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IDGBL - Game Design

Inventure - A blended learning experience for teaching engineering and design skills

Background

MakerClub is a network of out of school invention clubs teaching young people design and engineering skills with the assistance of an online learning platform, made up of tutorials and design briefs for building inventions. As Head of Education, observing user interactions with the learning platform is an important part of my role to ensure that the content is engaging. However I have noticed a lack of motivation to understand scientific concepts behind the inventions and an unwillingness to find information for themselves, which learners have suggested is 'boring' or 'too much like school'. For the last two years, we have tried to solve this problem through gamification techniques, defined as the application of game elements into alternative settings (Lee and Hammer 2011). In particular we awarded points and badges for completing lessons and quizzes which then unlocked new tutorials, however these techniques have been criticised as lacking excitement and usefulness (Kapp 2012) often causing learners to lose interest (Kohn 1993a), potentially explaining the lack of engagement and motivation I have witnessed.

In an attempt to solve these problems I have designed the game *Inventure*, making use of narrative and player choice to engage learners at MakerClub in scientific knowledge and skills, helping them to solve problems and construct tangible inventions in the real world. The overarching pedagogies at play in Inventure and the accompanying physical environment are constructivism and constructionism. The former emphasises the need for learners to construct their own knowledge based on experience (Piaget 1976), while constructionism expands on this, claiming that knowledge construction takes place through the making and sharing of a physical product (Papert 1993). It is intended that through using Inventure, players will construct their own knowledge both in the digital world and through making in the physical world.

The Game

Aim

To enable young people to discover the knowledge and skills needed to become inventors, using a playful, contextual and project based approach.

Audience

Young people in Key Stages 2 and 3 or equivalent (age 8-13).

Learning Outcomes

- Understand key scientific and engineering concepts, applying them to the creation of inventions
- Be able to use computational thinking to solve problems using electronics and programming
- Understand and use a range of tools correctly including Computer Aided Design (CAD) software

Game Type

Inventure is intended for educational purposes over entertainment, therefore could be categorised as a serious game (Dicheva et al 2015) and a learning game, which relies on the transfer of skills learnt in-game to real life scenarios (Warren and Jones 2017). However, the name *Inventure* plays on themes which take inspiration from point and click adventure games such as the Monkey Island franchise as well as mystery and puzzle games like Hidden City treasure hunts, which all involve some level of independent exploration and discovery from the players. By turning invention into an adventure, it is hoped that learner engagement with the content will improve, encouraging an intrinsic desire to learn.

Format

Video games have the potential of motivating and engaging users and improving outcomes (Linehan et al 2011). Although Inventure is designed to be played digitally it is intended to be delivered using a blended and possibly flipped learning approach. Blended learning can be defined as a mixture of face-to-face delivery and computer-based delivery (Graham 2006). For it to be classed as flipped, the online learning is carried out in advance of a structured, face-to-face environment (Reidsema et al

2017). Players can use the game to find quests and improve their knowledge and skills, however the physical making of an invention needs to happen in a collaborative space where there is adult support and equipment; such as a classroom, club or makerspace.

Overview

Inventure sees players travel through Tinker Town, a fictional location consisting of non-player characters (NPCs) who have problems or tasks the player needs to solve. Problem based learning (PBL) contextualises the knowledge and has been likened to a constructivist, student-centred approach found to promote independence, motivation and critical thinking (Akınoğlu and Tandoğan 2007). Players are required to use the knowledge and skills they learn in game to help them invent a physical solution to the problem at a MakerClub. This *project* based approach to learning, according to Resnick (2017), increases engagement and creativity due to learners choosing projects that are meaningful to them.

Game Play and Rationale

Getting Started

Players begin their adventure in a small town where their guide, Robertha the robot, will deliver a tour of 'the basic artifacts, skills and tools the player needs' (Gee 2007, 139), starting by giving players a map of the town showing key locations. Robertha acts as a mentor throughout Inventure, scaffolding learning and ensuring that the learner only encounters elements within their regime of competence (Gee 2007), argued to improve problem solving skills (Wood et al 1976). Initially Robertha will only highlight the town square to the players, returning to introduce new locations (See Table) and game features as the players discover them. This is an example of what Gee (2007) refers to as providing explicit information just-in-time and on-demand meaning that hints and guidance are provided for learners when they need it or when it can be understood in context.

Tinker Town Location	**Players can find:**
The Town Square	• Vital locations to provide help to players when needed • Starter quests from local townsfolk • Routes out of the city for more advanced quests

The Library	● A librarian who can help them find information needed to help with an invention. ● Computers for looking up information and for practising programming and CAD skills.
The Workshop	● A variety of tools and materials useful for inventing. They can be clicked on for more information on how the tool or material should be used. ● A computer for learning how to use CAD software for 3D Printing and Laser Cutting
The Lab	● A range of experiments representing scientific concepts useful for inventing such as, simple machines, electricity and forces. They can be clicked on for information on an experiment to try or a video or animation demonstrating how something works. ● A computer for learning about how to program different electronics components.
The Gallery	● Photographs of inventions which they have uploaded throughout their time playing the game. ● A wall of fame displaying the top rated projects across **all** players in any given month

A Typical Quest

Players are given a choice of locations marked on the map where they can find starter quests. This ability for player choice is typical of video games, distinguishing them from the linear narrative found in books or movies and has been referred to in relation to education in different ways: multiple routes (Gee 2007); and wide walls (Resnick 2017) outline the importance of learners being able to rely on their strengths, working on projects which reflect their interests to ensure they are meaningful. By using a narrative to introduce design briefs and subject knowledge it can encourage 'challenging and stimulating curiosity and fantasy' claimed to be 'major components of intrinsic motivation' (Dettori and Paiva 2009, 58). This is preferable to the gamification techniques we have used which act as extrinsic motivation, claimed to be less effective at promoting learning (Kohn 1993b). Furthermore the player control over the direction of the narrative allows for increased

ownership, which is suggested to 'lead learners to exceed all expectations' (Martinez and Stager 2013, 24)

Clicking a quest location will allow players to enter and speak with NPCs. One location might be a sweet shop where the owner tells the player that when the shop gets busy he finds it difficult to serve everyone their sweets, he needs help building an invention to solve this problem. Players are left to explore the room for clues which they can find by clicking on objects and people, reminiscent of games like Monkey Island, encouraging learners to search for knowledge themselves as it is required. This has been found to be a particularly useful model within maker education, valued higher than a 'traditional "just-in-case" model that covers a curriculum fixed in advance in the hopes that it will include something that will later be useful' (Gershenfeld 2007, 7).

Blended Learning and Transfer

It is intended that Inventure would be played as part of a wider experience where young people would also have access to materials, tools, a workshop space and tutors, allowing them to build tangible inventions related to the problems faced by the NPCs. Having gathered information from the sweet shop, players will be required to design, prototype and build an invention **outside** of the game environment to help solve the NPC's problem. During this process, players might return to the game to remind themselves of key knowledge and skills that are helpful to their design but they would not be able to progress to a new quest until their invention has been made.

As this is a learning game, it is reliant on the skills learnt in-game being transferred to real life scenarios (Warren and Jones 2017), in this context, the transfer of knowledge and skills learnt in-game to the real-world, tangible invention. However, transfer between the digital and physical environment is not guaranteed and relies on (Bransford et al 2000):

- A level of mastery of subject matter
- Abstract representations of knowledge
- Being an active process
- Understanding that all new learning involves transfer

Due to the incorporation of PBL, much of the knowledge in Inventure is heavily contextualised in an attempt to make it more engaging and meaningful to young people. However, it can be problematic if students **only** learn abstract concepts in the context of a problem as they may struggle to transfer this to new situations (Bransford et al 2000). Therefore, an important consideration to make when presenting knowledge would be ensuring a variety of contexts are used to explain scientific concepts, both in-game and in the physical learning environment.

Educational Value and Assessment

In addition to the skills and knowledge outlined in the learning outcomes, the use of Inventure can have additional benefits:

- Design thinking is used by designers and engineers in industry when creating a product and is a useful process for developing 21st Century skills (Luka, 2014). Martinez and Stager argue that design thinking is best developed in students when used in a meaningful context, which the problem based approach in Inventure aims to achieve.
- Creativity has been named a key 21st Century Skill (ibid) and is arguably fostered through the playful and project based approach to Inventure(Bateson and Martin 2013, Resnick 2017). Learners will have the opportunity to demonstrate creativity through their responses to problems.
- Collaboration has also been defined as a 21st Century skill (Luka, 2014) and will be utilised through learners working with peers to develop and feedback on ideas in the physical environment.

There are a number of methods to assess the stated and unstated outcomes both in and out of game:

In the digital environment:

- Progress can be tracked by the tutor and learner including which locations have been visited, the quests that have been completed and the knowledge and skills the player has discovered through exploration.
- When learners complete an invention, they will be required to upload a photo and description to the gallery. The sharing of learning in this way is key to constructionism and allows for the product to be “shown, discussed, examined, probed and admired” (Papert 1993, 142) by peers and tutors.

In the physical environment:

- Tutors will observe the application of skills and knowledge from the game to the inventions in the physical space. This will allow for the assessment of knowledge transfer, design thinking and collaboration, providing immediate and meaningful feedback to the learners.
- Learners will have the opportunity to share their inventions in the physical environment as well by presenting to their peers. They will be expected to justify design decisions in relation

to the knowledge and skills they have learnt along the way, allowing for peer, tutor and self assessment of the learning outcomes.

Technical Constraints and Deployment

Creating a digital, educational game which is highly engaging could be a difficult, expensive and time consuming task (Kapp cited in Dicheva et al 2015). That being said, the core components of Inventure could work as a text-based adventure game similar to, Adventureland or A Dark Room. In the short term, there are some playful approaches that I have already started putting in place:

- Setting project briefs in the context of a problem and delivered by a character in need of assistance.
- Setting quests to find key information for improving knowledge and skills through the MakerClub platform and wider sources.
- The creation of a simple card game which defines a character and a problem for invention ideation.

Conclusion

Although the creation of Inventure as a fully functioning digital game is ambitious, it has helped me to approach the delivery of the MakerClub curriculum in a more playful way which arguably fosters creativity and innovation (Bateson and Martin 2013). Through creating meaningful project briefs and guided opportunities for learners to discover knowledge for themselves, within a narrative, players should be more intrinsically motivated to engage with the content (Dettori and Paiva 2009), improving their knowledge, problem solving and inventions.

(2191 words)

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