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Why we should design educational games with learners: The affordances of informant design

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Abstract: This paper argues that in "educational" game development, there is often a gap between design and learning. It suggests how involving learners in the design process, known as the informant design approach, is able to close this gap. One key affordance of such an approach is the provision of learning opportunities for the learners themselves where designing and learning are intertwined. Specifically, learners had opportunities to use their experiences as their resources for learning and game design and become more cognizant of their knowledge about their lifeworlds, particularly adolescents' gaming culture and Earth phenomena.

Keywords: Informant design, educational games, design, learning

Introduction

Increasingly, many studies have suggested that there are educational benefits in playing games, which have not been harnessed for formal schooling. For instance, the British Educational Communications and Technology Agency [1], or otherwise known as Becta, advocates that playing computer games is capable of developing information and communication technological (ICT) skills, increasing motivation, promoting collaboration, amidst other educational benefits. Other studies on computer games in education also report similar pedagogical benefits and put forward the argument that computer games not only provide edutainment but themselves are powerful learning environments [2][3][4][5][6][7].

While these studies promote the use of computer games for teaching and learning, there are also studies that contend that many computer games developed for teachers and students do not meet their teaching and learning needs [8]. Kim et al. [3] argue that it is difficult to maintain a balance between learning and entertainment when using games for teaching and learning. Gee [2] also highlights this difficulty when he contends that game activities often provide meaningless play and do not necessarily provide learning contents that encourage intellectual pursuits. Becta [1], although brings our attention to the educational benefits in using games for education, cautions that the educational focus can be easily lost when learners are distracted by the game interface. In short, the context of the game (such as the scenarios depicted, the activities or the game interface) is often disparate from the learning aspects in many "educational" games.

In this paper, we argue that when developing games for educational purposes, the gap between design and learning needs to be adequately addressed before teachers and learners can benefit from using games for teaching and learning. In our project, we aim to develop a 3D immersive game for learning Earth science and geography, named *Voyage to the Age of Dinosaurs* (VAD). Much literature has documented the difficulties learners have in understanding the Earth as a complex system (e.g., [10][11][12][13][14]). We aim to enable learners to immerse themselves into Earth system concepts through the game by providing ways of perceiving and understanding earth processes.

1. Designing with Learners Using the Informant Design Approach

In this paper, we present our arguments on how the gap between design and learning can be minimized when developing a 3D immersive game for the teaching and learning about Earth system science concepts. In informant design, the users are positioned as experts and their expertise are called upon when required at the various stages of development. When adopting such an approach in educational game development, learners as expert users provide insider's information about their learning difficulties and desired learning processes and outcomes [15][16][17]. The impetus for involving learners in the design processes stems from the need to develop a learning tool that meets their needs.

Over the course of three years, we conducted five progressive workshops in our informant design approach. In all five workshops, there were 22 students from two secondary schools (U.S. grade 7-10) as design partners. Each workshop illuminated learners' ideas about different narratives, earth's phenomena, games, and their roles in learning. Table 1 summarizes the flow of informant design workshops.

Table 1. Five informant design workshops

Theme	Purpose	Key activities
Workshop 1: Understanding Learner Conceptions	to understand students' existing ideas about earth science and dinosaurs	Focus group discussions on the causes of Earth's disasters and dinosaur fossilization
Workshop 2: Creating Learners' Narratives	to engage their prior knowledge and experiences for developing game narratives	Field trips and movie production
Workshop 3: Game Play and Ideas (Prototype I)	to solicit learners' feedback on commercial dinosaur games and VAD prototype I	Evaluation of two existing commercial games and VAD prototype I, and brainstorming of "hottest" game in town
Workshop 4: Experiencing the Game Narrative (Prototype II)	to enact game scenario in the physical setting using hands-on activities and test VAD prototype II	Participation in experiential learning (mock fossil excavation, compass/map reading, rock examination, and experimentation of pseudo plate movements using jelly)
Workshop 5: Designing Specific Parts of the Game (Prototype III)	to solicit learners' feedback on VAD prototype III and invite learners to design parts of next prototype	Evaluation of VAD prototype III and concept designs

The VAD game scenario starts with Dr. Konglong, an enthusiastic scientist who is eager to study feathered dinosaurs from early Cretaceous in Liaoning Province in China. He invites paleontologists wanna-be's to help him test his new invention by going through a portal to the past and boost his research by bringing real feathered dinosaurs. The players go through various quests in the present and the past worlds. These quests include meeting Dr. Konglong, finding fossils considering the distribution of rocks, assembling them, collecting rocks from the past, and capturing feathered dinosaurs after surviving volcanic eruptions.

In this paper, we will discuss workshop 5 in detail in order to illustrate what meaningful learning and design have taken place based on the informant design workshops. The VAD prototype III tested during the Workshop 5 introduced a quest and challenge at the beginning of the storyline, where the players look for Dr. Konglong. Adopting the curricular content (navigation in Geography), players had to get to various locations using clues (such as compass bearings and landmarks) and figure out the features of the specific locations (e.g., elevation) to obtain the directions to meet Dr. Kong Long (see Figure 1).

Figure 1. Prototype III, navigating using compass bearings

Workshop 5 tested out this new quest in the game as well as concepts of other quests and new avatars. We brought them the graphic designers' sketches of avatars and discussed how they see it, what roles they think different avatars play, and so forth. Utilizing paleontologists' methods of finding fossils, tools of excavating them, and extensive work of putting the pieces together, we engaged them in looking for fossil pieces among eroded materials (hands-on simulation using sands, other materials, and water), and digging and assembling fossils (paper-based games).

Most importantly, we gave them a focused task of designing quests around plate tectonics and dinosaur capture. For plate tectonics, we gave them resources (books and access to the Internet), and showed them a documentary video about mount St. Helen's volcanic eruption. Their task was to use concepts of plate movements, landforms, Earth's activities in developing a game quest. For dinosaur capture, we challenged them by giving some conditions, such as not to kill or abuse dinosaurs, not to use gun fires, and to use of natural resources and environment in the past world. Students gathered in their own groups and came up with their own ideas. In the following, we focus on their ideas about tectonic plates and game play.

2. Affordances of Informant Design Workshops

Kafai [15] argues for constructionists' approach to educational games, with which students design games for learning. Kafai and her colleague argue that designing educational games as project-based learning provides important affordances for young students' science talk even though some researchers are concerned about students' focusing too much on the aesthetics of the game design [16]. We argue that our informant design workshops have a potential to provide affordances for both science and design talks where learners' understanding about design is very important for learning. Students' experiences as gamers, students in school, participants in our workshops, and actors in their lifeworlds all mattered in their idea generations [18][19].

By Workshop 5, students had been working together in their four small groups (4-5 in each group; they named themselves as Allosaurus, Barney, Stegosaurus, and T-Rex groups); and their voices and interactions reflected the group dynamics developed. Many students became much more aware of their own gaming expertise, which gave them the confidence to provide criticisms and suggestions for the VAD prototype. Their foregrounding of the identities as designers, gamers, and informants who provide important ideas to the research team (as opposed the passive knowledge recipients) became much more apparent. In the following sections, we examine illustrative examples of how students might be making connections between the design tasks and their own ideas and experiences (i.e., gaming, lifeworlds, and previous workshops). The informant design workshops afforded opportunities for learners to use: 1) their pre-existing ideas and concepts; 2) game design components that are meaningful to them; and 3) their cultural models about the world.

2.1 Learners' Use of their Informal Ideas on Plate Tectonics

One of the crosscutting ideas about plate tectonics among the groups was that plate movements are related to volcanic eruptions and would make significant changes to the environment and the situation. Two of the groups (Allosaurus and Barney) used some type of man-made moving force (pushing plates by robots or a machine) to make the volcanoes erupt in the game. On the other hand, Stegosaurus and T-Rex were more specific on the internal Earth processes: convection currents and pressure. Stegosaurus used plate movements as the context for dinosaur capture quest, which would provide time limit for the play. Figure 2 shows their drawing and "Warning!" text that accompanied their description of how game players bring the dinosaurs back to the future within the time limit: *As the time becomes lesser and lesser, the plate tectonic movements will cause the volcano to slowly form and the pyroclastic flow from existing volcanoes becomes bigger*. They indicated movements within mantle (convection current), of magma (upward to the surface), and of plates (spreading) similar to those of oceanic ridges.

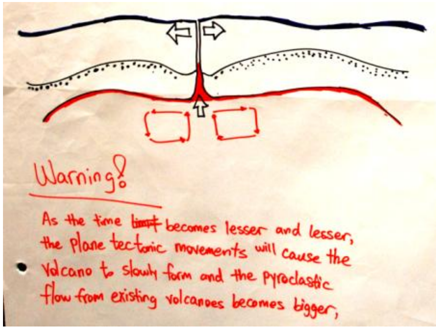

Figure 2. Stegosaurus' use of plate movements as context of play

T-Rex, on the other hand, moved directly into built-up "pressure" as the causing eruption of previously formed volcano without dealing with plate movements. They suggested making volcano erupt in order to destroy a factory that produces dinosaur-killing robots, after losing a battle with Huai Gu Tuo (a wicked character of the game):

> *… so you thought of an idea of using the volcano-Mt. Valbentor-to destroy the factory.*
> *In order to do that, you steal the pressuriser 3056 from Huai Gu Tuo at his company.*
> *[When pressure builds up in the volcano, it will erupt]*

In these examples, the learners participating in this informant design workshop had an opportunity to work with the concepts they had (or searched and interpreted during the workshop) about plate tectonics. In return, we, researchers, have a chance to understand their ideas about the concepts.

2.2 Learners' Meaningful Design Application for Plate Tectonics

Students often imagined becoming powerful through tools and environment in games. The tectonic plates' movements became the source of power in students' designs. In T-Rex's example above, players take the risks of breaking into the evil-doer's company as well as erupting a volcano, which is dangerous and impossible in the real world. At the same time, the player does a simple action of using the tool (i.e., the pressuriser 3056), which leads the complex process of volcanic eruption. As such, all the groups used plate tectonics (i.e., volcanoes) as power-related mechanism. There were variations in the role of volcanic eruptions. They used volcanic eruptions as player's means of destroying something improper, as something that should not happen (a bad guy trying to make it erupt to kill dinosaurs), or as a context that provides a further challenge to another quest.

Below is the example of Allosaurus' quest scenario, where players should stop the volcanic eruption and mass extinction of dinosaurs:

> *The bad guy, Huai Gu Tou, has managed to capture several dinosaurs and does not want Prof. KongLong to succeed in his plans to become rich and famous. So he plans to annihilate the entire dinosaur population by rearranging the tectonic plates in such a way that all the volcanoes on Earth would erupt at the same time and cause the extinction of all dinosaurs. Professor KongLong sent his team of avatars to retrieve the machine that Huai Gu Tou stole from him to rearrange the tectonic plates in order to prevent the mass extinction of dinosaurs.*

In Allosaurus' suggestions for this quest, it can be inferred that is a highly goal-driven effort (fighting for the justice and making improvements for the situations). The above scenario uses a machine to move plate toward or away from each other using + or – buttons (See Figure 3). Players would need to figure out how to create a mountain, for example, by moving specific plates in particular directions.

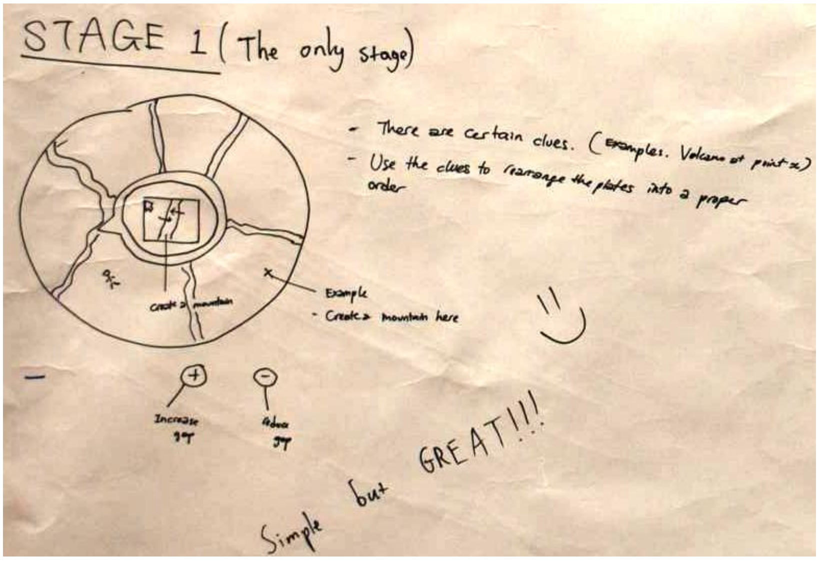

Figure 3. Allosaurus' ideas about a plate tectonics machine

Barney, on the other hand, suggested avatars manually pushing plates together using robots. With the exception of Stegosaurs, who used plates as power that already exists in the environment and controls their actions in the game, three other groups used plate tectonics (or rather volcanic eruptions by pressure, machine, or pushing with robots) as something that gives them power and opportunity to change the environment and the situation in the game in order to achieve their goals.

2.3 Learners' Cultural Models for Working with Plate Tectonics

The informant design workshop also allows learners to use their cultural models. Their designs pointed to their cultural models about the distributed nature of the world as well as games they play: people can achieve things by working with others, tools, and environment . Barney is the only group suggested on working with other players, but all groups focused on the use of the environment and tools: Allosaurus (the machine in Figure 4), T-Rex (the gun, pressuriser 3056), and Barney (the giant and powerful robot to push plates). Coming up with such situations, students tried to justify their use of powers in the scenarios, which signify the players' achievements in the game. Barney's scenario exemplifies such efforts:

> *Objective(s) - To exterminate certain species of dinosaurs via volcanic eruption*
>
> *Storyline*
>
> *The avatars enter the world of dinosaurs and find out that certain dinosaurs are existing in the wrong age. (Eg., T.rex in the Jurassic age). Dr. Kong Long contacts the avatars and instructs them to create a volcano by pushing tectonic plates together and using the eruption to wipe out ALL DINOSAURS THAT DO NOT BELONG TO THE AGE THAT Dr. Kong Long sent them to. To help the avatars achieve their objectives, Dr. Kong Long sends each of them a large robot to help push the tectonic plates together.*
>
> *How It's Done*
>
> *Players get their Avatars into the robots and the player controls his/her robot to push the tectonic plates to form the volcano to destroy the wrong dinosaurs.*

They suggested that multiple players should move plates together and make the volcano erupt in order to wipe out the dinosaurs that should be in different period from the current one (early cretaceous). They situated their knowledge about the dinosaur species and their existing eras and their ideas of plates and volcanoes in the situation and the quest objective (i.e., *To exterminate certain species of dinosaurs via volcanic eruption*). The work toward this objective is distributed among the robots (pushing power), the avatars (control of the robots, coordination among multiple robots, control of plate movement directions), the plates (destructive power, cause of volcanic eruption), and the situation (the driving force for the quest). In Barney's scenario (as well as others), the distributed nature of the meaningful situation, the environment, the tool, and other players becomes the important rule of the game.

Their game ideas show that each of them could be stronger and achieve things that are beyond their capabilities because of other players they collaborate, tools that enable them, and the environmental limitations and/or possibilities, and that these achievements are situated in a meaningful context (for justice, in most of the groups). More importantly, players would be learning/thinking about plate movements together with the tools, the game environment, and/or other avatars.

3. Discussion and Conclusion

Students' ideas show that they are indeed experts in what would work for them as a game and how they like to learn. Our approach provided learners to come up with game ideas that use Earth science concepts without adopting the instructionist approach. Participating in the designing processes is learning in itself. In addition, when learners are designers themselves, the learning benefit does not remain with them only, as argued by Kafai [15]. In Kafai and colleague's [16] work, the constructionists' approach was used only for benefiting learners who participated in the project-based game design. In contrast, our informant design approach benefited both learners as the designers as well as potential users of the game.

We have argued elsewhere for designing learning technologies around relational meanings and emotional experiences: situating the learning experience in the larger structure of practices and concepts to embed experts' knowledge and practices; and considering learners' emotional experiences as resources for them to engage in activities (Kim & Kim, 2010). Our students became quite good at following these principles through their workshop experiences without being taught. Emotional affairs were always apparent in their ideas (e.g., winning battles and gaining points), but it was more closely related to the main learning concepts. The groups' game narratives (which are extensions of the narratives of VAD prototype III) were goal-driven and highly emotional. For example, students used plate tectonics to arouse emotions to engage game players in actions (e.g., time-limit for urgency, devastation of volcanic eruption) and often to drive the goals of drastically changing the environment and the situation. At the same time, they tried to put their achievements in meaningful contexts not only for winning in the game, but also for helping the characters and the environment in the game. In their quest designs, students positioned plate tectonics (the focus of learning content) as the mechanism for their goal achievement and the motivation for collaborations, and game player as justice-fighter who can use the power of the Earth's processes.

Design and learning activities are interrelated. Participation in the informant design workshops demanded students to become cognizant of their prior knowledge of both the Earth science concepts and game design. Although learning was playful and informal as the students participated in the designing process, the ideas for game play were not disparate from the disciplinary knowledge they gained from their formal schooling. Game activities could be meaningful play when game developers make deliberate effort to close the gap between design and learning, such as through informant design approach.

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