Critical Spatial Thinking and Serious Geogames: A Position

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Abstract

Serious geogames are games with a spatial focus for non-entertainment purposes. Critical Spatial Thinking is the idea of applying concepts of critical thinking such as reflection, reasoning, and scepticism to challenging assumptions about spatial data, representations, methods, and analytical outcomes. In this position paper, we argue for a closer research and design connection between serious geogames and critical spatial thinking. Our position is based on our past work of developing serious geogames for general spatial thinking.
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1 Introduction

Serious geogames are an extension of serious games which are games with non-entertainment purposes (Michael and Chen, 2005) and have a spatial focus. *Critical Spatial Thinking* is the idea of applying concepts of critical thinking, such as reflection, reasoning, and scepticism to challenging assumptions about spatial data, representations, methods, and analytical outcomes (Goodchild and Janelle, 2010). In this position paper, we argue for a closer research and design connection between serious geogames and critical spatial thinking.

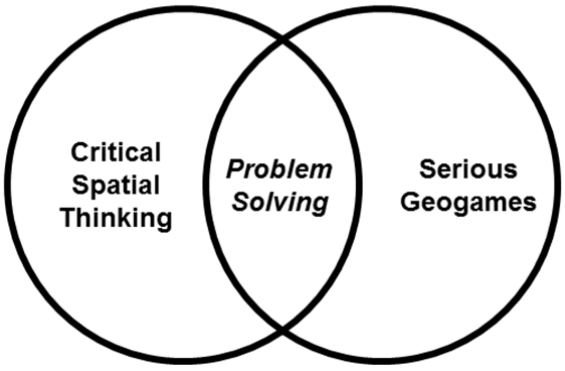
Our position is based on our past work of developing serious geogames for general spatial thinking (Blochel et al., 2013). In our past work, we were particularly interested in using serious geogames as simulation devices for building spatial thinking skills in the disaster management domain (Tomaszewski et al., 2014). The tight coupling of application domains with serious geogames led to our call for more incorporation of expert knowledge into serious game design and game player feedback (Tomaszewski et al., in press). In this position paper, we expand further upon the idea of incorporating expert knowledge into serious game design and the ability of expert knowledge to provide a critical spatial thinking perspective to a game player. We used case studies from the Serious GIS or 'SerGIS' game environment and a digital forensics game to illustrate how critical spatial thinking can be potentially gamified and evaluated.

2 Critical Spatial Thinking and Serious Geogames

Critical spatial thinking is fundamentally concerned with thoughtful engagement of the assumptions associated with spatial data, methods and representations. In particular, critical spatial thinking engages spatial reasoning and problem solving processes (Kim and Bednarz, 2013). For example, understanding why a given data set may not be relevant to a given problem due to scale issues or perhaps why a given data set could be misrepresenting an underline spatial phenomena due to aggregation or the classic modifiable areal unit problem (Goodchild and Janelle, 2010). Serious games, spatial or otherwise, also have a fundamental concern with simulating particular scenarios and using gaming concepts, such as scoring, game narrative, and realism to help a game player learn how to solve problems.

We argue that critical spatial thinking and serious geogames have a natural overlap in terms of the emphasis on critical engagement of problem solving (Figure 1).

Figure 1: Venn diagram showing the conceptual overlap between Critical Spatial Thinking and Serious Geogames.



Serious geogames add a unique element to this mix. The emphasis of using spatial technologies for problem solving, like geographic information systems (GIS), enable engagement with a wide range of issues associated with critical spatial thinking, such as scale, uncertainty, and representation.

Developing effective spatial problem solving skills is also fundamentally tied with developing critical spatial thinking expertise (National Research Council, 2006). Development of expertise comes in many forms—training, education, job experience, and formal and informal mentoring. In the following section, we describe how our serious geogame environment called 'SerGIS' incorporates spatial expertise as a critical spatial thinking element to a serious geogame

experience. We also discuss how incorporation of narrative exploration via related work in game-based education for digital forensics provides a promising pathway for problem solving and enhancing the geogame experience.

3 Expertise and SerGIS

Serious GIS or *SerGIS* is a geogame framework designed to allow for flexible development of geogames. Game development flexibility comes from an authoring framework where designers can choose a wide variety of web-based geospatial data to create geogame scenarios. For example, SerGIS has been used to build games that range from a wizard of OZ scenario to bird-induced airplane crash scenario. In SerGIS, game players go through a non-linear, question/answer structure and are awarded points for question responses and a final score at the end of the game. SerGIS was originally developed to train disaster management personnel on the capabilities of GIS for disaster management and build general spatial thinking skills without getting into the complexity and learning barriers that can come from formal GIS software training (Mathews et al., 2014).

Through successive evaluation of the SerGIS framework with game players, the incorporation of expertise into the SerGIS game experience was found to be an important element to enhancing the game experience for building critical spatial thinking skills that can teach and build spatial problem solving skills (Tomaszewski and Griffin, 2016). In the following section, we provide a brief walkthrough of how SerGIS engages critical spatial thinking via incorporation of expertise using a flood disaster management scenario in Malmö, Sweden.

3.1 SerGIS Critical Spatial Thinking Engagement via Incorporation of Expertise: Malmö Flood Scenario

Malmö is a coastal city located in the southern tip of Sweden across from Copenhagen. As a coastal city, Malmö is prone to flooding from intense weather events. Our team designed a SerGIS game to develop critical spatial thinking about responding to a flooding event in Malmö. In the game, players must respond to series of questions about solving flood-related problems. Each question has three answers (Figure 2).

Answers are weighted in that some answer choices are better than others for solving the problems. Each time a game player makes a choice, they are given expert feedback about the choice they made (Figure 3).

For example, note in Figure 3 when the game player selected the 'Kockums (RED)' choice that was shown in Figure 2, they were given feedback on why this was a poor choice both geographically in terms of population characteristics and spatially in terms of a seemingly counter intuitive spatial fact that although the area selected is near the coast, it does not have flooding problems. The rest of the game scenario has expertise like this that can help to build critical spatial thinking skills through the game experience as well as understanding the capabilities of GIS in general as per the original goals of SerGIS.

Figure 2: The SerGIS game framework. Note the three answer options shown on the bottom right of the image.

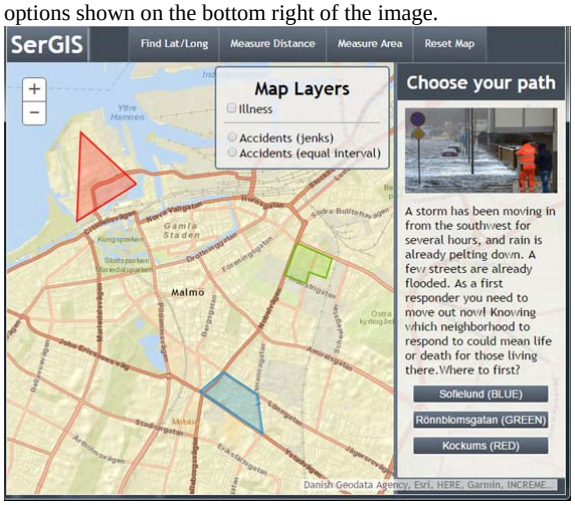


Figure 3: An example of receiving expert feedback after making a choice in SerGIS.

3.2 Game-Based Learning Through Narrative

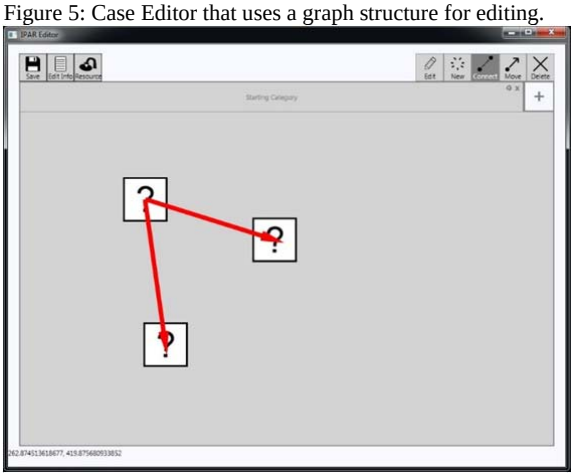
Although seemingly unrelated, recent work in game-based learning in digital forensics (Pan et al., 2015) has yielded excellent results with respect to "gamifying" a complicated problem solving task using narrative. In developing educational material for digital forensics, prospective students might have preconceived notions of "hacking" from movies, TV, and other media. But the reality of true digital forensics software and its complexity can deter students from entering this critical field. Thus, by bridging the concept of being a digital "detective" as part of real forensics cases, a game can motivate students to seek clues to solve actual problems with actual forensics tools.

In Figure 4 below, we show a portion of an introductory case in a game framework called IPAR (Image, Preserve, Analyze, Report). The player unlocks and reveals clues from a

"conspiracy board." Each clue requires investigation with software, external resources, tutorials, and qualitative responses. Because of the data-driven design, such cases are relatively easy to design using spatial relationships such as graphs, as shown in Figure 5, which demonstrates the IPAR editor.

Figure 4: IPAR game framework

Figure 5: Case Editor that uses a graph structure for editing.



Much like a choose-your-own adventure book, the IPAR framework provides an external interface for virtually any scenario. We propose linking the SerGIS and IPAR game frameworks, which would (a) provide easier access to editing scenarios, (b) incorporate more narrative aspects into a gaming experience, and (3) allow for expert feedback incorporation the geogame framework.

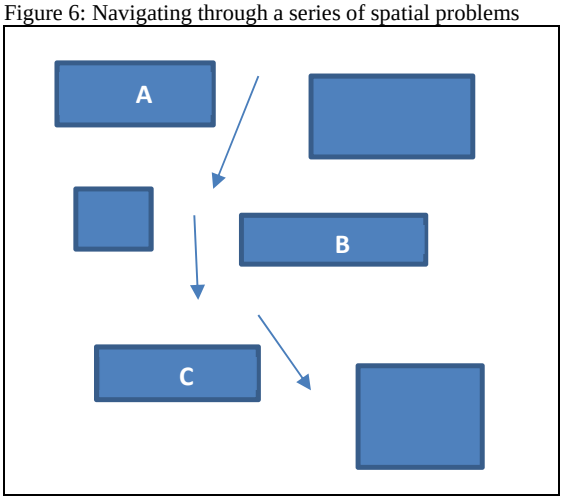
4 Convergence

The narrative framework of IPAR provides a potentially fruitful key to adapting a way for users to explore space—both the convergence of problem space with actual locations. To incorporate spatial thinking into an investigative framework, the IPAR editor and engine provides a tool to plan a series of tasks. The software is extensible enough to remove the "P" (preservation) and just focus on the directed acyclic graph of tasks for a potential focus on spatial analysis.

There is extensive literature for case/problem-based learning and teaching (Center for Research on Learning and Teaching (CRLT), 2016). In these fields, students and teachers process "complex, real-life scenarios" through discussion and reflection. IPAR provides a framework for dissecting an entire case/problem into a series of smaller problems that require quantitative analysis and qualitative responses. We propose to merge IPAR and SerGIS so that learners can step through visual problems one task a time, following the directed acyclic graph(s) of IPAR as "geospatial investigators." Moreover, this convergence provides a fascinating launching point for exploration within a 2-D or 3-D environment. For example, with the case-based problem framework, a player could be guided through a series of locations in a simulated environment (e.g., a game modeled in Unity or ArcGIS) with "clues."

For example, perhaps a player is tasked with identifying buildings with fire-escapes facing onto a street and considering a potential crowd flow, depicted in Figure 6. The combined IPAR/SerGIS framework can already handle the problem decomposition from problem-based learning. The player can use the motivation of being a detective to seek visual clues (and cues!) to solve spatially complex problems—what is missing is the spatial navigation via integration with a visual environment, which we hope to address as part of the IPAR/SerGIS convergence.

Figure 6: Navigating through a series of spatial problems



5 Summary and Conclusions

One future work activity would be evaluation of critical spatial thinking ability development via our serious geogame frameworks. This is a challenging task as valid and reliable measures of spatial thinking ability let alone critical spatial thinking are still a nascent field (Kim and Bednarz, 2013, Lee and Bednarz, 2012). However, the scoring mechanisms of SerGIS combined with qualitative techniques, like think aloud protocol have potential to provide mixed evidence on the utility of SerGIS to evaluate critical spatial thinking ability (Mathews et al., 2014). Additionally, we plan to explore how

broader critical thinking evaluation ideas can be incorporated into critical spatial thinking evaluation. For example, analyzing game player choices or geo-game designs themselves in terms of quality of critical thinking models via categories such as these non-exhaustive examples: *clarity* (are the spatial aspects of the game clear?), *logic* (does the game choice made represent a logical choice spatially in terms of scale or analytical tool used), and *depth* (does the game player's reasoning for a given question address the spatial/geographical complexities of the question?) (McLean, 2005).

In this position paper, we argued that there should be a closer research and design connection between serious geogames and critical spatial thinking. We provided evidence of how this perspective is particularly useful to spatial problem solving skill development using a flooding scenario from our SerGIS serious geogame frameworks. Ideally, further design and evaluation research can lead to serious geogames that address important societal problems such as disaster management and led overall improved spatial thinking via geogamification.

6 References

Blochel, K., Geniviva, A., Miller, Z., Nadareski, M., Dengos, A., Feeney, E., Mathews, A., Nelson, J., Uihlein, J., Floeser, M., Szarzynski, J. & Tomaszewski, B. 2013. A Serious Game for Measuring Disaster Response Spatial Thinking. *ArcUser* 16**:**12-15.

Center for Research on Learning and Teaching (Crlt). 2016. *Case-based Teaching and Problem-based Learning* [Online]. Available: http://www.crlt.umich.edu/tstrategies/tscbt [Accessed: 10 April 2017].

Goodchild, M. F. & Janelle, D. G. 2010. Toward critical spatial thinking in the social sciences and humanities. *GeoJournal* 75**:**3-13.

Kim, M. & Bednarz, R. 2013. Development of critical spatial thinking through GIS learning. *Journal of Geography in Higher Education* 37**:**1-17.

Lee, J. & Bednarz, R. 2012. Components of spatial thinking: Evidence from a spatial thinking ability test. *Journal of Geography* 111**:**15-26.

Mathews, A., Tomaszewski, B., Szarzynski, J. & Vodacek, A. 2014. Disaster Risk Reduction Spatial Thinking: A Serious Games Approach. *11th International Conference of the International Association For The Study Of Information Systems For Crisis Response And Management (ISCRAM).* University Park, PA.

Mclean, C. L. 2005. Evaluating critical thinking skills: Two conceptualizations. *Journal of Distance Education* 20**:**1.

Michael, D. R. & Chen, S. L. 2005. *Serious games: Games that educate, train, and inform*: Muska & Lipman/Premier-Trade.

National Research Council 2006. *Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum*, Washington, DC: The National Academies Press.

Pan, Y., Schwartz, D. & Mishra, S. Gamified digital forensics course modules for undergraduates. Integrated STEM Education Conference (ISEC), 2015 IEEE, 2015. IEEE, 100-105.

Tomaszewski, B. & Griffin, A. L. Students Learning about Disaster Situation Training using Serious Games for GIS (SerGIS). Association of American Geographers Annual Conference, 2016 San Francisco, California.

Tomaszewski, B., Konovitz-Davern, A., Schwartz, D. I., Szarzynski, J., Siedentopp, L., Miller, A. & Hartz, J. in press. GIS and Serious Games. In*: Comprehensive Geographic Information Systems*, COVA, T. J. & TSOU, M.-H. (eds.): Elsevier.

Tomaszewski, B., Szarzynski, J. & Schwartz, D. I. 2014. Serious Games for Disaster Risk Reduction Spatial Thinking. *Eighth International Conference on Geographic Information Science (GIScience 2014).* Vienna, Austria.