Designer Control and the Role of Space in Augmented Reality Games for Learning

Tanner Vea, Teachers College, Columbia University, 525 W 120th Street, New York, NY 11225,
thv2103@tc.columbia.edu

Abstract: Many examples of augmented reality (AR) games for learning establish both the designed, digital space *and* the physical space of the player as within the purview of the game designer. While this exertion of designer control may be beneficial for learning in some circumstances, it should not be considered inherent to AR games generally. In fact, it is potentially counter to the very affordances that make mobile technologies most powerful for learning.

Space in Augmented Reality Games

Previous research in augmented reality (AR) games has shown that a tight link between content and place can be an effective way to motivate learners and make academic tasks meaningful. Schrier (2006) designed an AR game called *Reliving the Revolution*, which "takes place" in Lexington, Massachusetts, at the site of the famous battle. Klopfer and Squire's *Environmental Detectives* (2007) allowed learners to engage in the social practice of environmental science and encouraged them to integrate the constraints and affordances of the local site into their problem solving. The AR games discussed by Perry et al. (2008) are similarly dependent upon their linkages to specific zoos. In each of these cases, a specific space serves as the designated setting for the game's action, and players must interact with particular features of the space in order to complete game objectives. However, this design approach carries with it some important implications. Without access to the designated spaces, players cannot engage with precisely those features of the environment that make these games powerful for learning. This consideration means that the context in which a particular game is effective is relatively narrow.

In the face of these potential challenges, it is worth interrogating our assumptions about the nature of game spaces in AR. When we do so, we find that the tight connection between content and place is not a necessary feature of AR games for learning. Rather, the specificity of the physical space is a continuum along which designers of AR learning games can intentionally vary.

Game Space and the Role of the Designer

Salen and Zimmerman (2006) reviewed the role of space in video games. They argued that the nature of game spaces is mediated by the affordances and constraints of particular technologies. In many video games to this point, the game space has been defined on a single plane, the plane of the digital space provided to the player by the game designer. From this perspective, the goal of the designer with regard to space is to "immerse" the player in the *designed* space, and to minimize the *physical* surroundings of the player—encouraging the player to forget the physical world.

However, AR games (and mixed reality games as well) problematize this unilateral definition of the game space by designers. AR games entail a game space that is defined on two distinct but integrated planes: the digital space of the design, and the physical space of the player. For AR games to work, the relationship must be well defined: one plane of space must "augment" the other.

Reliving the Revolution, *Environmental Detectives*, and other games of their ilk exemplify one response to this need. The designers of these games attempt to define an appropriate or allowable physical space from which the digital game space may be accessed. There is a one-to-one relationship. *Reliving the Revolution* can't help you relive the revolution if, for example, you try to play from Lexington, Kentucky instead of Lexington, Massachusetts. While there are sound pedagogical reasons for the designer to exert this kind of control, such an approach is not inherent to AR and may actually run counter to some of the cultural expectations of our present technological moment.

Player Agency: Mobile Media and Culture as Practice

Another of Salen and Zimmerman's (2006) arguments is that game spaces both enable and constrain player action. The essay "Walking in the City" by de Certeau (1984) provides a helpful metaphor for thinking about how the player as agent and designed game space as structure interact:

> [I]f it is true that a spatial order organizes an ensemble of possibilities... then the walker actualizes some of these possibilities. In that way, he makes them exist as well as emerge. But he also moves them about and he invents others, since the crossing, drifting away, or improvisation of walking privilege, transform or abandon spatial elements. (p. 98)

This statement serves as an argument for thinking about culture as practice. Cultural values and appropriate ways of being are not merely handed down to individuals by the structure; rather, they emerge dynamically from the *interaction* of the individual and the structure. Salen and Zimmerman invoke de Certeau to suggest that game spaces interact with the player's agency to mutually define possibilities in video game worlds. However, through the lens of AR, this passage from de Certeau takes on another valence. It brings into question the design goal of trying to determine the game space unilaterally.

Numerous scholars investigating the specific implications of mobile media on learning have emphasized the highly personal quality of mobile technology as one of the main affordances of mobile technology that makes it unique (Klopfer, Squire, & Jenkins, 2002; Naismith et al., 2004; Squire, 2009). Because of their small form factor and portability, mobile devices are ideal for learning content that is tailored to the individual. And yet, the prevailing design practice at this time seems to be that the principle of personalization not be extended to the definition of AR game spaces.

This is not to say that the physical space of an AR game doesn't matter; it certainly does. Squire and Klopfer refer, for example, to the way in which navigating slopes, rough terrain, and fences played an important role in players' decision making in the *Environmental Detectives* game. However, designers of AR games should broaden their perspective of AR to include designs that leave the choosing of the physical space of the game to the player. Many of the pedagogical benefits of navigating a *particular place* may still be available when navigating *any place*. As one example, the embodied cognition perspective could motivate AR game designs in which the player moves across a physical space while following her location on an on-screen number line. In such a game, moving through space can help learners "get a feel for" (Black, 2010) the difference in numerical magnitudes, but any given space will do. Projects like ARIS (Gagnon, 2010) are beginning to explore the possibilities of "play-anywhere" AR games. Furthermore, removing restrictions on where AR learning games can be played may help expand their reach to new constituencies. In other words, if instead of hanging out in Lexington the player wants to go walking in the city, maybe the designer should be ready to follow.

References

Black, J. B. (2010). An embodied/grounded cognition perspective on educational technology. In M.S. Khine and I. Saleh (Eds.), *New science of learning: Cognition, computers, and collaboration in education.* New York: Springer.

de Certeau, M. (1984). Walking in the city. *The practice of everyday life.* (S. F. Rendall, Trans.). Berkeley: University of California Press. (Original work published 1980).

Gagnon, D. J. (2010). *ARIS: An open source tool for producing mobile learning experiences*. University of Wisconsin-Madison.

Klopfer, E., & Squire, K. (2007). *Environmental Detectives*—The development of an augmented reality platform for environmental simulations. *Educational Technology Research and Development*, *56*(2), 203-228.

Klopfer, E., Squire, K., & Jenkins, H. (2002). *Environmental Detectives*: PDAs as a window into a virtual simulated world. *International Workshop on Wireless and Mobile Technologies in Education*. Vaxjo, Sweeden.

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). *Literature review in mobile technologies and learning*. *FutureLab Report* (Vol. 11).

Perry, J., Klopfer, E., Norton, M., Sutch, D., Sandford, R., & Facer, K. (2008). AR gone wild: Two approaches to using augmented reality learning games in zoos. *Proceedings of the 8th International Conference for the Learning Sciences - Volume 3* (pp. 322–329). International Society of the Learning Sciences.

Salen, K. & Zimmerman, E. (2006). Game spaces. In K. Salen & E. Zimmerman (Eds.), *The game design reader.* Cambridge, Mass.: MIT Press.

Schrier, K. (2006). Using augmented reality games to teach 21st century skills. *ACM SIGGRAPH 2006 Educators Program on - SIGGRAPH '06*, 15. New York: ACM Press.

Squire, K. (2009). Mobile media learning: Multiplicities of place. *On the Horizon*, *17*(1), 70-80.

A Tool for Supporting Game Design Education: Tower Defense Generator

José P. Zagal, Pitchatarn Lertudomtana, DePaul University, 243 S. Wabash Ave, Chicago IL 60604
Email: jzagal@cdm.depaul.edu, p.lertudomtana@gmail.com

Abstract: In education, game design is often used as a means to an end: for example, to learn computer programming. Inspired by the notion of constructional design, or the design of tools to support other's design activities, we are exploring the use of tools to support learning game design as an end in itself. We present a work-in-progress tool called *Tower Defense Generator* that allows student game designers to actively, and reflectively, explore a game's possibility space while developing a deeper understanding of the key features of the tower defense sub-genre, and how those features interact to produce meaningful gameplay experiences. TDG allows learners to use different heuristics to procedurally generate game levels that can then be analyzed, playtested, and modified. We argue that these (and other) features provide for an environment with the appropriate amount of scaffolding to encourage powerful and interesting design explorations in support of learning.

Introduction

Game design and development is often used to help students learn something else, for example, computer programming (e.g. Overmars, 2004). When doing so, learners may develop an "experience in design (i.e., planning, problem solving, researching, dealing with time constraints, [...], and bringing everything together into one project)" (Kafai, 1996). However, the end-goal isn't for students to learn and critically reflect on game design (see Games & Squire, 2008 for an exception). We are exploring ways to help students better learn and practice game design through the use of mixed-initiative design tools. A mixed-initiative approach is one where content (e.g. game levels or maps) "is created through iterative cycles between the human designer and procedural support" (Smith et al., 2010). The idea is to empower a designer by making it easy to rapidly examine alternative designs and automatically check for basic playability (e.g. is it possible to complete this level). We are also inspired by Resnick's notion of constructional design as "a type of meta-design: [that] involves the design of new tools and activities to support students in their own design activities" (Resnick et al., 1996). We believe that combining these ideas can help us develop better tools for practicing game design while also facilitating reflection and learning about game design. We introduce a work-in-progress tool to assist in the design of "tower defense" games. Our tool, *Tower Defense Generator* (TGD), encourages learners to actively, and critically, explore the design space of tower defense games while helping them develop a deeper understanding of the key genre features and how they interact.

Tower Defense Generator

In tower defense games players must position static defenses (i.e. towers) to prevent increasingly tougher waves of various kinds of enemies from reaching and/or destroying an endpoint. Players also collect resources (usually by killing enemies) that are used to purchase or upgrade existing towers. Successful play requires deciding which towers to build, where they should go, and when to upgrade them. In some games, tower placement is also strategic in that it can create paths or mazes that enemies must navigate, thus providing more time for the towers to attack. The pace of these games is moderate and does not require rapid button presses (Ta et al., 2009) and, from a player's perspective, they are easy to play even while they may require tactical and strategic sophistication (Avery et al., 2011). This makes them ideal candidates for learning game design; they are simple to play, but hard to understand deeply. Popular titles in this genre include the flash-based browser game *Desktop Tower Defense* and the multi-platform *Plants vs. Zombies*.

TDG is a tool for the designing tower defense games. It consists of a map generator, a map editor, and separate specifications for towers, enemies, and waves (in XML). Finally, there is a game engine that given a map, tower, enemy, and wave specifications, allows the player to play the game. Due to space, we will only describe the map generator.

TDG's procedurally generated map creator (see Figure 1) allows learners to explore the possibility space of playable maps. In addition to certain "baseline" parameters such as the dimensions of a map, TDG includes a variety of heuristics for map-generation that learners can select from, configure, and then analyze the resulting output. For example, maps can be randomly generated after specifying general parameters such as density of certain terrain features (e.g. traversable vs non-traversable). Alternately, a branching algorithm can be used to create paths that enemies could follow. Each heuristic generates maps with a distinctive "feel", and providing these options encourages learners to reflect on the kinds of game experiences that result from different geographical layouts and how they may align (or not) with their design goals. Rather than focusing on the creation of a single map, our tool provides several for them to analyze, question, and explore. This avoids overwhelming learners with too much freedom and helps limit the scope of their explorations to a single idea. Our approach, in a nutshell, is to provide a "grey box" that avoids the inaccessibility of a "black box" and the complexity of a translucent "white box". By providing a way to rapidly test (play) a map and edit it, we also encourage the kind of iteration (and reflection) that is essential to design and learning. In other words, rather than help generate an "ideal" map, our goal is to help learners reflect on what features make a map successful (or not), learn to identify not-quite-there maps that could be successful after some changing, and be able to make and test those changes.

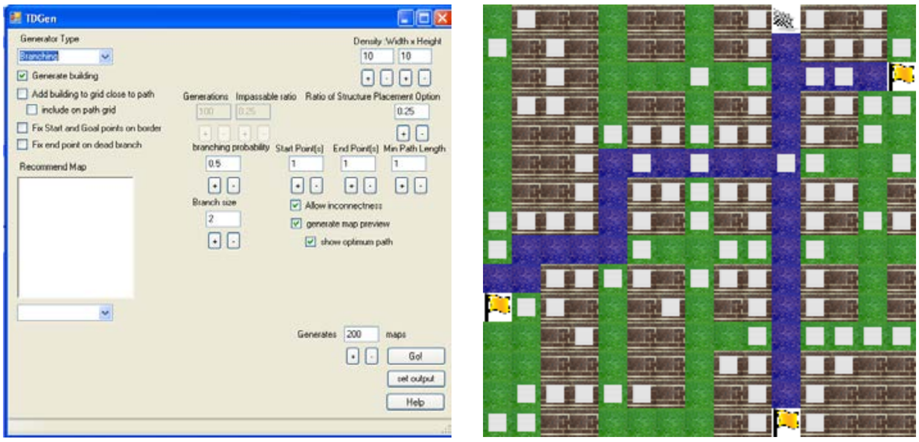

***Figure 1*: Map generator and sample map with one end point and three spawn points.**

Future Work

We are embarking on a formative assessment of our tool in a college educational setting. Additional developments include allowing users to define their own map-generation heuristics and tools for visualizing and modifying pacing and game balance. We are also exploring features for annotating maps with design goals, notable features, tracking the history of changes, and allow easier sharing.

References

Avery, P., Togelius, J., Alistar, E., & van Leeuwen, R. P. (2011). Computational intelligence and tower defence games. *2011 IEEE Congress on Evolutionary Computation (CEC)* (pp. 1084-1091).

Games, I. A., & Squire, K. (2008). Design thinking in gamestar mechanic: The role of gamer experience on the appropriation of the discourse practices of game designers. *Proceedings of the 8th international conference on International conference for the learning sciences - Volume 1* (pp. 257-264). Utrecht, The Netherlands: International Society of the Learning Sciences.

Kafai, Y. (1996). Learning design by making games. In Y. Kafai & M. Resnick (Eds.), *Constructionism in practice*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Overmars, M. (2004). Teaching computer science through game design. *Computer, 37*(4), 81-83.

Resnick, M., Bruckman, A., & Martin, F. (1996). Pianos not stereos: Creating computational construction kits. *Interactions, 3*(5), 41-50.

Smith, G., Whitehead, J., & Mateas, M. (2010). *Tanagra: A mixed-initiative level design tool*. Paper presented at the FDG '10: Proceedings of the Fifth International Conference on the Foundations of Digital Games.

Ta, D.-N., Raveendran, K., Xu, Y., Spreen, K., & MacIntyre, B. (2009). *Art of defense: A collaborative handheld augmented reality board game*. Paper presented at the ACM SIGGRAPH Symposium on Videogames.