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# Educational Games Design: Creating an Effective and Engaging Learning Experience

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<p>The purpose of this thesis was to study the use of games as a medium to teach and to see how they can create a fun experience for the learners while being able to be effective as a learning tool. Despite there being many educational games, there are few that are considered to be successful. Slapping educational content into a game is not enough. Some design elements need to be considered and finding the correlation between gameplay and content is important.</p> <p>This paper is divided into two parts. The first part examines learning theories, concepts of fluid and crystallised intelligence, and issues of the traditional school system. The second part focuses on game design, looking at gamification and game-based learning, Flow Theory, elements of game design and User Interface design. Finally the paper looks into the Finnish education system and its reform. I received guidance on the thesis from Sanoma Pro and was also able to get an insight into their digital learning solutions, in particular their gamified platform Bingel.</p> <p>The results of the literature review were applied to Animal Kingdom, a game that teaches primary school children about animals. By focusing on balancing gameplay and content, maintaining flow, and through use of visual elements children can be engaged in learning a subject. The game was tested in Maunula primary school and I also received feedback from their 3rd grade teacher.</p> <p>There are various methods that can be applied in educational games especially as technology continues to advance. This thesis presents a few of the methods that games can approach to create effective and engaging learning experiences.</p>	
Key words	game-based learning, gamification, flow, UID, education

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## 1. Introduction

The modern educational challenge involves the task of engaging students, stimulating their interests and retaining their attention [1]. Digital games can create active and engaging learning environments [2]. There is research to suggest that digital games and education can go hand in hand, in fact we can already see examples of schools implementing game-based learning into their curricula. Despite many educational games in the market, several still fail in reaching adoption or success [3]. There are many factors that have to be considered when designing an educational game, not just the addition of educational content.

My interest in educational games sparked when attending a talk by Gonzalo Frasca, a game designer and academic researcher from Uruguay, at Aalto University. His talk made me note the importance of education and realise that games can be made to serve purposes other than to deliver pure entertainment.

My early experience with educational games was with JumpStart typing from the JumpStart Learning games series. The game taught basic typing by having the player type out words that appeared on the screen to avoid the character from crashing into obstacles. In the 3rd grade, where we were just starting to learn to type, I had already learned to do so and could proceed to more advanced tasks. It is experiences like these that make me appreciate learning games and so my thesis will focus on the topic of educational games.

In August 2016, the Finnish education system went through a reform and the key principles were the inclusion of technology in schools and the shift away from traditional teaching practices. This change will bring forth new teaching methods and focus on a student-oriented environment. This paper will focus on the use of games as a medium to teach students a subject, looking at game-based learning and gamification as examples.

The thesis will be divided into two parts, the first part will look at the issues of the traditional school system and how they are solved through digital games, some examples of early educational game titles, different learning theories and how they are applied in games, and the concepts of fluid and crystallised intelligence to understand how we learn, obtain and maintain new knowledge.

The second part will focus on the design of games, by evaluating game-based learning and gamification and looking at some examples. DragonBox Algebra will be used as an example of a successful educational game and will be reviewed for its design approach in engaging students in learning algebra. The paper will also look at the theory of Flow, Marc Prensky's elements of fun in games and User Interface design.

The paper will also look at the educational system in Finland and its reform and finish with Sanoma Pro's Bingel as a current example of gamification in the classroom. My research will then be applied to Animal Kingdom, a learning game that aims to teach children about animals.

## 2. Games and Learning

This section will examine how we learn from games and how they steer away from the traditional school system. Next, it will study the psychology of how we learn by evaluating different theories for learning and by going through the concepts of fluid and crystallised intelligence.

### 2.1. Traditional School System

If one asks a child "What is work?", they will say "school and homework". Asking them "What is play?", many will say "video/games" [1]. We have all probably felt this way at some point in our childhood. The need for high-quality education is important but traditional teaching methods are no longer kindling children's motivation to learn. [94, 100.]

We learn by exploring and that gives us pleasure so naturally we're inclined to enjoy learning, it is the school system that kills that. (Gonzalo Frasca, March 17, 2014, a lecture in Aalto University part of Aalto Games Now).

The traditional way of teaching, also known as the "sage on the stage" model, involves a teacher at the front of the classroom providing a lecture to students. This scenario brings up several issues: one, it limits the interaction between the students and the teacher, placing students in a "passive" role making no room for active learning; two, it disregards the different learning styles and abilities in the classroom that result in some students being held back or discouraged from learning [4]; and three, it demotivates students because they have little interest in the subjects they are being taught [5].

Also with the rapid rise in technology, the new generation of children, the N-generation, no longer find the traditional way of learning relevant or engaging. From an early age they are exposed to smartphones and tablets and their expectations when it comes to learning are different [6; 94, 2-4]. "We are working hard to educate a new generation in old ways, using tools that have ceased to be effective...If we want to improve education, it is incumbent upon us to invent radically new ways of learning that mesh with their new world, style and capabilities." [94, 7.]

Today, children have access to a lot of information. They can learn from watching videos on YouTube or by taking courses online. Technology has allowed on the devel-

opment of students' research skills and on learning to be carried out at students' own pace [7]. Now it is more about how students can use this information to prepare them for the real world.

Learning is not only about memorising dates or formulas. It is acquiring the necessary skills and thought processes needed to respond appropriately under challenging situations [8]. Students are being fed information when they should be developing their own understandings to build up their knowledge. Schools should help prepare students for real-world challenges through effective and interactive experiences that will motivate them and actively engage them in the learning process. "The goal of studying is no longer to make the grade, earn a diploma and find a good job. Rather it is to understand what is happening around one, to develop a personally meaningful sense of what one's experience is all about. From that will come the profound joy of a thinker." [93, 141].

## 2.2. Learning Through Games

Digital games are an interactive technology that can be used to engage children in the learning process [9]. We are living in a time where digital games are at their peak, with the video games industry averaging at 16 billion in revenue for the past 6 years [10].

Digital games are being researched for academic purposes for their potential to serve as a medium for conveying learning materials. They have proven to be effective in terms of engaging students in educational experiences towards achieving specific learning goals [8]. Digital games have been valued for their motivational capacity thus being able to convey a motivational educational experience. "Games are an industry standard in terms of designing for engagement, interactivity, immersion and collaboration." [11]. Below are 12 elements of games that Marc Prensky lists in his book *Digital Games-Based Learning* [94, 106]:

- Games are a form of fun. That gives us enjoyment and pleasure.
- Games are a form of play. That gives us intense and passionate involvement.
- Games have rules. That gives us structure.
- Games have goals. That gives us motivation.
- Games are interactive. That gives us doing.
- Games have outcomes and feedback. That gives us learning.

- Games are adaptive. That gives us flow.
- Games have win states. That gives us ego gratification.
- Games have conflict/competition/challenge/opposition. That gives us adrenaline.
- Games have problem solving. That sparks our creativity.
- Games have interaction. That gives us social groups.
- Games have representation and story. That gives us emotion.

Looking back at the issues with traditional teaching and the list above, games can make students take a more active role through interaction with a game, by exploring different options and unleashing their creative thinking skills to tackle obstacles. This is done by the rules that games establish. "Rules impose limits—they force us to take specific paths to reach goals." [94, 119]. Having these constraints telling us what we can or cannot do widens our ability to think creatively.

Games also allow for a more personalised experience through instantaneous feedback and adjusting themselves to the ability of the player to create what is known as "flow" (which will be discussed later in chapter 3). "Outcomes and feedback are how you measure your progress against goals." [94, 121]. Immediate feedback is probably the most important aspect of games. They tell us whether we are doing something right or wrong and help us progress through the game. "The player is learning constantly how the game works, what the designer's underlying model is, how to succeed, and how to get to the next level and win." [94, 121]. What is more, feedback makes us more confident to take on different options, to try again when we fail and seek for help.

Game developer Zach Barth points out, "one of the things that's obvious with educational games is that you're trying to teach something. And one of the things that's not obvious about entertainment games is that you're trying to teach something." [12]. Games teach themselves, but what is more is that they give one the necessary information for the current situation and let the player build on that information to act accordingly. "You don't read a manual on how to play SuperMario and be expected to memorise it before playing the game." [13].

Finally, games give players motivation and can kindle their interest in the subjects the games are teaching. An important aspect of digital games is that they give players agency, or the feeling that they can make a difference. Players are often confronted



with tasks or objectives where they have to make a choice on how they will solve them. They are not being told how to solve them, instead they have to figure it out on their own even if it means failing a few times [14]. In the end that is what games are about. They are about failure, but they let one try again and explore other options. "To progress in a game is to learn; when we are actively engaged with a game, our minds are experiencing the measure of grappling with (and coming to understand) a new system. This is true whether the game is considered 'entertainment' or 'serious.'" [8].

### 2.3. Early Educational Games

Educational games have seen their start since the Middle Ages with the game of chess which taught the strategies of war, but it wasn't until the mid 20th century that people began to associate games and learning [15]. Johan Huizinga (1872-1945) was a Dutch Historian who wrote a book in 1983 titled *Homo Ludens* (Playing Man) which discusses the importance of play in culture and society. This book has become an important part of the history of games and continues to be a reference in game design. [16.]

With the arrival of personal computing, there was the possibility of commercialisation of learning games in the 1980s. Early titles taught students Maths, History and problem solving. These games showed that educational games were not just a tool for teaching but they showed that education can also be fun. [15.]



Figure 1. Early Educational Games. A) Lemonade Stand (1979). B) The Oregon Trail (1985). [90.]

Early examples of educational games include *Lemonade Stand* (1979), where players have to run their own lemonade stands by choosing the number of ingredients to purchase, how to price their lemonades, and how to advertise them (figure 1A). The profit

the player gets at the end of the day is affected by conditions like the weather. This game taught players business and economics and inspired similar future titles like Zoo tycoon. [17.]

The Oregon Trail (1985) is another great example of an educational game. It was designed to teach students about pioneer life in the 19th century. The objective is for the player to lead a family across the West in hopes of making it to Oregon. The game was developed in 1971 by an 8th grade history professor Don Rawitsch for his class with help from professors Bill Heinemann and Paul Dillenberger. The game was released in 1985 for Apple II, with the user having to answer prompts printed on the screen (figure 1B). The player has to hunt for food, ration supplies and face obstacles such as crossing rivers and even face death as members of the party could fall ill with diseases or exhaustion. [17.]

The Oregon Trail was a prime example of educational context in video games and was popular among elementary school students up until the mid 2000s. This game paved way for future educational games.

## 2.4. Learning Theories

### Behaviourist Learning Theory

Behaviourism views learning as the change in behaviour caused by an external stimuli. Also known as the "carrot on a stick" approach to learning, the key principle of behaviourism is the reward or punishment of behaviour. Rewards reinforce the behaviour while punishments disregard them [18].

Games that apply these principles include games like Farmville. These games condition one to repeat actions to achieve a goal or reward. A term given to these games is "Skinner box". Psychologist B.F Skinner, theorised that one could condition volition, or change the way people made choices through reinforcements such as points and power-ups [19]. Some argue that gamification is a product of behaviourist approaches to game design [18].

In this approach, the learner takes a passive role, absorbing information through drill and practice. The role of the teacher is to correct any mistakes the learners make. [20]. While this approach may work when recalling facts, it does not work where in-

formation needs to be further processed, such as when learning a language, solving a problem, or where critical thinking is involved. [21.]

### Cognitivist Learning Theory

Cognitivism views learning as a change in knowledge as opposed to a change in the learners' behaviour. It states that learning is an internal process coming from one's own experiences [22]. The process of cognitivism starts with the transmission of information that learners can put into a familiar context. This can be accomplished through the use of metaphors and analogies. [21.]

This theory places students in a more active role as they process the information they receive. The role of the teacher is to correct any misconceptions [20]. Games that apply this theory include puzzle games or games that require critical thinking. Behaviourism uses rewards and feedback as reinforcements to modify behaviour as opposed to cognitivism which uses feedback to guide the learner towards their learning goal. [22.]

### Constructivist Learning Theory

Thus far, we have discussed theories that fall into the objectivist learning category. Objectivist theories view knowledge as existing outside the mind of the individual. Behaviourism and cognitivism focus on the transmission of information from someone who knows, i.e. the teacher, to the learner. [24.]

The constructivist theory, developed from the views of Piaget and Vygotsky, takes cognitivist principles further by encouraging the learner to build their own knowledge. Learning occurs through observation, processing and interpretation. Jonassen states that the difference between cognitivists and constructivists is that "cognitivist psychologists think of the mind as a reference tool to the world; constructivists believe the mind filters input from the world to produce its own unique reality." [quoted in 21, 55]. The role of the teacher changes to one of a guide for the students and learning becomes an exploratory process. [20.]

Examples of games that use this theory are open-ended games like Minecraft or Spore, where the player is provided with elements that they can experiment with and manipulate [23].

### Social Learning Theory

The social learning theory describes learning that takes place in a social context. Rather than the learning occurring within an individual, it occurs in groups through observations, discussions and sharing. Because of the different levels of experience that can exist in a group, the learners can learn from each other. For example in games like World of Warcraft that rely on teamwork, players can learn by observing or imitating other players. [25.]

Soviet psychologist Lev Vygotsky (1896-1934) developed the concept of the "Zone of Proximal Development" which is the gap between what a learner can achieve on their own and what they can achieve with help from others. "Through increased interaction and involvement, students are able to extend themselves to higher levels of cognition." [25.]

### Situated Learning Theory

The situated learning theory was developed by Lave and Wenger in the early 1990s. Following Vygotsky's work, it states that "the learner and what is being learned are always situated in activities, processes and contexts." [26]. Learning comes from more than just external reinforcements. It comes from the individual's interaction with others through language, symbols and making sense from their experiences.

With digital games, experiential learning becomes possible by replicating real-world scenarios and transferring the learning into actual practice [27]. "Without taking these factors into consideration, we only encourage students to develop isolated, unrelated skills for external rewards." [28].

### Fluid and Crystallised Intelligence

Fluid Intelligence and Crystallised Intelligence are two concepts studied by Raymond Cattell, an American psychologist, in the 1960s. Fluid intelligence is described to be the

ability to solve new problems, use logic in new situations and identify patterns. Crystallised intelligence is the ability to use learned knowledge and experience. [29.]

On the basis of the concepts of fluid and crystallised intelligence, Andrea Kuszweski, a behaviour therapist, outlines 5 ways we can increase our fluid intelligence. These include: seeking novelty, challenging ourselves, thinking creatively, networking and doing things the hard way. [30.]

Kuszweski states that as we engage in a new activity, we create new synaptic connections which play a role in the formation of memory. These connections build on each other increasing neural activity and triggering dopamine, preparing our brains for learning [30]. Research has gone to show that playing video games stimulates dopamine release in our brains and that "propels us to explore new avenues for reward in our environment," says neuroscientist Jaak Panksepp [31].

About challenging oneself, Kuszweski says that "in order to keep your brain making new connections and keeping them active, you need to keep moving on to another challenging activity as soon as you reach the point of mastery in the one you are engaging in." [30]. This ties in with the next factor: thinking creatively, which is described to be the means of using our entire brain to make associations, switching between conventional and unconventional thinking and creating solutions for the task at hand [30].

The presentation of new challenges can make us learn something new, thus creating new synaptic connections, or pathways. If we encounter a similar situation our brains return to those existing pathways making faster and stronger neuroconnections [32]. If our brains practice going outside their normal comfort zones, the better they will get at creative thinking [33]. The next point is networking. By communicating with other people we can expose ourselves to new environments and new ideas [30].

About doing things the hard way, Kuszweski suggests to "stop googling until you've given your brain a chance to resurrect the memory on its own." [30]. Just as we have to exercise our bodies or we will lose mass, we have to exercise our brains. Video games train our brains by making us face obstacles that require us to use our memory whether it is to remember critical sequences or track narrative elements [34].

These ways of increasing our fluid intelligence share the same qualities like those of video games. If we look at the game of Mario as an example, at first we are presented with the "goomba" enemies which we learn can be killed by jumping on their heads. As we progress through the levels we are faced with slightly more difficult enemies which we can learn to beat based on how we defeated the previous enemies and so forth. It is at this point that we start using our crystallised intelligence when we run into a different type of enemy.

### 3. Games and Engagement

Educational games have the potential to teach children and engage them in learning. However, they have had little success due to their design [37]. They do not use the full potential of the medium. Educational technology still lacks research on how to design a game environment that can teach something whilst maintaining an engaging and entertaining experience for the player [38].

This chapter will look at Flow Theory, researched by Mihály Csíkszentmihályi, a Hungarian psychologist, that describes how people achieve a state of flow, or extreme engagement [92]. Next it will look at game-based learning and gamification, designing for meaningful play and user interface design. It will finish by evaluating DragonBox Algebra, an example of a successful educational game that engages students in learning algebra.

#### 3.1. Flow Theory

An important factor in learning as well as in a game's experience is motivation. If players lose their motivation, it is because they are no longer having fun [35]. The same way goes for education. To keep students engaged in learning we need to maintain their motivation.

Mihály Csíkszentmihályi, a Hungarian psychologist, studied how people felt when they were most immersed in an activity. His research led to his theory of optimal experience based on the concept of flow which he describes to be "the state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it." [92, 4]. Learning best occurs when people are engaged in activities.

Through his research, Csíkszentmihályi outlines 8 major components of flow: confronting tasks we have a chance of completing, clear goals, immediate feedback, concentration, removing our worries and frustrations from awareness, sense of control over our actions, loss of self-consciousness and an altered sense of time [92, 49]. At least one of these components has reflected how people felt when their experiences were most positive which resembles what gamers experience when they are immersed in games.

From these 8 components the first 4 are needed for a flow state to exist. The first is to make the person feel they have a chance of completing a task. Csíkszentmihályi points out that engagement occurs when the “opportunities for action perceived by the individual are equal to his or her capabilities.” [92, 52]. If an activity is too difficult we become frustrated and feel that it is not worth it. On the other hand, if the activity is too easy; we get bored and will move onto something else. This is further illustrated in figure 2.

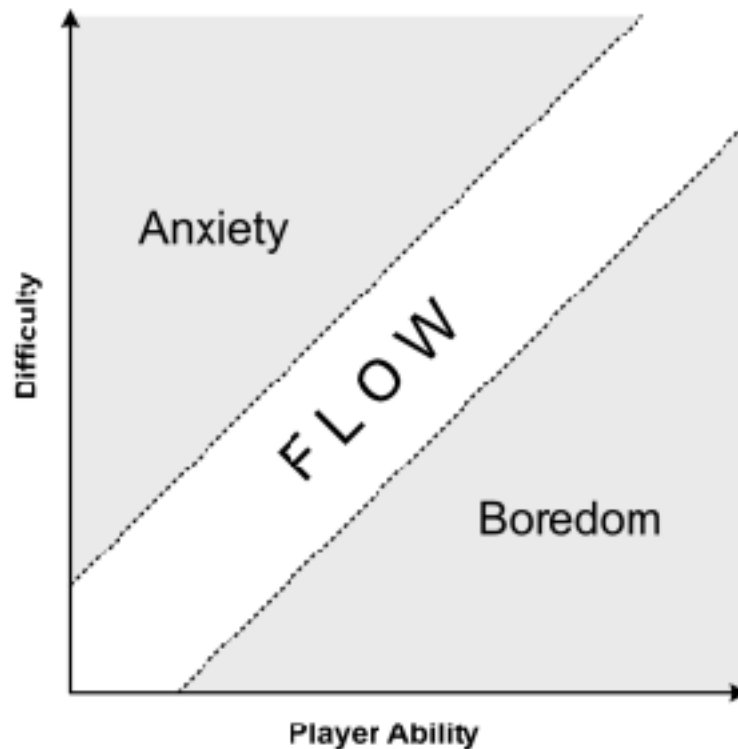


Figure 2. Maintaining a Flow State. [88.]

Maintaining a balance between challenge and the player’s ability is important when it comes to motivation and learning. “One cannot enjoy doing the same thing at the same level for long. We grow either bored or frustrated; and then the desire to enjoy ourselves again pushes us to stretch our skills, or to discover new opportunities for using them.” [92, 75]. The goal is to be at the point where the player can succeed if they try hard and this is where the fun in games comes from.

The next two components of flow are clear goals and immediate feedback. “A tennis player always knows what she has to do: return the ball into the opponent’s court. And each time she hits the ball she knows whether she has done well or not.” [92, 54].



Through feedback, players can see the immediate consequences of their actions. This is the key when it comes to learning as it informs us of our progress and can help us learn from our mistakes. "Almost any kind of feedback can be enjoyable, provided it is logically related to a goal in which one has invested psychic energy." [92, 57].

Games are good at putting players in a flow state. Let us look at Angry Birds as an example. The task of the game is to destroy the piggies to rescue the eggs. At the start, we are presented with the red bird, a slingshot and pigs hidden behind wooden or glass structures. The first few levels introduce the player to the rules of the game. Then the player is introduced to another type of bird with different features, thus increasing the challenge of the gameplay. However because the player's skill is also gradually increasing, there is a balance between ability and challenge, thus maintaining the player in a flow state.

The feedback in Angry Birds is shown as soon as the player flings the bird towards the pigs. A slight change in the angle in which the bird is launched will bring different results each time encouraging the player to change his/her tactics to destroy all the pigs with the least number of birds possible. There is also the sense of satisfaction that comes from destruction (the breaking of the glass, the explosions) and its cartoon style makes it funny and enjoyable.

The fourth component of flow is concentration. "Enjoyable activities require a complete focusing of attention on the task at hand—thus leaving no room in the mind for irrelevant information." [92, 58]. While many commercial games are good at doing this, it is a re-emergent problem in educational games. They take one out of the game by adding some kind of "icky, disgusting" learning [36]. The term for these kind of games is chocolate-covered broccoli and will be discussed in the next section.

### 3.2. Chocolate-Covered Broccoli

Chocolate-covered broccoli is a term used for educational games that hide the fact they are educational by disguising the content (the broccoli) with fun elements of games (the chocolate). Games that do this make learning look bad, when it can in fact be a fun and rewarding experience. "The goal for educational game design is not to teach but to have fun. Learning is a byproduct of repeating the gameplay." [95, chapter 1].

The problem with this approach is that it separates the learning from the gameplay and then we get games where the gameplay is interrupted with some educational content. The game Math Blaster often falls under this category as its gameplay consists of answering math problems that lead to animations and some shooting [40], and the engagement of playing the game is lost. "Simply slapping educational content onto generic play is an often-seen formula for failed educational games. It takes you out of the world of the game." [41].

Designing an educational game is a difficult process because it involves solving two goals during the game time: enjoyment and learning. "By focusing on the relationship between core mechanics and learning, we can estimate the effectiveness of a learning game by identifying the linkages between them." [42]. Learning can be made more enjoyable by integrating the learning content directly into the gameplay [41]. As the theory of situated learning suggests, the learning is embedded in activities, processes and meaningful contexts.

### 3.3. Gamification and Game-Based Learning

Game-based learning is essentially learning through the use of games. It is the integration of digital games into the learning process to create a more engaging and immersive learning experience.

As discussed in section 2.2, games can provide a personalised experience. Some people learn at different paces from others and games support that. Students no longer have to feel overwhelmed by the pace or complexity of the subjects being taught [27]. The process of play in video games revolves around learning a skill in order to solve problems and proceed to the next level where the player will learn a new skill. The tasks presented in games are often repetitive, which helps strengthen memory and provides real-time learning with immediate feedback, keeping players informed of their actions. It is amazing how quickly a child can learn a game and explain it to someone who has never played it.

The most important aspect of digital games is that they allow learning by doing. They add an additional layer of interaction to learning that cannot be achieved through reading books alone. Games can recreate real-world scenarios and place the student in that

world, such as the 19th century in The Oregon Trail. There is much that digital games can achieve while also being fun and enjoyable. Figure 3 shows a comparison between game-based learning and gamification.



Figure 3. Gamification vs. Game-Based Learning. [89.]

Gamification is the process of adding game elements to a non-game situation [44]. This method has been seen in corporate to reward their customers. Starbucks for example is using a star system to reward consumers for making purchases. Upon collecting a certain number of stars they can get a free beverage [45]. Gamification is also used in education in an attempt to turn the learning process into a game and while it does have potential it is often misused or poorly implemented [46].

The issue with the approach to gamification is that it applies only certain features that make up an entire gaming experience to gamify a course. These features or so-called “behavioral principles” include leaderboards, experience points and badges and they ignore other important elements of games such as narrative or contextual interplay of the player [46]. They do serve their purpose in terms of motivation and should not be disregarded but there is only an extent to which they become useful [28]. “Many educators have added a simple gamified element to a class without offering a truly gamified learning experience.” [44].

The popular gamified language application Duolingo is an example of gamification in education. It is a quiz-based application for learning a new language and it uses gamification to engage its users through the use of badges, achievements and the possibility to share progress with others. Duolingo is definitely motivating and while it can be helpful in the students’ learning, it can probably only do so to an extent. A language cannot be solely learned through a quiz-based learning application. To learn a language requires one to talk with native speakers to understand how words are used [47]. The learning has to be experiential and interactive.

Gamification takes a behaviouristic approach to game design when it should go beyond to encourage learners to think critically and solve problems. The use of rewards and achievements could be used as feedback to guide the player throughout the gameplay. If we think of our favourite games, it is not just the points that make them fun. There are many factors that contribute to whether a game is fun. We play games because of their story, we get attached to characters, games challenge us and give us feedback. This does not only apply to educational games but to commercial games as well. “If we look at commercial games, they have all the ‘game elements’ but most games are still boring.” [48].

#### 3.4. Design

Educational games are competing with commercial games. Children have high expectations in today’s video games, especially when it comes to graphics. “There are a lot of cheap, cruddy educational games out there and the problem is often both poor design and poor production values.” [39]. In order to meet those expectations educational games must be just as vibrant, fun and engaging. NASA invested on a multiplayer

game titled Moonrise Alpha to show lunar architecture. This is an example of an educational game of high production value and it has over 1.4 million downloads through Steam. [41.]

This section will look at the design of games and what makes them engaging by looking further at Prensky's 12 elements of play and Csikszentmihalyi's theory of Flow. It will also look at Nielsen's usability heuristics and how they can be applied to game design.

### Usability Heuristics

Usability is defined as "a quality attribute that assesses how easy user interfaces are to use." [49]. It is important for when a player approaches a game for the first time because it is through the interface that they will learn to play a game and it will thus determine whether they will decide to continue to play it [50]. If the interface is poorly designed, it can keep a player from enjoying a game.

Usability guru Jakob Nielsen developed 10 usability principles for heuristic evaluation: 1) Simple and natural dialogue, 2) Speak the users language, 3) Minimise the user's memory load, 4) Consistency, 5) Feedback, 6) Clearly marked exits, 7) Shortcuts, 8) Good error messages, 9) Prevent errors and 10) Help documentation [96, 20]. Usability heuristics are used to assess how good the design of a software is. Game designers have to craft a player's experience through a system of interactions and meaningful play emerges from the way players interpret and interact with the system [97, 374].

Nielsen's 10 usability heuristics were designed mainly for desktop applications, but they can still be applied to the design of games. Melissa Federoff describes how these heuristics can be adapted to game design [50].

The first usability heuristic, simple and natural dialogue (aesthetic and minimalist design), says information should be presented in a natural and logical order. The system should avoid presenting information that is irrelevant or not needed [96, 20]. User interfaces should be kept to a minimum as every additional piece of information makes it one more thing to learn and one more thing that could be misinterpreted [96, 115]. This translates in a pretty straightforward way into game design in that the interface

should be kept simple and non-intrusive, making it easy to access the game environment [50].

The second usability heuristic, speak the users language (match between the system and the real world), says the dialogue should explain itself to the user in familiar words, phrases and concepts [96, 20]. Similarly with games, through the use of metaphors and analogies to the real world, designers can make it easier for players to navigate the world created for them and interact with it [50].

The third heuristic, minimise the users' memory load (recognition rather than recall), states that information should be visible or easily retrievable whenever appropriate. This heuristic ties in with the tenth heuristic, help and documentation, that suggests that systems should provide help and documentation [96, 20]. Games however should not rely on manuals that teach how to play the game. Games should teach the relevant skills throughout the gameplay. [50.]

The fourth heuristic, consistency (consistency and standards), states that "users shouldn't wonder whether different words, situations or actions mean the same thing." [96, 20]. If a user knows that a certain action will return the same result, they will feel confident in trying out what is called exploratory learning because they will have the basic knowledge required to carry out another action [96, 132].

The fifth heuristic, feedback (visibility of system status), states that the system should constantly be informing the users about what is happening [96, 20]. "Not only do scores assist in telling the player where they stand, it is a form of positive feedback that encourages mastery of the game." [50].

The sixth heuristic, clearly marked exits (user control and freedom), states that users should have the ability exit a certain situation in the system through an "emergency exit", such as an "undo", have they stumbled upon a function by mistake [96, 20]. While this is not necessarily relevant to games, the concept of control and freedom is important in game design. Players should be given the ability to control the way they explore their environments. This can be done by allowing players to save their games at different locations so that they can revert to certain checkpoints and thus explore the game at their own pace [50].

The seventh heuristic, shortcuts (flexibility and efficiency of use), suggests the use of accelerators to make experienced users manoeuvre through the system at a faster pace. This allows for a system to cater for both inexperienced and experienced users [96, 20]. This is important in games design as games should draw players of different skill levels. This can be done by having the game adjust its difficulty levels to the skill of the players.

The eighth and ninth heuristics are good error messages (help users recognise, diagnose and recover from errors), which suggests presenting error messages in plain language as well as providing a solution, and prevent errors (error prevention), which states that to avoid having to use good messages in the first place, the design of the system should prevent problems from occurring [96, 20]. Federoff writes that "error messages are not necessary during game play because commands are made through physical actions instead of syntax and results of actions are obvious and can be reversed easily." [50]. These heuristics however could be applied in the case that a player wants to quit a game by being prompted to save before quitting. [50.]

### Meaningful Play

The goal of successful game design is to create meaningful game experiences for players [97, 33]. Meaningful play comes from the player's interactions with the system and the context in which the game is played, which can take the form of spaces, objects and narratives [97, 41]. Meaningful play can be created through Mark Prensky's elements of games and Mihaly's components of flow which include feedback, clear goals, rules and adaptivity.

Feedback is a recurring component and it is essential in improving knowledge and skills acquisition. Feedback is a motivating component for the learner if it is delivered correctly [51]. This includes being timed appropriately, being of relevance to the current task, positive and whether they can help improve the performance of the player. While there is no definition of what type of feedback is best, below are some examples for feedback implementation taken from Design Better Games! Flow, Motivation, & Fun [52]:

- Simple progress indicators such as task completed messages, completion/failure meters, and level indicators are standard mechanisms for feedback.

- Changes in the user interface (enabling/disabling actions) and interactions with in-game characters are a great way to provide feedback.
- Counters (e.g., 5 out of 6), quest progress (e.g., check marks), and other completion marks are important ways to give feedback about current progress.
- Guidance in response to a player's lack-of-action. This can reduce difficulty and also act as a form of feedback. This can include directing players to "look over, go here" or "look at this".
- Do not use subtle visual changes of text. Even large changes in text can be overlooked if the colour or shape does not change. Generally, you should consider using motion (visual or audible) or sharp contrast to direct attention to the feedback. If the player does not notice, the feedback, then the feedback did not occur.
- Natural consequences in response to player actions can be particularly powerful. This means exactly what the name implies and includes things such as watching a fire go out because they use the hose correctly, seeing water stop spraying when a patch is applied, or visualising the results of a catastrophic failure.
- Point scoring (e.g., 10,000 points), non-competitive high-scores (e.g., default scores to beat), and performance ratings (e.g., 3 of 4 stars) are standard ways to give feedback on how a player is performing relative to expected norms.
- Resource indicators should always be used, if the resource is important to the task. Make sure to give clear feedback about increases and decreases of key resources. Consider using scrolling numbers that are centrally located, but non-permanent (e.g., "XP: +10", "Coins: +5").
- Little badges or semi-permanent icons (e.g., "+8") can be used to provide feedback about progress that is less critical or not time-sensitive.
- Keep feedback focused on players' progress towards the goals of the game. Feedback about unimportant actions should be minimised — they are a distraction.

One of the biggest factors that influence decisions to play games is story [10]. Naughty Dog's *The Last of Us* is an example of games that take one through compelling stories and memorable characters [53].

"Representation means that the game is about something." [94, 125]. These representations can be symbols that encode information, in this case some educational content, and it is up to the player to interpret their meaning. They are supposed to serve as mental models that underly a message they want to teach to the player. This information should also be given to the players when they need them, rather than all at once,



and the challenges presented in the game should parallel what the player has learned. This goes back to the concept of flow, where the difficulty of the task should be balanced with the skill of the player.

"Gameplay takes place within a representational universe, filled with depictions of objects, interactions and ideas out of which a player makes meaning." [97, 364]. In order to create meaning, the context in which the game is played has to be established as well. This is done through the rules of the game. "The context of play affects how players understand and act upon the representation the game creates." [97, 366].

Game-based learning can involve commercial games whose initial purpose may not be for education or can involve games that are designed for a curriculum. An example of a commercial game used for educational purposes is Minecraft. The game "fosters life skills like creativity, curiosity, exploration and teamwork.", [54] so it only makes sense for its transition to education. A version of Minecraft, Minecraft: Education Edition, has been designed for teaching purposes covering subjects from programming, science and math to art, languages and history [54]. Teachers can add features to and set controls in the game to fit their classrooms. [55.]

Examples of digital games specifically designed to teach a subject include Scribble-nauts, which teach creative problem solving, logic and spelling, and Code Spells, a game that teaches Java by helping gnomes perform tasks by casting spells (or commands) [56]. However there is a game that is being praised as one of the most innovative math learning game and that is DragonBox Algebra from Norwegian based company WeWantToKnow [57].

### 3.5. DragonBox Algebra

DragonBox Algebra is a multi-platform math game with the goal of teaching children algebra. Released in May 2012, it has won numerous international awards and brought surprising results having been able to teach 93% of the children playing it the basics of algebra after 1.5 hours of gameplay [57].

#### Gameplay

The first level of the game shows us a board with two sides, a box, and several cards with characters or dice. The goal of the game is to get the "dragon box" alone on one

side of this game board, by getting rid of the other cards around it. Progressing to the next level introduces the concept that each card has a day card and an opposite night card (figure 4A).

The night cards represent negative numbers. Dragging the night cards to their respective day cards creates a vortex, representing the value 0, which the player can tap to remove, thus leaving the box on its own to complete the level.



Figure 4. DragonBox Gameplay. (2012) DragonBox Algebra 5+ (Version 1.3.1) [Mobile application software]

Algebraic rules are gradually introduced as you proceed through to the next levels such as the property of equality (figure 4B). The player can add cards from the deck to the board, tapping on them to turn them into night cards if necessary. The concepts of addition, multiplication and division are also covered. By the time the player reaches the fourth chapter they see the appearance of the plus and equals symbols (figure 4C). Finally at the last chapter the cards are replaced with letters and numbers (figure 4D). "By then, the player should be comfortable with the algebraic logic and can solve equations in the game". [57.]

Each level can award the player a maximum of three stars for getting the box alone, solving the problem in the right number of moves and solving it with the right number of cards. The game gives the player the option to undo moves or retry the level (figure 5).



Figure 5. DragonBox Feedback. (2012) DragonBox Algebra 5+ (Version 1.3.1) [Mobile application software]

## Design

DragonBox Algebra was designed by Jean-Baptiste Huyhn, a math teacher, through observation of his students and research into cognitive theory [69]. Huyhn encountered several challenges in the classroom which included lack of motivation, difficult subjects, communication barrier between the teacher and students, time constraints and not enough feedback. [59.]

By outlining these challenges he sought out to find a solution which revolved around the use of video games. Huyhn states that through games one can create a context, that can motivate kids, and create digital manipulatives, virtual objects you can manipulate to get an intuition of what the concepts are, in this case the concepts of mathematics. "We didn't introduce numbers on purpose, because it can scare people. All

rules were introduced with characters.” [60]. We learn through metaphors, and by comparing an unknown to something we know can make difficult concepts easier to understand. [61.]

Games give players an individual experience, the ability to learn at their own pace, and most importantly the time on task in games is high. When one plays the game, he/she is immediately playing around with math concepts. “The game is focusing on mathematical rules from the very first level to the very end of the game.” [62].

The approach of the design of the game was to play with the basic concepts of algebra. The first design principle used by Huyhn is “no words”, but to focus more on the intuitive experience. The more the teachers talked in the classroom, the less the students would understand them, so he realised that teachers were forming a barrier between the subject and the learner. The second principle is “no pre-requisites”, so that anyone can play. [59.]

The third and fourth principles are to use the big ideas of mathematics and not to approach the curriculum in small chunks. In Huyhn’s example, we cannot learn what a function is with one occurrence of it. We are taught functions at school and it takes us 5 years until we cover all the different types in order to see the differences between them. DragonBox covers almost 5 years of what is covered in school in algebra in a single game. [59.]

The final design principle is representation. DragonBox has taught the value of representations and how powerful the brain is as soon as one begins to understand patterns. “Once children understand the concept, the changes in representation won’t distract them. They have no problem identifying the  $x$  as the box once the game creates the concept of the box being the unknown.” [59].

## Conclusion

Through the use of clever design, children can be taught algebra concepts without making them feel as if they are learning mathematics. From my experience of playing the game, it did not feel like solving algebraic equations. Despite it being targeted at 5 year olds I found enjoyment in playing the game and the introduction of numbers and letters did not take me away from the experience.

DragonBox has created an enjoyable gaming and learning environment by being able to maintain the relation between content and gameplay. This game leaves kids with the thought that algebra is fun and more importantly boosts their confidence by letting them know that they are good at maths [63]. The game introduces relevant algebraic concepts for the current level and as the game progresses it is able to maintain the balance between the challenge and the player's skill, keeping them engaged and motivated, maintaining flow.

With a clear goal and immediate feedback, the learning process becomes more effective as it allows the player to go back and try again and explore different ways to approach the equations. The game avoids to give out hints to give players the chance to figure things out for themselves. Additionally, this allows students to learn at their own pace. "Discovery-learning is much more effective than instructional based teaching." [64].

DragonBox Algebra is designed to be used as a teaching tool in the classroom and covers common core standards. There is however still a matter about the learning components not being transferable out of the game, "at least not to the standard equations solving format" [63]. Jean-Baptiste Huyhn describes that "DragonBox is about the mechanics of the algebra processes and abstraction. It is 100% algebra math skills, but it doesn't replace teachers. It requires help to transfer the knowledge to pencil and paper." [62].

In an interview in Forbes, Jean-Baptiste Huyhn says games like DragonBox are a must-have for educators as they a) deliver a learning experience fine tuned for the individual, b) the feedback loop in game makes it possible to achieve formative assessment and learning at the same time and c) social elements can be easily incorporated [65]. Huyhn says that what makes the DragonBox games different from others is that they don't pay attention to the curriculum, however that makes it more difficult when trying to sell the games to schools. [66.]

The DragonBox method aims to create games where the learning is at the forefront [67]. To achieve this we have to understand how kids get motivated and how they learn [59]. The success of DragonBox led to two other titles: DragonBox Elements and

DragonBox Numbers with the latter having recently won the award for best learning game at the 2016 Games for Change [68].

## 4. Finnish Educational Reform

Finland's education system is regarded as one of the best in the world. Everyone can go to school in Finland and there is great trust in Finnish public schools [70]. The foundation of Finland's education starts with highly trained teachers.

Teachers have a big role in creating a learning environment in the classroom. Students in primary school do not take part in standardised tests, rather they are assessed by their teachers on the basis of objectives written in the curriculum. "Finnish teachers have a greater level of autonomy than many other global educators and are heavily involved in curriculum planning and student assessment" [71]. Planning of the curriculum is based on acts and decrees issued by the Parliament and Government while the national core curriculum is decided by the National Board of Education [72].

Finnish education aims for a student-oriented environment. The goal of primary education is to encourage independence and active learning in order to develop students' self-assessment and study skills to make them aware of their own progress and learning process. [71; 73.]

### 4.1. Finnish Serious Games Industry

The Finnish games industry is growing rapidly. Its revenue was at 2.4 billion euros in 2015, almost 3 times more than it was in 2013 [74]. After the release of Angry Birds in 2009, the mobile games market expanded giving rise to new gaming companies. "Before Angry Birds, mobile games were a niche, just like educational games are right now...it is just a question of who is going to make the 'Angry Birds' of learning." [70.]

Within the games industry, there is also a steadily increasing industry in serious games as new serious games companies emerge. Revenue for serious games in 2015 was at 9 million euros, an increase of 5 million from the year before, and it is estimated to reach 17 million in 2016 (figure 6).

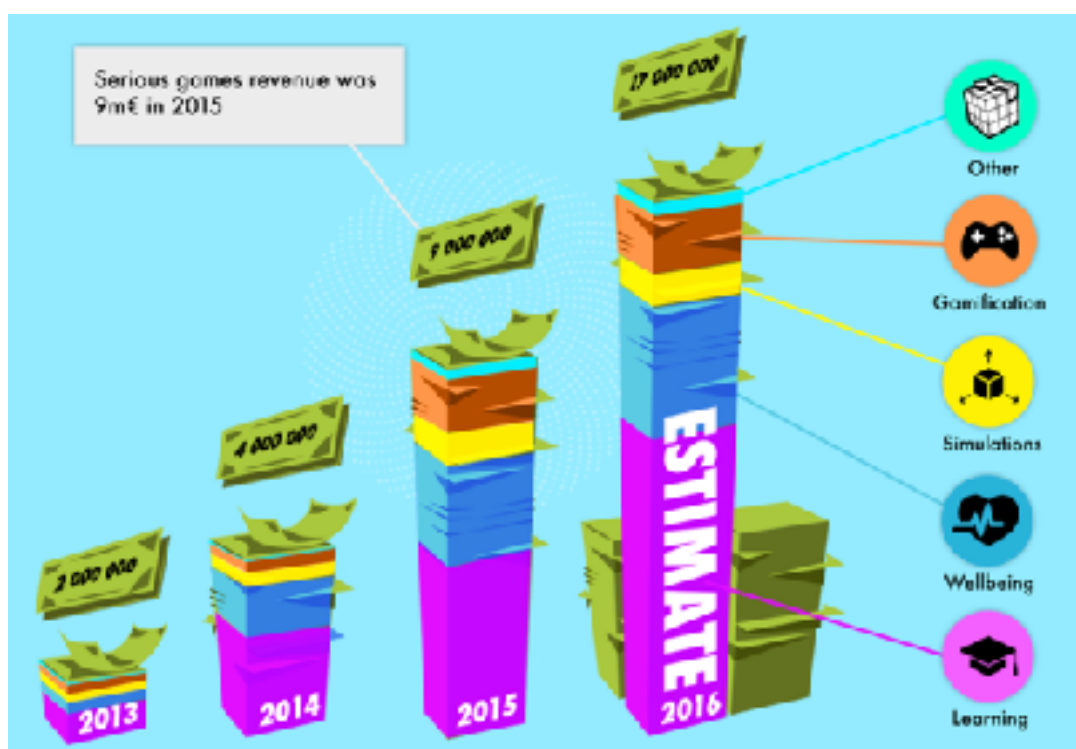


Figure 6. Serious Games Revenue in Finland. [75.]

Serious games mostly cover areas in learning and wellbeing. Finland's successful serious games companies focused on learning are Teacher Gaming LLC (1.2 million euros in revenue), which creates educational versions of entertainment games like Minecraft and Kerbal Space Program for classroom use, and game studios Ludocraft & Worddive (0.5-1.0 million euros in revenue). [75.]

Other companies include NordicEdu, developers of educational games, and the learning game studio Lightneer, whose background includes veteran game designers from Rovio and Digital Chocolate, co-founded by Peter Vesterbacka and CEO Lauri Järvillehto. Having collaborated with CERN, they have released their first game Big Bang Legends that focuses on teaching particle physics. [76; 77.]

Finland has a global reputation in education and a strong talent for games development, and while there is potential for serious games, they still face a few obstacles, one of which includes funding. "In our own experience the serious game projects haven't been initiated due to - or rather the lack of - funding." [75]. Companies operate on tight budgets and it shows in the quality of games they produce. "Learning games are currently in painstakingly similar situation as mobile games were in 2007; they're a



niche product, produced quickly, often with small budgets and inexperienced game design teams.” [78].

Finnish publishing companies also play a big role in Finnish education, companies like Otava Publishing Company Ltd., digital eLearning/publishing company Tabletkoulu, and educational publisher Sanoma Pro, Finland’s leading provider of learning solutions. [79.]

#### 4.2. Educational Reform

Finland’s education system went through a reform in August 2016 which included changes in course objectives, lesson-hour distribution, national core curricula and local curricula. Due to the impact that advancements in technology have on children today, schools need to adapt to these changes by renewing pedagogy, learning content and school practices [80].

Some key factors of the educational reform will focus on increasing the active roles of students and to develop their problem-solving skills [80]. Curriculum changes will include phenomenon-based learning, in which a course will take a real-life topic that will cover a range of subjects, topics such as the European Union or Finnish history, which would cover languages, geography, sciences and economics. “Educators in Finland think, quite correctly, that schools should teach what young people need in their lives.” [81.]

Meanwhile, The Playful Learning Centre of the University of Helsinki, is looking to introduce a more “playful” learning approach to pre-schools. “We would like to make Finland the leading country in terms of playful solutions to children’s learning,” said Olavi Mentanen, director of the PLC project. [82.]

#### 4.3. Sanoma Pro

Sanoma Learning is one of Europe’s leading media and learning companies with a focus on learning solutions. As part of the Sanoma Learning division operating in Finland, Sanoma Pro provides content and learning materials for schools, from pre-school to upper secondary education, advancing from print to digital media.

Sanoma Pro is Finland's largest educational publisher in providing digital educational solutions. They are leaders in the Finnish educational market, with their learning materials being used in almost every school in the country. "Our solutions are developed through very intensive collaboration with our customers, and our authors are the best professionals in their own subjects." [83].

With the new reform aiming to bring digital into education and encourage students to drive their own learning, Sanoma Pro are able to use their digital learning materials to full extent. Sanoma Pro will be introducing game-based applications that will cover Maths with the "Wonder Bunny Math Race" mobile game and the "Troll Camp" game which will teach the Finnish language [84]. One of their current digital solutions is Bingel, a gamified learning platform consisting of fun and engaging exercises related to subjects based on the Finnish curriculum. The exercises on Bingel are available for most of the subjects in primary education.

#### 4.4. Bingel

Bingel is a gamified environment that creates a new and fun way for children in primary school to work on digital exercises. It was developed by the Belgian Sanoma company VAN IN in 2011 and released in Finland in 2015. [85.]

The motivation to complete exercises comes from the world that Bingel creates and through its engaging story. The world of Bingel takes place on a fictional island in the sky tormented by a dragon and it is up to the player to protect the residents of the island from it. The most recent added storyline was to find the missing star player from the Finnish ice hockey team, which has shown to be of interest among students.

The task of the player is to solve the presented events in the story by completing exercises. I had the opportunity to play with this platform. It is for the 3rd-grade level and so far has subjects in Maths and the Finnish language. Completing exercises rewards the players Ping Ping, the virtual currency in Bingel, which allows them to purchase items for their avatars and play mini-games. Each school year has its own exercises on its own island with its continuing storyline.

One of the key features of Bingel is automatic level adjustment. There are 3 levels of difficulty for each exercise that adjusts depending on the result of the previous exercise as shown in figure 7 below.



Figure 7. Bingel Feedback. [Web based application software]

Each exercise gives the player two chances to get the correct answer. The green circle indicates the answer was correct on the first try, yellow in two tries and red means the answer incorrect both times after which the right answer will show up on the screen. The difficulty of the next question is determined by how the student performed on the previous question.

Automatic level adjustment is an important feature in the application as it creates a personalised learning experience by adjusting to the students' skill level. The ability to go back and retry the exercises allows the students to learn at their own pace and they can receive more Ping Ping for completing them again.

A strategy that Bingel adopts is making sure the learner knows what the learning goal is, as opposed to DragonBox where learners are unaware that they are learning algebra. This strategy gives time for students to see the question and stop to think about it

and it is done by having them perform an additional step of hitting the “OK” button after selecting their answer. This additional step gives students time to reflect on their answers and lets them be in control of the learning. “Having the learner to be in control of the pace he moves on is good for his working memory.” [97].

What proved most popular among the students was the avatar customisation. The students can purchase items for their avatars with the Ping Ping they accumulate by completing the exercises (figure 8).



Figure 8. Bingel Avatar Customisation. [Web based application software]

Gamification pioneer Yu-Kai Chou outlines in his Octalysis gamification framework, 8 core drives that motivate us in everything that we do. Two of these are “Epic meaning and calling” and “Ownership and possession”. Epic meaning and calling, similar to agency, makes us feel that we are a part of something big, that we have the opportunity to make an impact. In this case, the player has to save the island. [86.]

The second core drive, ownership and possession, motivates us by feeling that we own something and because it belongs to us we want to improve it and protect it [86]. The

player gets this from their avatars by wanting to buy items for it and thus giving players the motivation to complete more exercises.

Bingel is a good example of gamification that extends itself from the use of common gamification practices. The inclusion of narrative, characters and mini-games make a more engaging experience. Bingel also facilitates the work of teachers, by letting them choose the exercises suitable for the class, and also making it easier for teachers to track the progress of their students. Teachers can also provide feedback to their students by giving them stickers, additional Ping Ping and writing comments [85].

## 5. Animal Kingdom

The literature review done in the thesis was applied to Animal Kingdom. Animal Kingdom was a project started by 2 colleagues and I with the intention of teaching children about animals. For my thesis I wanted to continue working on this project by adding more features to it based on the theories covered in this paper. The final game was made using Construct2.

### 5.1. Concept

The idea was to create a game for kids with interactive elements that can teach them about animals. This game is to be played on a tablet as we wanted to make use of different sensory devices like sound and touch. We wanted to make the game available for children at schools or even outside of school. The idea is to get children to become familiar with animals such as what locations they are native to, pick up on terms like "carnivore", "herbivore", "omnivore" and be aware of types of species and endangered species.

The goal of the game was initially to unlock all the animals in the gallery by finding them in the different locations on the map. Finding an animal will reveal its picture on the gallery which the player can later view to read more about it.

### 5.2. Gallery

Animal Kingdom went through an iterative design process, having users test our designs up until creating the prototype on Construct2. We started out on pen and paper, then created a mockup using the myBalsamiq application to test the functionality. While the designs gave a good idea of what we wanted to create, the tools we used proved to be far too limited for the testers to be able to figure out how the application worked.

The next stage was moving on to the graphic design of the application. To understand how our application worked as well as how to navigate it, the design of the user interface was crucial. The usability principles that we tested were 1) simple and natural dialogue, 2) speak the user's language, 4) consistency and 5) feedback.

We started with the design of the gallery page where the user could view the animals they had unlocked (figure 9). We relied on the use of metaphors, e.g. the jeep to ex-

plore, map to view the world map, locks to show that there are missing animals to be found and the arrows to show that the user can swipe left and right to navigate the gallery.

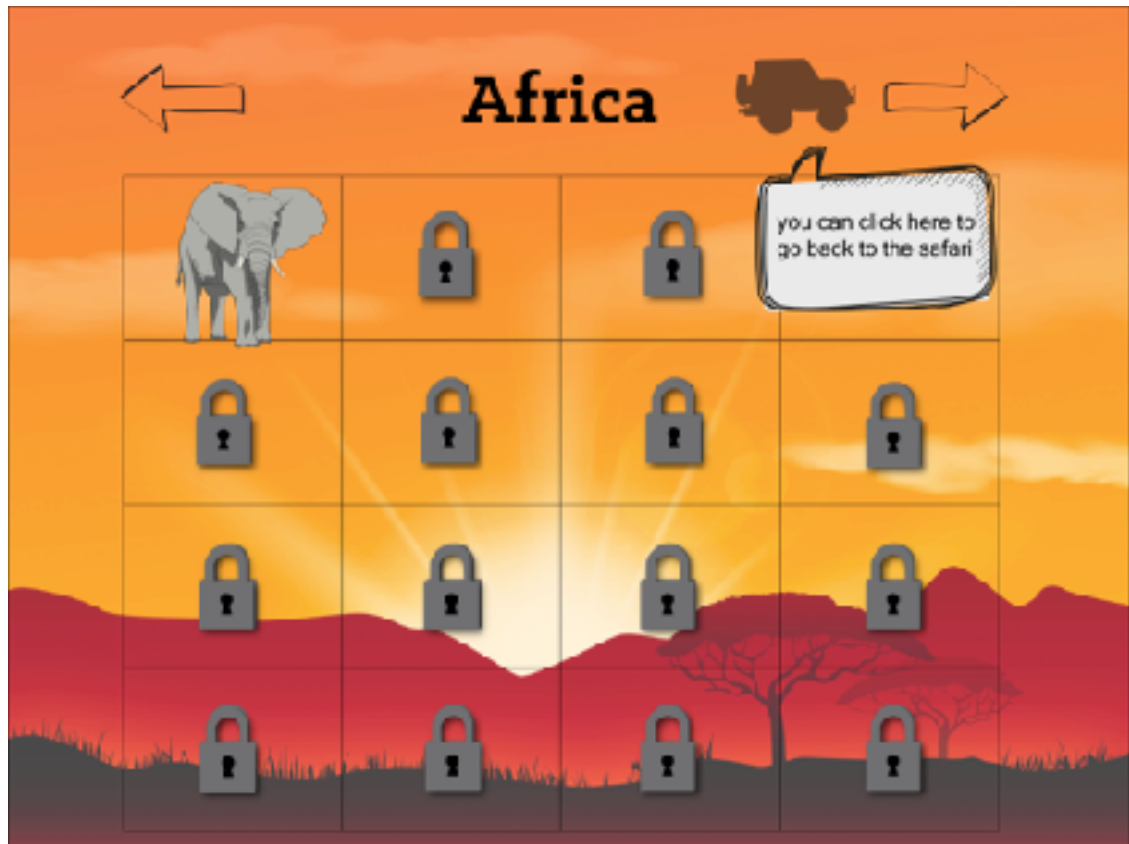


Figure 9. Animal Kingdom gallery page.

We had our testers look at figure 1 above and without telling them anything about what our application did they would tell us what they thought they could do with it. The overall responses included 1) it looked like a memory game or levels that had to be unlocked, 2) jeep didn't look clickable, 3) arrows looked clickable.

The lock metaphor as well as the way in that the boxes were arranged made it look like a memory game. The gallery was supposed to tell the users they have to find a missing animal, so we had chosen to use the mental model of a photo album. A mental model serves as a guide to show how the application should work and what actions users should take. The photo album was to give users the idea that it has to be completed. In addition to the photo album we added empty polaroids that made it clear that something was missing in the photos. The paw prints were used to show what animal to search for (figure 10A).

Our new version of the gallery page (figure 10A) was tested again and this time we noticed that the purpose of the arrows in the gallery was not clear and none of the testers interacted with the arrows. They did not realise that there were other pages in the gallery they could view. For the final version of the gallery we changed the arrows by adding names to them. The addition of the carousel at the bottom was to inform the user that they can swipe on the screen to navigate the gallery (figure 10B).

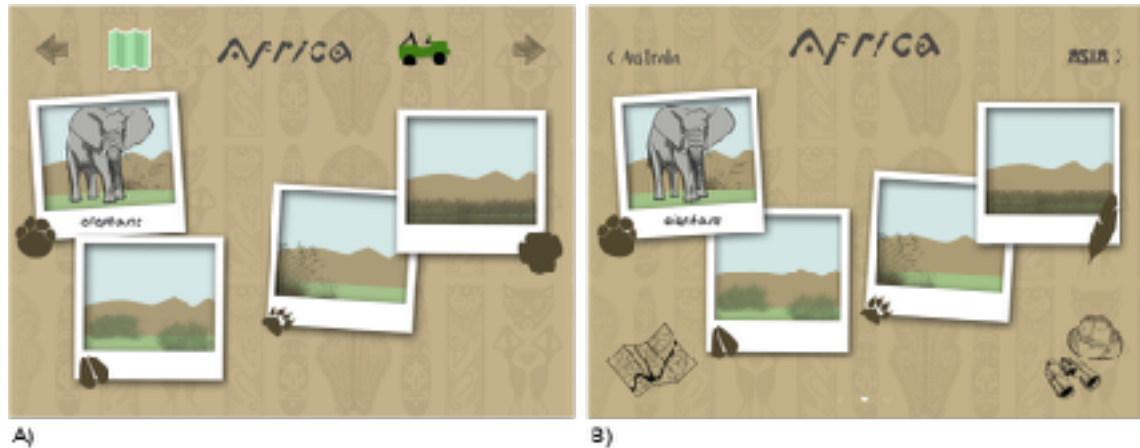


Figure 10. A) Second version of gallery page. B) Final version of gallery page.

We continued with the mental model of the photo album for the next part of the application where the user scouts different locations to take a picture of the missing animals.

### 5.3. Gameplay

The goal of the game is now to complete the photo album with pictures of animals that one will find by navigating to different locations on the map. Upon finding an animal the user will take its picture and it will be added to the photo album which the player can later view to read more about the animal. Finding all the animals in the first location will unlock another location on the map (figure 11).



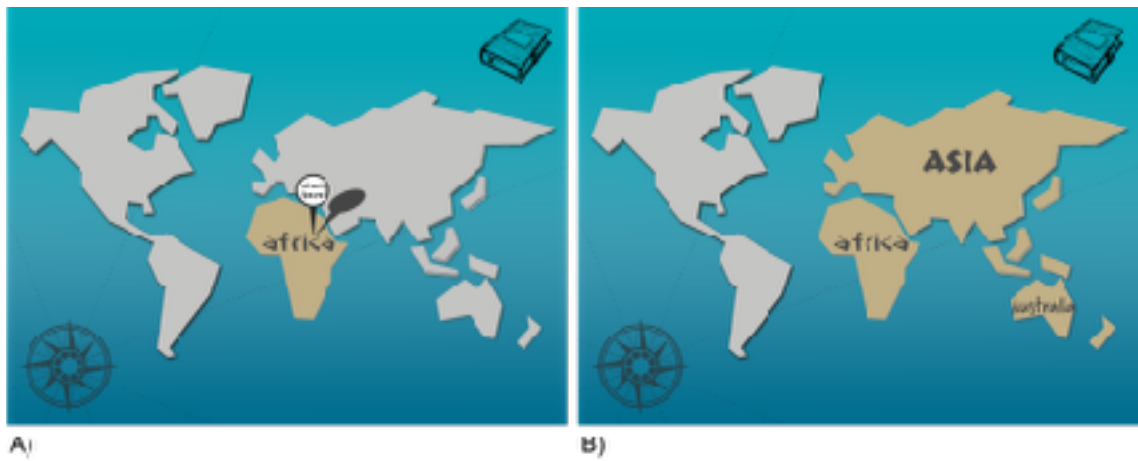


Figure 11. A) Start. B) All unlocked locations.

Tapping on the first location takes the player to what we call the scene. By swiping left and right the player can explore the scene. Tapping on an animal will reveal a dial with four options (figure 12).

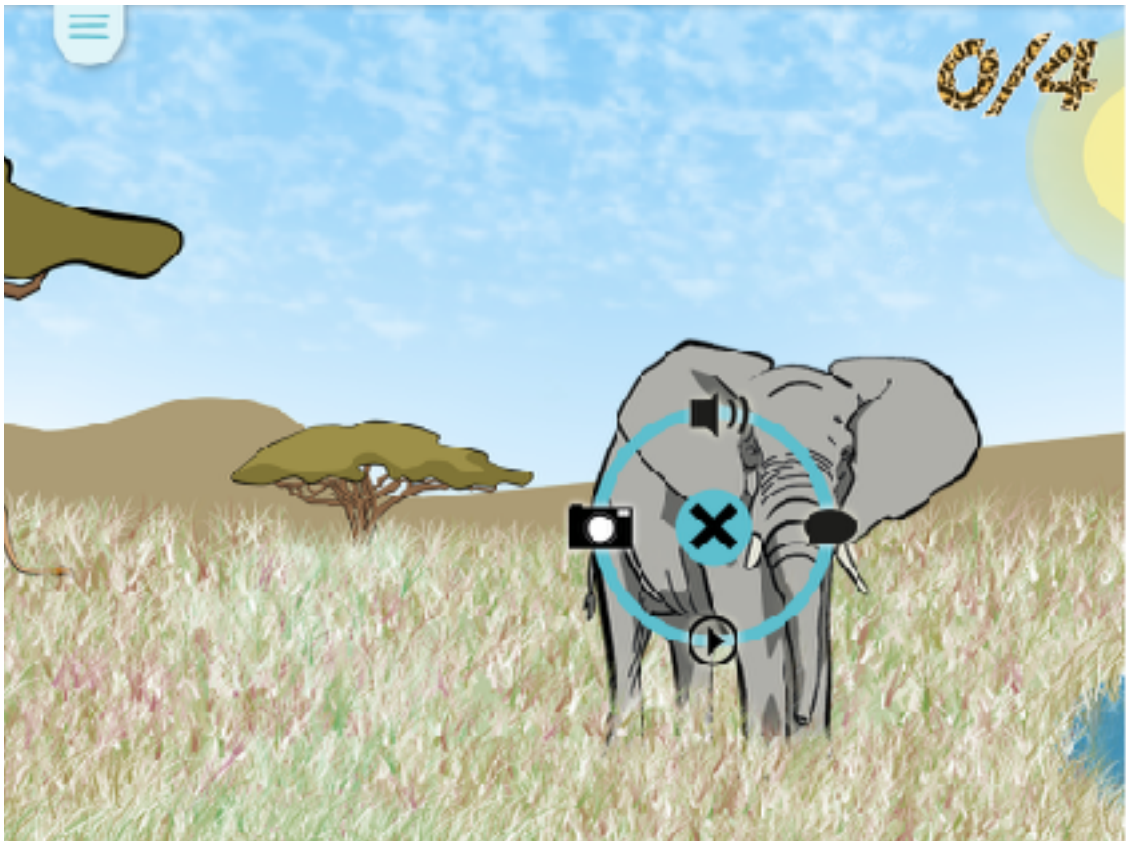


Figure 12. Searching for the animals.

The speaker will play the sound the animal makes, the speech bubble will play a fact about the animal, the play button will trigger an animation and the camera will take a picture. The counter on the top right shows how many animals the player has already found. Pulling down the menu burger at the top will give the user the option to return to the map or go to the photo album.

After taking a picture of the animal, the user is given the option to go back to the photo album, to the page of the newly found animal (figure 13). For the animal pages, the text was kept to a minimum and I resorted to using more visual elements. I applied the cognitivist theory which suggests the transmission of information occurs through the ability of the learner to put new information into a familiar context. This was accomplished by comparing the weights to household objects and sizes to that of an average person. Presenting the size and weights of the animals through numbers alone was ignored and did not give much of an explanation. The animal pages also gave descriptions of the animals, also including photos, their eating habits and their habitats.

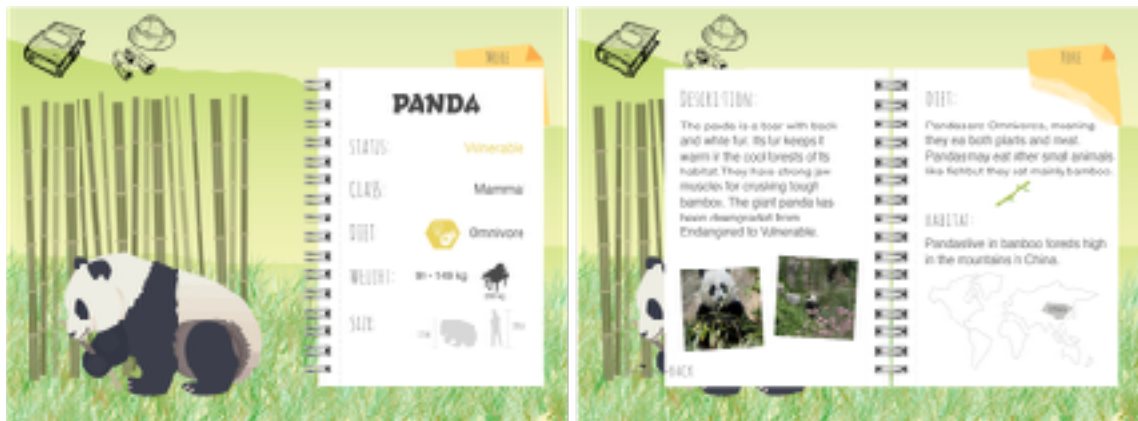


Figure 13. Animal Pages.

#### 5.4. Flow and Learning

The first component of flow that was looked at was confronting tasks we have a chance of completing. This dealt with balancing challenge and ability. To add challenge to the game, a memory game was added that the player has to get past in order to continue to the new location. This activity also serves as a form of assessment where the player will need to recall what he/she learned about animals in the previous locations (figure 14).

As the player learns about more animals, more cards will be added to the memory game. Rather than making an “out-of-context quiz” on educational content, the game should teach the player the content that will be used to solve challenges. James Paul Gee describes using the information learned in a game to solve these challenges, making them easy at first and gradually increase in difficulty as more information is learned. (91)



Figure 14. Memory game.

Another way to add challenge to the game was by hiding some animals when the player goes searching for them in the scenes, for example hiding a Koala behind a tree so the user would have to tap on the tree to brush off its leaves. The empty polaroids on the photo album would also serve as clues for where to look for the animal. This is a good example of giving players that sense of exploration we intended for them to have.

The feedback in the game was done through the use of:

- Sounds and visuals to note something was unlocked or completed.
- Enabling or disabling actions or showing text on the screen.

- A counter has been added on the top right of the screen when visiting a new location that tracks how many animals have been found in the current location.
- The photo album also shows how many animals have to be found.
- Finding all the animals will show text telling the user a new location has been unlocked.
- On the map, the unlocked locations are displayed by having their colour changed and the name of the location appearing on top.

We wanted to give the player a sense of adventure by having them go on the search for the different animals in their habitats. This will give them the chance to interact with the application through touch and swipe when navigating the photo album and the different habitats. Applying the theory of situated learning, we wanted to put the learners in an environment that replicated a safari accompanied by the use of visual elements, sounds and animations.

Meaningful context is created by making the subject matter directly related to the environment in which the player is put. Having created the mental model of the photo album we tell the player that they have to fill it up, like completing a sticker collection or filling up a pokedex. Having established this task we give players a role and a motivation to begin their journey. It is through the interactions in the game that the learning will start taking place.

## 6. Results and Analysis

I had the chance to visit the Maunula primary school and carry out play tests of Animal Kingdom with 2 students from each 2nd and 3rd grade classrooms. There were three things that I was evaluating in each play test. The first was the learning, to see if the students were able to learn from playing the game. This was done by giving them the same quiz before and after playing the game with some questions about the animals in Animal Kingdom. I also had a small discussion with the students asking them if there were things they had learned or that they had not heard of before.

The second part evaluated how much fun they were having. This was done again through a discussion where I asked the students about their overall experience and if there were parts in the game they found fun and whether there were parts they found boring. The questions also included the difficulty of the game and how clear the tasks were. The third part evaluated the user interface. I sat with each player and observed them play through the game. I told them what their task was and then let them explore on their own. This tested to see how difficult or easy it was for them to pick up the controls of the game.

Below I have listed my observations from the play tests:

Positives:

- Most of the students had not heard of Komodo Dragons. They enjoyed learning about it.
- Quiz results showed improvement on the second round. The second time they were able to associate the animals to their native habitats and could answer the questions related to the Komodo Dragon.
- Students took their time to think about their answers in the memory game rather than picking randomly to find the correct matches.
- Most of the students found the game fun. Their favourite parts were searching for the animals, unlocking new levels and the memory game.
- The difficulty of the game varied among students. Most said it wasn't too easy nor too difficult.
- Students wanted to see more levels (other continents), more animals and more hiding spots for the animals.

### Negatives:

- Students knew most of the animals in the game so they skipped the animal pages.
- Students were unsure about questions on terms like "carnivores", "omnivores", and "endangered".
- One student found the memory game too difficult so that was his least favourite part. Another student's least favourite part was going back and forth from the scene and the gallery.
- Students did not know where to start. After telling them which icon was the explore icon, they were able to navigate through the game easily.
- 3 of 4 icons on the dials were ignored (sound, animation and narration). Students were focused on just taking the picture of the animal.
- The counter at the top was not very visible. I had to point it out to them.
- The explore icon looked like two separate icons.
- The memory game has only one correct match. There were cases where a question could have multiple answers.

### 6.1. Learning

From my observations, it seems the learning took place particularly during the memory game. It was at this point where the students were taking their time to think about the answers. Information was obtained for example when making incorrect matches and by having the correct matches be displayed a little longer for the student to process them. However, because the students had not read through all the animal pages, when looking back at the questions on the quiz, students missed out on the definitions of terms like "endangered", "carnivore" and "omnivore", which were explained on the animal pages.

The memory game did have the definitions for omnivore and carnivore but I noticed the confusion in the students in that each card in the memory game had only one correct pair, but there were moments where a card could have more than one pair. For example there was a card saying "a carnivore" and the correct match was the card that read "eats only meat" but students kept selecting "a carnivore" and matching it with the picture of a lion.

The reason for the students skipping out on the reading parts was because they were already familiar with the majority of the animals in the game. The Komodo Dragon was

the most popular animal among the students so the game should focus on introducing more exotic animals. Interest in animals was also an important aspect affecting the gameplay. The 2nd-graders seemed to have more interest in animals than the 3rd-graders.

Perhaps the way I set up the game for them also affected whether they read about the animals or not. I explained the task of the game to be finding the missing animals and so the students were more focused on completing their photo albums with pictures. For example many did not click on the icons on the dial for sound, narration and animation. They immediately clicked on the camera icon.

Prior to the test at the school I had a play test of the game with another second grader. He had more time to play the game and do some more exploring leading him to see what the other options on the dial did. For example after figuring out he could hear the sounds the animals made he went to listen to the sounds all the other animals made. Given more time, the students at Maunula primary might have done some more exploring.

Animal Kingdom is meant to be a game that can be played during children's free time, to make them familiar with animals, and it can be used as an assignment to play before going to class. Apart from teaching children about animals, this game could also be used to teach the English language and the memory game could be modified to include definitions.

## 6.2. Flow and User Interface

Overall the students said they had fun playing Animal Kingdom. They did want to see more unknown animals and new locations. The memory game was also a favourite among the students. In terms of difficulty, the game was found to be in between being too easy and too difficult. The addition of the memory game definitely added a challenge compared to how easy it was to find the animals. The Koala was the hardest to find and the students preferred to have more animals hiding behind objects. Students did notice the photos as clues and used them to look for the Koala.

Each student knew what their task was. The only struggle was knowing where to start. It probably had to do with the design of the homepage (figure 15). After selecting "ex-

plore” or “gallery”, the player could not go back to the homepage. Also, the page had text for the icons, whereas they had been omitted from other pages.



Figure 15. Homepage.

I had to explain that they needed to tap the icon with the binoculars or the map to start. Afterwards they quickly picked up the controls of the game and knew how to move between the map, the gallery and the scene. The icons for the gallery and map were self-explanatory. The memory game was familiar to all students and they knew what they had to do when it appeared for the first time. They knew they had to pass it in order to proceed to the next level and it did not take them away from the experience of the game.

### 6.3. Future

For the future I would apply changes to issues covered previously and also have small tutorials to make it clear what has to be done. The tutorial could be done with the inclusion of characters that would “talk” to the player. The game should also include more exotic animals like the Komodo Dragon as that could increase the likelihood that



the players would read the animal pages. However the animal pages could also be re-designed to make learning about an animal come from some sort of interactivity. An idea is to have a small puzzle game with the animal where the player has to pass obstacles, thus learning about their types and abilities and feed them the right food to learn about their eating habits.

From my discussion with the teacher of the 3rd grade class I visited, the level of information presented in the game is good for up to the 3rd grade. Her class looks into different environments and how animals adapt to living in them, which could be an area explored further in the game as well. Another interesting point was how the game provides a safer environment for students to learn and also lets them search for information independently.

Overall I am pleased with the result of Animal Kingdom and do believe it has potential in teaching children about animals. It places students in an environment where they can interact with, see and listen to animals. As technology continues to advance new methods can be incorporated into learning. Augmented reality, for example, presents a new level of interactivity. As in Pokemon Go, children can go outside to explore and hold their phones up to an animal or plant to learn about it.

## 7. Conclusion

One of the challenges in education is engagement. Children love to learn, yet they do not have that same intrinsic motivation to learn in schools. In a rapidly changing environment, traditional teaching methods alone are no longer effective.

The objective of this thesis was to study the use of games as a medium to teach, to see how they can create a fun experience for learners while being able to be effective as a learning tool. There are already examples of games being used in classrooms but there are still very few that have proven to be successful, which is why the goal of this paper was to study methods that games could implement in terms of design and delivering content.

First a literature review was carried out researching different learning theories and understanding how we learn. Whether one theory is better than the other really depends on where and how it is going to be applied. With the focus being on increasing students' active roles and making knowledge be an internal process, we might be leaning more towards objectivist theories. Combining theories can also work such as with Bingel which uses a gamified approach to answering questions but also applies constructivist theory allowing students to reflect on their answers before continuing with the next exercise.

The second part of the paper looked at elements of games that make them fun and delved into the Flow theory to understand how we can be immersed in the activities we do. We want to motivate children to learn and so these games need to be attractive and fun. For example, Bingel makes use of game elements such as narratives and characters to create a more engaging learning environment, thus motivating students to complete exercises. DragonBox Algebra shows how gameplay and content can be combined to engage students in learning algebra.

It is important to understand the correlation between the educational content one wants to deliver and the gameplay. This will make the learning more enjoyable because the players are placed in meaningful contexts making what is being learnt relevant to the gameplay. Games must allow players to make use of the information learned to increase their fluid intelligence allowing room for critical thinking and self-evaluation.

Additionally games must establish clear goals, balance challenge and ability to maintain flow, take advantage of every situation to give feedback and design a clear user interface to help guide the player towards their goal. The use of representations, story and characters are also important in giving players emotion and agency, motivating us to take on the journey of the hero.

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