THE LOGICAL JOURNEY OF REIMAGINING "ZOOMBINIS"

Adventure, Research, and Computational Thinking

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ABSTRACT

TERC, FableVision Studios, and the Learning Games Network have redeveloped and re-released the popular game from the 1990s, The Logical Journey of the Zoombinis. The 2015 version, called Zoombinis, was redeveloped for mobile, desktop, and WebGL platforms. The relaunch was aided by a longstanding and devoted fan base, which enabled a successful Kickstarter campaign to help support the re-launch. In addition, the re-release of the game triggered research interest about how Zoombinis supports the development of Computational Thinking (CT) in upper elementary and middle school learners. Many of the skills players use to solve the logic puzzles in Zoombinis require CT practices such as Problem Decomposition, Pattern Recognition, Abstraction, and Algorithm Design. To study the development of CT in Zoombinis, The Educational Gaming Environments group (EdGE) at TERC conducted a nationwide implementation study with over 30 classes of learners in grades 3-8. This research uses Educational Data Mining to design and validate automated assessments of CT that use the data logs generated through Zoombinis gameplay. This allowed a study of CT skills that

players demonstrate implicitly during their puzzle solving. Thus far the research study has found that 1) teachers highly value activities that help them connect CT in the game to their math, science, and other class content, 2) teachers are finding that students with individualized educational plans (IEPs) are becoming class leaders in Zoombinis activities, and 3) patterns have been identified in the players' gamelog data that can reliably be said are consistent with CT. Future work in Zoombinis includes packaging the game for school use with teacher and classroom materials, as well as further development of Zoombinis in alternate media (e.g. AR/VR/XR and/or linear programming).

BACKGROUND

Arising out of data literacy research done at TERC in the early 1990s, *The Logical Journey of the Zoombinis* was created by Scot Osterweil and Chris Hancock to help kids "find the fun" in core mathematical and logical concepts and became an instant sensation in "edutainment" games. Well before the current push for education in CT, Osterweil and Hancock recognized the need for learners to understand the types of problem solving required to design algorithms, networks, and information systems. The designers originally intended to create a game that would engage players in the thinking necessary to understand databases. That was an "out there" idea in the '90s, but hugely salient today.

Osterweil and Hancock were also prescient in understanding that the digital age would bring a learning revolution centered around play. Game-based learning has taken off as a research field and a commercial industry, but it is still rare to find a game where the game mechanic is inherently aligned with a meaningful learning mechanic. Plass, Homer, & Kinzer (2015) explain that it is this alignment between game mechanic (a player's intended activity in the game) with learning mechanic (how players are intended to learn through their game activity)

that also allows the design of an assessment mechanic (how their in-game activity can be used as evidence of learning). *The Logical Journey of the Zoombinis* was the first in a series of three CT games and is still what some consider the first and, arguably, one of the few true learning games.

The original '90s release won numerous awards including the "Best Home Education for Pre-Teens" CoDIE Award. The series also gained an extensive loyal fan base. A Facebook group of 6,000+ members self-spawned without promotion from TERC or any of our partner publishing companies. This fan base became very useful during the re-launch of the game. A pre-release survey received over 1,000 responses with over 150 educators responding with quotes such as:

> *I bought this for my daughter when she was three or four. She's got great logic and spatial skills as a result. However, I used to play it every night after putting her to bed. I swear it helps me learn new things and keeps my mind sharp. I love it.*
>
> Zoombinis *helped develop many of the logical thinking skills that I use daily as a programmer and have made me so successful.*
>
> *At 25, I recognize how much the pattern recognition and logic games actually benefited me and taught me some serious critical thinking.*
>
> Zoombinis *was incredibly valuable when I homeschooled my kids. They love, love, loved it. We all played it. Now they're in college, and taking computer coding. And surprize, surprize, they have suddenly realized why they're so good at it.*
>
> *I used it in an after-school program for underprivileged kids and it was their first exposure to computer games and using logic. It was a huge hit!*

With this kind of encouragement, TERC set upon re-releasing the game.

THE RELAUNCH OF *ZOOMBINIS*

Zoombinis was originally developed in the 90s by TERC in partnership with Broderbund. Two sequels followed in the early 2000s, with much success. But with the dot-com crash and collapse of the edutainment market, *Zoombinis* fell on hard times, passing through the hands of a series of publishers with no updates or maintenance. By 2010, it was hard to find a PC/Mac that *Zoombinis* would run on. Nevertheless a hard core fan base of *Zoombinis* players and educators persisted, keeping old machines running and tweaking configurations to keep the game alive.

The rapid onset of iPad and Android tablets offered a perfect interactive experience and new opportunity for *Zoombinis* to be reborn. After some discussion with the publisher Houghton Mifflin Harcourt, who then held the rights to *Zoombinis*, the game was released back to TERC along with a hard drive of all the original assets including the audio files and artwork.

Based on the educational value of the game, the core base of enthusiastic fans, and the coming of tablets, TERC's Board funded the redevelopment of *Zoombinis* for tablets. TERC chose the highly-regarded Boston-based FableVision Studios, working with Learning Games Network (where Scot Osterweil worked), to redevelop and re-release *Zoombinis* for today's audience and modern devices. A marketing firm, The Game Agency, who in turn involved Tinsley PR, were key players in raising awareness of the relaunch.

The re-launch of *Zoombinis* relied heavily on previous fans. In addition to a fan advisory board and a new Facebook page centered around the redevelopment effort, TERC launched a Kickstarter to 1) raise additional funds to enhance the redevelopment and 2) further engage new and old fans alike. The

Kickstarter raised over double its goal, ending at a little over $100,000, which covered development for the Mac, Windows, and Amazon Kindle platforms as well as improvements to the game itself. *Zoombinis* launched anew in fall of 2015.

By the time research was launched in 2016, the market had rapidly shifted. Most schools were using Chromebooks by then, so a WebGL version was developed for our research study and to bring the game further into the school market. Knowing that the functionality of some puzzles would have been compromised if the interface was scaled down for small phones, the decision was made to stick with tablets. Since smartphones are now bigger, development is under consideration for the newer, larger phones.

The re-release of *Zoombinis* has now been in the marketplace for over three years with several maintenance updates. TERC partnered with Encore Software for the desktop release and *Zoombinis* became a #1 paid app in the Educational section of the MacOS App Store. The re-release won a Parents' Choice Silver Honor Award and a REVERE Award in the "Beyond the Classroom, Play category."

PREMISE/SUMMARY OF THE GAME

Zoombinis is an adventure puzzle game where players must guide their pack of adorable Zoombinis on their journey to Zoombiniville to escape the evil Bloats who wish to do them harm at every turn. Players lead packs of 16 Zoombinis through a series of 12 puzzles (each with four levels of difficulty), eventually having to get 400 Zoombinis to their new village, Zoombiniville, to win the game. The ever-changing puzzles, where the rules are different for each new pack of Zoombinis, mean players must figure out *how* to solve the puzzle, not learn specific solutions.

Each Zoombini has a unique combination of hair, eyes, noses,

and feet. The game begins with a Zoombini creator where players can customize their pack of 16 (e.g. creating all one feature the same to reduce the ambiguity of the puzzles, or just making a group of Zoombinis that they like) or they can choose a random group and be on their way.

Figure 1: The Zoombinis Map tracks player progress through the game (Journey mode) and allows players to jump directly to any of the 12 puzzles at any of the four levels (Practice mode).

Puzzles require players to sort, match, and sequence their Zoombinis by attributes to solve the challenges and traverse the land (see Figure 1). For example in the puzzle shown in Figure 1, Allergic Cliffs, players must figure out which Zoombinis can cross which of the two bridges, with each bridge supported by a cliff face with Zoombini-related allergies. In Figure 2, for example, the upper cliff face is allergic to pink noses, while the lower cliff is allergic to all non-green noses. At higher levels, the

allergies become more complex (e.g., green noses and propeller feet).

Figure 2: A screenshot from the Zoombinis puzzle, Allergic Cliffs.

STUDYING COMPUTATIONAL THINKING IN ZOOMBINIS

Many of the skills applied in *Zoombinis* gameplay falls under the category of Computational Thinking. Computational Thinking (CT) is the set of ideas and practices considered vital for computer science skills, and has been attracting increased attention over the past several years in K-12 education (Barr & Stephenson, 2011; Grover & Pea, 2013; Shute, Sun, & Asbell-Clarke, 2018; Weintrop et al., 2016; Wing, 1996). When studying Zoombinis, we focus on four fundamental facets of CT:

Problem Decomposition: The reduction of ambiguity or complexity of a problem by breaking it into smaller, more

manageable parts. This is comparable to isolating variables or systems to test.

Pattern Recognition: The recognition that objects are arranged following a rule or rules. The identification of groups of solutions or characteristics of solutions that can be categorized.

Abstraction: The removal of details to identify and extract relevant information to define main idea(s) or solutions.

Algorithm Design: The creation of an ordered list of instructions for solving a problem or doing a task. The creation or explication of general solutions to a problem or family of problems.

In a national implementation study, over 50 classes in grades 3-8 used *Zoombinis* as part of their STEM or general education curriculum. Teachers spent at least 10 hours of class time having kids play the game and/or using offline activities that helped make connections between the game puzzles and CT. Students were also encouraged to play the game at home.

The class activities were designed to help bridge the *implicit* learning that occurs in the game to *explicit* learning in classrooms. Learners often demonstrate more knowledge in their everyday activities than they are able to express on a test or assignment at schools (Sternberg, 1996). When players learn in games, that knowledge may be implicit—demonstrated through behaviors but not expressed in words by the learner—and need to be leveraged by teachers for classroom learning (Rowe et al., 2014; Thomas and Brown, 2011).

EdGE at TERC designed a set of materials teachers could use to help bridge implicit game-based learning in *Zoombinis* to explicit CT learning in their classroom. Some of the classroom activities had the class act out the puzzles, where some of the class were the rule makers and the others had to follow them. The teacher could support their learning by asking questions about patterns

and abstractions while the students "become" the puzzle. Other activities used graphical organizers, such as data tables, to help students keep track of their information as they solved the puzzles. Many of the activities made connections to STEM learning as well as CT.

To study the development of implicit and explicit Computational Thinking, the research team at EdGE conducted a nationwide implementation study in the 2017-18 school year with over 30 classes of upper elementary and middle school students. Not only did EdGE observe classroom practice and collect log data from teachers about how they used *Zoombinis* in the classroom, they also collected log data from the game, recording every game event with a timestamp and a playerID.

EdGE worked with colleagues from University of Pennsylvania to build and validate implicit CT learning assessments in *Zoombinis*. They used Educational Data Mining (EDM) methods grounded in extensive video and screen capture observations. First researchers analyzed observations of over 70 players playing the first two levels of three of the *Zoombinis* puzzles: Allergic Cliffs, Pizza Pass, and Mudball Wall, and have identified common strategies with high inter-rater reliability (Rowe et al., 2018). And now EdGE is building EMD models to automatically detect that evidence within players' data logs.

EdGE also worked with Empirical Games to build and validate a series of online assessment tasks that measure CT outside the context of *Zoombinis*. During the implementation study, each class completed a 30-minute pre- and post-test with these tasks, which are used as a measure of their CT gains during the study period. Teachers also gave independent ratings of each of their students' CT skills.

Analysis from this study is expected to be completed in early 2019. EdGE will compare the strategies players used in the game

to their performance on external pre/post tests of CT, as well as how their teacher rated their CT practices. EdGE also looks at how much bridging teachers did in each class. They anticipate that learners who demonstrate strategies consistent with CT and who are in classes with high bridging will show the greatest performance on external post-tests of CT, when accounting for their pre-tests.

In discussions with teachers in the study, they reported that often their learners who typically struggle in class were excelling with *Zoombinis*. CT may come more naturally to learners who have cognitive challenges, such as autism, because they may be strong at seeing patterns and abstracting those patterns. Companies such as Microsoft recognize this overlap, starting hiring programs specifically for people with autism. The team is looking at ways to leverage this fun and engaging way of reaching learners who may have many talents, but who may need other ways to express them.

THE FUTURE OF *ZOOMBINIS*: WHAT'S NEXT

Zoombinis serves as both an entertaining activity and as a game-based educational tool. Early research shows that its impact in the classroom is positive, particularly for learners who may struggle academically.

As part of the research, a suite of classroom activities has been developed, intended to support teachers' bridging of game-based learning to classroom learning. These activities include Teacher Guides for off-line and online activities; connections to coding, science, and math; and wall posters and other materials that teachers can use to support the connections between gameplay and other activities. Now that the research is coming to a close, TERC plans to package the game and educational materials in a classroom product.

The team is also seeking ways to extend *Zoombinis* gameplay to

the next generation of learners. Ways to use Augmented Reality and even Virtual Reality are being considered to create immersive and multiplayer *Zoombinis* experiences. As the game moves to new platforms and media, the team behind *Zoombinis* will endeavor to keep the quality of the game experience and the learning experience to as high a standard as it has enjoyed for the past two decades.

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