Description of the Educational Math Game "Monkey Tales: The Museum of Anything"

Sylke Vandercruysse, Marie Maertens, and Jan Elen

Abstract In this contribution, we present the game-based learning environment Monkey Tales in which pupils and students can practice mathematics. The learning content and goals, as well as the story line and game design are discussed. The environment can be used for several research purposes, such as studies which focus on the effects of the use of educational games in the classroom (e.g., effect on performance, motivation) as well as studies which focus on learners' behavior in the game and their mathematical performances during game play.

Keywords Mathematics • Math game • Game design • Educational game

The Monkey Tales series is a set of commercial 3D game-based learning environments (GBLE), designed for mathematics practice in elementary school.[1] The series is designed and developed by the game-developer Larian Studios and the educational publisher Die Keure. The GBLEs are based on the national curriculum for math instruction as developed by the Flemish ministry of education. The GBLE is available in Belgium, the Netherlands, the United Kingdom, and the United States. In all versions, the mathematical content is identical and based on the Flemish math curriculum. The story line and content are, however, translated so they can be used in the different countries. Especially for the version in the United States, the original GBLE has been redesigned to follow the Common Core Standards as well as the DoDEA (Department of Defense Education Activity) standards.

[1] A demo-version can be found on http://www.monkeytalesgames.com/UKen/games/2.

S. Vandercruysse (✉)
Center for Instructional Psychology and Technology, KU Leuven,
Etienne Sabbelaan 53, Kortrijk 8500, Belgium
e-mail: sylke.vandercruysse@kuleuven-kulak.be

M. Maertens
ITEC—iMinds—KU Leuven—Kulak, Interactive Technologies, KU Leuven Kulak,
Kortrijk, Belgium
e-mail: Marie.Maertens@kuleuven-kulak.be

J. Elen
Center for Instructional Psychology and Technology, KU Leuven, Leuven, Belgium
e-mail: jan.elen@ppw.kuleuven.be

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Table 1 Different GBLEs of the monkey tales series with the recommended age of players

Name of the game	Recommended age of the players
The princess of Sundara	7 years and up
The museum of anything	8 years and up
The abbey of Aviath	9 years and up
The castle of Draconian	10 years and up
The valley of the Jackal	11 years and up

The Monkey Tales series consists of different GBLEs (see Table 1), according to the different elementary school grades. As the GBLE is developed for different countries (i.e., Belgium, the Netherlands, the United Kingdom, and the United States), the recommended age for each GBLE is presented in Table 1 instead of the intended grade.

Each GBLE has its own story line. In the first part of this contribution, we will describe the story line and game-environment in more detail (see section "Story Line and Game-Environment"). Secondly, the learning content, which is presented in a fun and challenging manner, is outlined (see section "Learning Content"). As the Monkey Tales series contains mainly rehearsal exercises, the GBLE is not meant to instruct but to reinforce lessons learned in school covered in the previous grades. Third, the specific game-elements of the Monkey Tales games will be discussed as they reveal specific choices of the game-developers according to the game design (see section "Game-Elements"). In the fourth part of this chapter, we focus on the customization of the commercial GBLE for research purposes (see section "Use in Research").

Typology

The Monkey Tales series can best be described as an adventure game (Rollings & Adams, 2003). Elements of an adventure game that appear in the Monkey Tales series are an interactive story line in which the player has to solve puzzles, the aim of collecting items during gameplay and the lack of physical activities such as shooting or combatting. In addition, some characteristics of action games (e.g., the use of levels and an enemy at the end of a level/game) and role playing games (i.e., players have to explore the world, driven by quests) can be linked to the Monkey Tales series (Rollings & Adams, 2003). In addition, when considering the way math is offered to players, we can describe it as drill and practice because players learn through rehearsal, repetition, and practice of tasks (Burkolter, Kluge, Sauer, & Ritzmann, 2010).

Use

The Monkey Tales series is a pc-game; some technical requirements are essential to be able to install the game on your pc (with the CD-ROM) and play it. The requirements are determined for the platform (i.e., Windows XP SP2 or higher, Windows Vista or Windows 7), processor (1.6 Ghz or higher), RAM memory (512 MB or more), graphic card (Intel GMA950 or higher, ATi 9600 or higher, or GeForce 5 or higher), sound card (DirectX 9.0c), and video memory (128 MB).

In practice, the Monkey Tales series is suitable for double use. On the one hand, Monkey Tales can be used at school during class hours (e.g., to differentiate between high and low performing players) or as homework (e.g., to rehearse the learning content which was taught at school). Second, as the Monkey Tales series is seen as stand-alone, it is possible for children to play the GBLE outside the school context. Parents can buy the commercial GBLE so children can play Monkey Tales at home, again irrespective whether the associated textbooks are used in class.

Story Line and Game-Environment

In the Monkey Tales series, learners have to prevent that Huros Stultos conquers parts of the world. In order to master the universe, he has accomplices who steal knowledge and make all other people stupid. Huros trained an army of super intelligent monkeys who are experts in math. Luckily, Huros Stultos' plan was discovered by the old gray professor Moudrost and his assistant Emótje. During the game, players help Moudrost and Emótje to stop Huros and his assistant-monkeys. As the monkeys are very good at math, players can only ruin Huros Stultos' plans by defeating all the monkeys, i.e., being smarter than them in the math games. For example, in "The museum of Anything," the huge dinosaur Carmen Pranquill (also an accomplice of Huros Stultos) has taken over the museum whereby no one dares to enter anymore. Hence, the museum is closed for public. To assist Moudrost and Emótje, players have to search every room, defeat all accomplices and find Carmen Pranquill to conquer her. When the game is finished and the player wins, the museum is cleared, so people can again enter and gain knowledge. In what follows, we will exemplary focus on "The Museum of Anything" as all GBLEs have an analogue story line and game-environment.

Each GBLE contains several stages which represent different parts of the museum (e.g., the entrance hall, the sealife center, hallways, storages) and each stage consists of seven rooms (see section "Rooms") and within each room a mini-game (see section "Mini-Games"). After each stage, the Bridge of Death (as depicted with a bridge-icon) is presented to the player to close a stage (see section "Bridge of Death"). At the end of the entire GBLE, players play the Boss Level (see section "Boss Level"). So in the entire GBLE, players play 48 rooms, five Bridges of Death, and one Boss Level. The overview of a part of the GBLE with the different stages and rooms is presented in Fig. 1.

Fig. 1 Overview of the museum of anything

The first time players enter the GBLE, they can choose to visit the learning levels. By doing this, they learn all the tips and tricks to move from one room to another and solve the puzzles. They get to know most common puzzle elements (see Fig. 2) and learn how to operate them (e.g., use the Ctrl-key to get an overview, activating magnets which attract metal boxes). This is done by Emótje who explains and illustrates what players have to do by using an interactive tutorial. For example, when she tells players to use the Ctrl-key to get an overview, a keyboard is displayed and the Ctrl-keys are highlighted. During the learning levels, the players can test tips and tricks to experience the different functionalities in the GBLE in order to be able to solve the puzzles.

Rooms

Every room has two major components: first, a console with a mathematical mini-game and second, a 3D-puzzle in which the console is integrated.

There is a console in each room and each console contains a monkey. When players activate a console, they can play a mini-game. As part of the overall gameplay and in order to be able to advance in the GBLE, players have to play the mini-games to beat Huros Stultos' monkeys. If a player wins a mini-game, he liberates the imprisoned monkey which is added to his personal zoo (see Fig. 3) and advances to the next room. All the liberated monkeys are brought together in the player's

Fig. 2 Room with several puzzle-elements (e.g., lasers and magnets) and bananas

Fig. 3 Personal zoo with two liberated monkeys

personal zoo. At the end of the GBLE, the zoo is full with monkeys as players liberate one monkey in every room. Players can visit their zoo at any moment during gameplay. When players lose a mini-game, a new mini-game with an easier math rule is offered. It is compulsory for players to win a mini-game in each room. Otherwise, they cannot move onto the next room.

In each room, players have to (1) reach the console in order to activate it and (2) gain as much bananas as possible for their monkeys. In the rooms, the console is part of a larger 3D-puzzle and players have to think logically to solve those puzzles

to be able to reach and activate the console. While solving these puzzles, bananas (see Fig. 2) can be collected. Players need enough bananas to feed all their monkeys (see Fig. 3). The more bananas the monkeys eat, the happier they will be. So the bananas are the first scoring mechanism.

Mini-Games

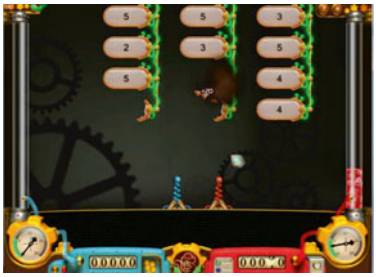
The GBLE contains six different types of mini-games: Number Cruncher, Math Cards, Pebble Rebel, Cannon Battle, Rocket Science, and Cypher shooter (see Table 2 for more details about the tasks players have to perform in the different mini-games). Information about the actions and tasks in the different mini-games is offered just-in-time when players activate a mini-game for the first time. For example, when a player for the first time enters in the mini-game *Number Cruncher*, Emótje tells how the *Number Cruncher* works and explains the different actions and tasks: Move left or right by using the arrow-buttons, shoot at a number by using the spacebar and finally how to get liberated from the green toxic slime by fast pressing on the arrow-buttons.

Each mini-game features math exercises in accordance to one specific math rule (e.g., item "8 × 6 = …" for the math rule "Table of 6"). Research about the Monkey Tales series revealed that mini-games differ with respect to difficulty (Maertens, Vandewaetere, Cornillie, & Desmet, 2014). As Maertens et al. (2014) stated, the number of elements and element interactivity that is present in the mini-games, influences the complexity and difficulty of the mini-games and is likely to affect the in-game performance for learners with low and high math ability. The mini-games Number Cruncher and Pebble Rebel are the most difficult mini-games because the number of mental and motor actions that should be performed simultaneously is rather high, leading to higher element interactivity and thus higher added difficulty (Maertens et al., 2014). In contrast, Cannon Battle and Rocket Science are the easiest mini-games. In these latter mini-games, the number of motor actions is less than in the more difficult mini-games. Hence, the element interactivity is much lower. Combining difficult, mediocre, and easy mini-games together results in sufficient fun and challenge without arousing frustration.

Bridge of Death

At the end of each stage, players have to cross the Bridge of Death (see Fig. 4). The Bridge consists of tiles. When on a tile, a multiple choice assignment is presented to the players (see Fig. 5) and after answering the question correct, the next safe tile will light up green. When the player makes an error, the bridge will lie and the player has to guess which tile is safe and take the risk of falling through the Bridge of Death. When players fall through the bridge, they have to start all over again. So, players have to reach the other side of the bridge by giving multiple correct answers in a row and hence choosing the correct tiles.

Table 2 Description of the six types of mini-game in the game-environment

Number Cruncher 	Players are controlling the blue rocket and the monkey controls the red rocket. By using the left and right arrow, players can navigate left or right. An assignment is presented at the bottom of the screen and three different answers can be chosen (of which only one is correct). Players have to shoot the correct answer by pressing the spacebar. While doing this, they have to avoid the green toxic drops falling from the roof because this makes them immobile for a few seconds. By making combo’s they can get higher scores. Combo’s can be upgraded by giving as many correct answers in a row
Math Cards 	During the mini-game “Math Cards” players are playing at the poker table. Cards with numbers are running on the table. At the bottom of the table, an assignment is given. This assignment can be completed by dragging the right card into the blank. There are also yellow bonus cards which improve players’ score. But players have to watch out for the monkey who is very smart and tries to solve the puzzle before they will do
Pebble Rebel 	During the mini-game, “Pebble Rebel” players are in control of the blue spaceship and the monkey controls the red one by using the arrow keys. At the bottom of the screen, an assignment is presented (i.e., complete the series). Several rocks fly into the space containing different numbers. Players can catch a rock by flying against it. Then, they have to shoot it in the blue basket by pressing the spacebar. By combining several rocks players have to try to compose the right answer. When the right answer is collected, they can press enter. While playing, players have to watch out for tornados that make them immobile for a few seconds
Cannon Battle 	During the mini-game, “Cannon Battle” players are controlling the blue cannon at the left side of the screen. They can move the cannon up or down by using the arrow keys. At the bottom of the screen, an assignment is presented (i.e., shoot on everything that equals 100). Several chips with correct and incorrect answers are falling down
	Players must try to hit the correct answer as fast as possible. From time to time, purple chips are falling down. When players hit the purple chip, the monkey is paralyzed for a few seconds. When the monkey shoots the purple chip, the player is immobile

(continued)

Table 2 (continued)

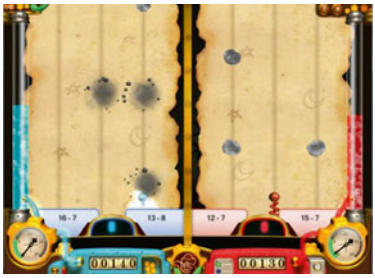
Rocket Science 	In the Rocket Science mini-game, the player and the monkey fly with respect to the blue and red rocket. Both fly independent. They have to avoid the rocks by solving assignments. After completing the right exercise, they fly to the right. If they complete the one on the left side, they fly to the left (i.e., 16–7 to move to the left and 13–8 to move to the right). When a wrong answer is giving, the position remains. When a rock hits them, their rocket is damaged and time is lost. Green arrows are accelerators which make the rocket go faster. Hostile ships can kill the player so they have to calculate fast to avoid them or shoot them first by using the spacebar
Cypher Shooter 	The mini-game Cypher Shooter is a shooting gallery. The math-assignment appears at the bottom of the screen (i.e., "Shoot on the numbers smaller than 7") and on the treadmill, cards with the possible answers pop-up on the screen (i.e., 2, 4, and 8). By using the mouse to aim and throw a ball towards the cards (left click) with the correct answer, they gain points (blue/left score). By choosing—as fast as they can—the right answers, they can beat the monkey (red/right score). Special bonus cards can be collected to improve the score

Fig. 4 Endgame bridge of death

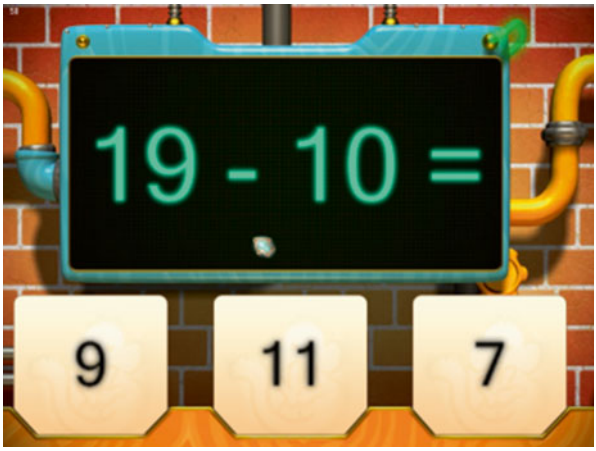


Fig. 5 Multiple choice assignment in the bridge of death

Fig. 6 Boss level with eight consoles

Boss Level

The Boss Level can be compared with a room, but with eight consoles instead of one. So in order to win the Boss Level, eight mini-games with math content have to be played (see Fig. 6). The mini-games are the same as those in the regular rooms (see section "Rooms").

Learning Content

The learning content of each game from the Monkey Tales series consists of a sequence of math rules (e.g., "Table of 6," "Addition to 100," "Odd and even"). The sequence is defined by the math curricula as developed by the Flanders' ministry of education. In Table 3, the sequence of the math rules in the game "The Museum of Anything" is displayed. The math rule "tens and units" is the most easy math rule and "Subtraction to 100 with bridge Ten Unit – Ten Unit" the most difficult one.

Each math rule is operationalized by a predefined number of items that can be offered to Monkey Tales players. Items in a mini-game do not differ with respect to the underlying math rule, they only differ in the numbers that are used (e.g., items "40 + 20" and "30 + 40" for the math rule "Addition to 100 with tens"). It is assumed that items having the same rule as origin will also have the same difficulty level.

Game-Elements

To discuss the Monkey Tales game, we follow the recommendation from Aldrich (2005) to think about distinct game-elements instead of thinking about games as such. In the following sections, specific game-elements will be discussed as they reveal specific choices of the game-developers. In general, it is presupposed that

Table 3 Math rules in the game "the museum of anything"

Math rules	
Tens and units	Table of 4
Number of times	Division table of 4
Split	Table of 3
Table of 2	Division table of 3
Division table of 2	Table of 6
Understanding numbers to 100	Division table of 6
Addition with 3 tens	Table of 8
Subtraction with 3 tens	Division table of 8
Addition with 1 ten	Table of 9
Subtraction with 1 ten	Division table of 9
Table of 10	Table of 7
Addition and subtraction to 100 without bridge	Division table of 7
Division table of 10	Structure of tens
Structure of 100	Addition to 100 with bridge Ten Unit + Unit
Odd and even	Subtraction to 100 with bridge Ten Unit – Unit
Table of 5	Addition to 100 with bridge Ten Unit + Ten Unit
Division table of 5	Subtraction to 100 with bridge Ten Unit – Ten Unit

players and their learning process would benefit from these game-elements (Garris, Ahlers, & Driskell, 2002; O'Neil, Wainess, & Baker, 2005; Prensky, 2001; Vogel et al., 2006; Wilson et al., 2009).

Goal

The goal of the game is clearly presented to the player at the beginning of the game and this is supposed to be beneficial for players' motivation and engagement (Akilli, 2007; Bergeron, 2006; Garris et al., 2002; Hays, 2005; Malone, 1980; Prensky, 2001). The players get an introduction of Moudrost and Emótje before the GBLE starts. This is done by showing the players a short introduction movie in which Moudrost and Emótje explain the story line and goal. During this introduction, they hear about the occupation of The museum of Anything by the huge dinosaur Carmen Pranquill. Then, the player gets the quest to defeat the dinosaur and his accomplice monkeys. For feeding the monkeys, the player must also gather bananas. So the goal is twofold (1) liberate the museum by defeating monkeys in every room of the museum and (2) catch bananas for them. After finishing a level, Moudrost repeats the importance of beating as much monkeys as possible and to go on with the liberation of the museum. During the puzzle-solving, the players are shown directly how much bananas they already gathered and how happy the monkeys are.

Content Integration

The Monkey Tales series can be categorized as an extrinsically integrated GBLE because the learning content is not integrated with the core game-mechanics which embody the rule-systems and player interactions, but separates the learning and the playing component in the game. After completing a part of the learning content, students are provided with a reward by having the chance to advance in the game without dealing with learning content (e.g., solving the 3D-puzzle). This differs from intrinsically integrated games which

> (1) deliver learning material through the parts of the game that are the most fun to play, riding on the back of the flow experience produced by the game, and not interrupting or diminishing its impact and; (2) embody the learning material within the structure of the gaming world and the players' interactions with it, providing an external representation for the learning content that is explored through the core mechanics of the game play. (Habgood, Ainsworth, & Benford, 2005, p. 494).

It is argued that intrinsically integrated games motivate and engage players more than extrinsically integrated games because they maintain the flow experience (e.g., Garris et al., 2002).

Competition

Competition is often inevitably implemented in GBLEs in the shape of a score, bonus, or high-ranking. In this GBLE, competition can be defined as the activity of players comparing their own performances with the performance of a virtual opponent (i.e., the monkeys), as described by Alessi and Trollip (2001). This is in line with Fisher's (1976) interpersonal competition and with Yu's (2003) anonymity competition. According to Cheng, Wu, Liao, and Chan (2009) competition is motivating because it creates an extra challenge, and the learning activity provides more structure by prefacing a clearly defined goal. The extra challenge is created through the desire to win that is generated by competition and the opportunity to improve their own performance (Franken & Brown, 1995). The proposition of these researchers that competition is an important motivator within games is supported by a large number of studies (e.g., Charsky, 2010; Ebner & Holzinger, 2005; Tjosvold, Johnson, Johnson, & Sun, 2006; Worm & Buch, 2014).

Scoring Mechanism

The GBLE contains a double scoring-mechanism. On the one hand, players have to answer items correctly to beat the monkey. The number of items players have to answer correctly before the monkey is defeated, differs from mini-game to mini-game (see Table 4). By solving the assignments correctly, players raise their score. Secondly, bonuses and obstacles are implemented in the games which also influence players score. Three mini-games have implemented bonuses: yellow bonus cards in Math Cards, blue bonus cards in Cypher Shooter, and purple chips in Cannon Battle. Although these points have no specific purpose in the entire game, they offer extra points. Opposite to the bonuses, obstacles are implemented in the other mini-games

Table 4 Gameplay mechanics of the six types of mini-games in the game-environment

Mini-game	Gameplay mechanics
Number Cruncher	The mini-game contains 12 items and the winner is the player/monkey with the most correct answers
Math Cards	The mini-game stops when the player/monkey has four correct answers. The yellow bonus cards have no influence on winning/losing the mini-game, they only provide extra points
Pebble Rebel	The mini-game stops when the player/monkey has three correct answers
Cannon Battle	The mini-game stops when the player/monkey has seven correct answers. A wrong answer gives an extra correct answer for the opponent
Rocket Science	Player and monkey play independently in this mini-game. The winner is the player/monkey who first reaches the finish
Cypher Shooter	The mini-game stops when the player/monkey has ten correct answers. Hitting the blue bonus cards has no influence on winning/losing the mini-game, they only provide extra points

to make it more difficult to answer items correctly, for example, tornados in Pebble Rebel, green slime in Number Cruncher and rocks in Rocket Science. Unfortunately, this second mechanism is not transparent for players so it is not clear how much extra points players can earn with certain actions. Additionally, while solving the 3D-puzzle games (i.e., collecting as much bananas as possible), players can raise their score.

This game-element (scoring mechanism) is related to the competition element in the game. When searching for the effects of competition, the scoring mechanism plays a distinctive role. On the one hand, competition is stated to have positive consequences because it is related to challenge, and challenge in turn has been related to intrinsic motivation (Malone & Lepper, 1987). On the other hand, according to Aldrich (2005), overemphasizing a score can make students rely too much on the scores and will make them less engaged in the learning materials. Consequently, adding a score can subvert motivation and learning instead of supporting it.

Adaptivity

The commercial version of the game features adaptivity on the level of the math rules: When players lose a mini-game against the monkey, a—presupposed but not empirically verified—easier math rule is offered. This type of adaptivity is a basic example of adaptive item sequencing: If a learner fails to complete a task, the subsequent task is easier and when a learner successfully completes a task, the subsequent task is more difficult, hence increasing the challenge. With the implementation of this adaptivity mechanism, the learning content is adapted to the skills of the player (i.e., the learner; Wauters, Desmet, & Van Den Noortgate, 2010).

Feedback

Different kinds of feedback are integrated in the GBLE. Players get feedback about their accuracy (whether their solution is right or wrong), their efficiency (how many assignments did they solve correctly), and their progress (how many rooms they still have to conquer).

A first kind of feedback is the immediate corrective feedback in the mini-games. When players answer an assignment, they get immediate feedback about the accuracy of their answer. This—more simple but immediate—feedback (FT, correct/wrong) might suffice for the players because they already master the learning content from earlier grades, whereas learners who still need to learn the content or the problem take more advantage of more detailed/elaborated feedback (Vandewaetere, Cornillie, Clarebout, & Desmet, 2013). However, no textual or content-related feedback is given to the players. This was a conscious decision of the game-developers, who were concerned that this kind of feedback would disturb the game-flow.

Fig. 7 Feedback: Scoreboard after mini-game

Additionally, when a mini-game is finished, regardless who won, players get feedback about their accuracy. This visually presented feedback informs the player about how well they performed in the mini-game; they can see how many assignments they solved correctly and how many wrong. They also see how many points they earned during this mini-game and the difficulty of the math rule that was incorporated in the mini-game. They also get this overview of the monkeys' scores, so players can be compared (see Fig. 7). In this case, the player outperformed the monkey and won the mini-game.

Finally, players also get visual feedback about their overall progress in the GBLE. Before players enter a new room, they get an overview of the museum and see their progression: How many rooms are already passed, how many rooms still needs to be done (see Fig. 1). By giving the players this overview, they get a reminder of the game goal (reach the end-game to beat the dinosaur) but also stimulated by seeing the approaching end-game.

Use in Research

The game-based learning environment "The Museum of Anything" is used in various studies as, for example, in the studies "Performance in educational math games: Is it a question of math skills?" (this volume) and "The integration of competition as game-element in vocational math course" (this volume). Because the Monkey Tales series are already existing commercial game environments, no thorough

adjustments of the environment can be carried through. More concrete, the story line and the game-environment cannot be adjusted and remain the same for research purposes as in the commercially released version of the games. However, some customization is possible to conduct studies. For instance, the adaptivity mechanism can be deactivated, the learning content can be changed and all player actions can be logged in log files.

First, the existing adaptivity mechanism (i.e., easier math rule after losing a mini-game) can be disabled. Consequently, if a player loses a mini-game against the monkey, the same math rule in the same mini-game format is offered. The removal of the original adaptivity model entails that the math content and hence the mini-games were offered in a fixed order: Each console contained one specific mini-game with all items following the same fixed math rule.

Second, the content of the GBLE can be adapted. The math rules that are used in the GBLE can be adapted to the age or curriculum of the target group and consequently the environment can be applied for different target groups. However, these changes are only possible after consultation with the game-developers. Access to the math rules is necessary which can only be given by the game-developers. After receiving this access, the math rules can easily be adapted, but have to be in line with the format of the mini-games (i.e., not all math-rules can be applied in all the mini-games because of the specificity of the mini-games).

Another advantage of using the Monkey Tales Series for research purposes is the possibility of logging all the actions of the players. The logging can happen online (on a server) but also local (on the pc the player is using). During playtime, all actions are logged (e.g., number of bananas picked up while solving the 3D-puzzle, number of correct answers during the mini-games on the math exercises, time-stamps). These extensive log-data create extra research opportunities, for instance, to investigate players' game behavior, learning, and performance during game-play.

To conclude, Monkey Tales can be used for a variety of research purposes. First, it can be used for studies which focus on the effects of the use of educational games in the classroom (e.g., effect on performance, motivation, …). Although the Monkey Tales series were developed for learners from 7 till 11 years, the content can be adapted and the environment can be applied for different target groups. Secondly, the availability of accurate log files allows researchers to look at learners' behavior in the game in a very objective way as well as their mathematical performances during game play. However, contact with the developers is essential to receive these log files, as well as for several manipulations in the environment itself. This constrains the widespread use of the environment for research purposes.

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