or the game mathematics content, but related to achievement and awards. Student 4 suggested collecting items for the monkey, Student 12 suggested that the monkey should wear different hats based on the student`s achievements in the game, and Student 21 indicated that the monkey should respond to the student's performance: "like at the end, once you see your score, and if you did really good then it would do a victory dance."

5. CONCLUSION

In response to the need for more empirical ALT and GBL research, this article addresses the design of an educational game (*Heroes of Math Island*) in the context of emotion and learning. By exploring students' attitudes toward the game and its emotional agent, and the affective states experienced by learners during gameplay, this article emphasizes the importance of taking emotions into account in designs for GBL. Exploration of gameplay with a focus on emotions may pave the road to a more long-term goal of responding to students' cognitive and emotional needs in promoting ALTs and GBL.

Data suggest that participants learned from their interaction with the *Heroes of Math Island* game, as there was a significant improvement from pre- to post-test and a moderate to high Cohen's effect size value. Another important finding is that students were highly engaged and determined to finish the "quest." These findings together with the improvement from pre-to post-test are important as evidence of learning gains in a context of increased attention and focus on the subject matter. Boredom, an emotion detrimental to learning was not observed and was reported by only one student, and frustration was infrequently observed or reported. These results are optimistic, indicating that the game mechanics and learning activities currently implemented in the game are adequate and attractive for this age group.

There are various limitations, including the number of participants. Although there was not a problem with the number of data points used for emotion analysis, data were collected and analyzed from 15 participants; the emotions identified or observed need to be tested on a larger sample. Second, the study took place in a laboratory and observers were present with participants. Methodologies used were appropriate for the age group but we acknowledge that participants may have felt compelled to report a positive sense of the game. A more extensive study should be conducted with participants and in a more naturalistic school setting. Third, the game used in this study incorporated a simplified agent; however findings can be used for design of ALTs and ITSs. Extrinsic motivators, such as emotional agents, prompts, and reward systems, are part and parcel of gameplay. Research is needed on participants' preferences and responses to these types of motivators in GBL.

Admittedly, we have to attend to the potential cognitive tutor to complement the emotional agent. As one of the students reasoned, "If you are making too many mistakes then I would want to go to the Wiseman." Culture and identity are increasingly important in the design of game agents, avatars, characters, and tutors (Demirdjian & Demirdjian, 2020; Harrell & Harrell, 2012; Petrina & Zhao, 2021). Research questions remain regarding the gender of agents in gameplay. For instance, is a wisewoman or wiseperson in gameplay merely symbolic or is there an effect for girls and women or gender non-binary players? Relations between players and avatars or agents appear to be gendered but much more research is needed (Lehdonvirta1, Nagashima, Lehdonvirta, & Baba, 2012).

Accounting for emotions in game design (e.g., the emotional agent) is critical for affect-sensitive ALTs. However, we found disagreement with respect to the emotional agent. The participants in this study offered feedback and suggestions for the future improvement of the emotional agent; the monkey's actions and contributions to gameplay need to be redesigned. Overall, we believe that this study offers a good starting point for future design of an agent that gives appropriate and timely emotional cues and responds to users' needs. More empirical research is needed for pedagogical agents and companions: what effect would a less intrusive, more useful agent have? The question is no longer whether educational game designers should include agents with or without emotions (Scheutz, 2002). The question is how well do agents augment, generate, and respond to players' emotional states during gameplay?

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APPENDIX

Table 2. Post-Questionnaire

	Disagree	Neutral			Agree
Scale 1. Do you agree with the following statements about your game experience?					
1. I wanted to have fun when I was playing the game.	1	2	3	4	5
2. The monkey was annoying.	1	2	3	4	5
3. The level of difficulty was right.	1	2	3	4	5
4. I wanted to learn when I played the game.	1	2	3	4	5
5. I felt upset when I did not answer correct.	1	2	3	4	5
6. I became curious about math (divisibility/prime numbers/factorization) by playing the game.	1	2	3	4	5
7. The monkey reacted correctly to my emotions.	1	2	3	4	5
8. I didn't care whether I had fun or not.	1	2	3	4	5
9. The game was too easy or too hard for me.	1	2	3	4	5
10. I was proud to see the monkey happy.	1	2	3	4	5
11. I wanted to learn math by playing the game.	1	2	3	4	5
12. I felt shame when I made mistakes and the monkey was sad.	1	2	3	4	5
13. I didn't want to think about math (divisibility / prime numbers / decomposition) when I was playing the game.	1	2	3	4	5
14. I didn't mind to see that the monkey was sad.	1	2	3	4	5
Scale 2. Please tell us what emotions you experienced when you played the game.					
1. I had fun when I chose my avatar.	1	2	3	4	5
2. I had fun when the monkey was happy.	1	2	3	4	5
3. I had fun when the monkey was sad.	1	2	3	4	5
4. I had fun when the monkey was confident.	1	2	3	4	5
5. I had fun when the monkey was frustrated.	1	2	3	4	5
6. I had fun when I finished the quest.	1	2	3	4	5
7. I had fun when I responded to math questions before play.	1	2	3	4	5
8. I had fun when I responded to math questions after play.	1	2	3	4	5
9. I had fun when the rocks turned into gold.	1	2	3	4	5
10. I had fun when prime number rocks were removed.	1	2	3	4	5
11. I had fun when I got hints.	1	2	3	4	5
12. I had fun when I got examples.	1	2	3	4	5
13. I had fun when I visited the castle.	1	2	3	4	5
Scale 3. Please tell us any other times you did not have fun: Do you agree with the following statements about your game experience?					
1. I learned math when I played the game.	1	2	3	4	5
2. I learned math when I made mistakes.	1	2	3	4	5

continues on following page

Table 2. Continued

	Disagree	Neutral			Agree
3. I learned math when I got hints.	1	2	3	4	5
4. I learned math when I got examples.	1	2	3	4	5
5. I learned math when I helped the miners.	1	2	3	4	5
6. I learned math when I finished the quest.	1	2	3	4	5
7. I learned math when I had harder questions.	1	2	3	4	5
Scale 4. I also learned math when: Do you agree with the following statements about your game experience?					
1. I was already good at divisibility before I played the game.	1	2	3	4	5
2. I was already good at prime numbers before I played the game.	1	2	3	4	5
3. I was already good at decomposition before I played the game.	1	2	3	4	5
4. I played video games before.	1	2	3	4	5
5. I like playing video games.	1	2	3	4	5
6. I played before math games.	1	2	3	4	5
7. I like playing math games.	1	2	3	4	5
8. This game was boring.	1	2	3	4	5
9. This game was more interesting than video games that I played.	1	2	3	4	5
10. This game was more interesting than math games that I played.	1	2	3	4	5
11. I would like to play the game again	1	2	3	4	5
12. I believe that I can learn math better by playing this game.	1	2	3	4	5
13. I would like to see more quests.	1	2	3	4	5
14. I like math.	1	2	3	4	5