Minecraft as a Generative Platform for Analyzing and Practicing Spatial Reasoning

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Abstract. As excitement for Minecraft continues to grow, we consider its potential to function as an engaging environment for practicing and studying spatial reasoning. To support this exposition, we describe a glimpse of our current analysis of spatial reasoning skills in Minecraft. Twenty university students participated in a laboratory study that asked them to recreate three existing buildings in Minecraft. Screen captures of user actions, together with eye tracking data, helped us identify ways that students utilize perspective taking, constructing mental representations, building and place-marking, and error checking. These findings provide an initial impetus for further studies of the types of spatial skills that students may exhibit while playing Minecraft. It also introduces questions about how the design of Minecraft activities may promote, or inhibit, the use of certain spatial skills.

Keywords: perspective-taking, eye-tracking, learning environments

1 Introduction

Recent research has begun to broaden the field's conception of the practices and contexts in which individuals engage in spatial reasoning. Some researchers (e.g.,[7]) have suggested that the field consider how spatial cognition varies across different contexts. Thus, spatial thinking should be viewed as a variety of related skills that develop in specific contexts, rather than a domain-general ability. In this paper we extend research on spatial reasoning and games [e.g., 1–3] by examining Minecraft, a popular sandbox video game, as a context for both studying and practicing spatial reasoning skills. As a sandbox game where users can explore virtual worlds, collect resources and build structures out of blocks, Minecraft represents a noticeable departure from many previously analyzed games, such as first-person shooters and Tetris. Furthermore, Minecraft contains several in-game components (e.g., discrete blocks, a cartesian grid, and an infinite supply of blocks) that, we argue, make it particularly well-suited for studying and teaching spatial reasoning. Hence, this paper will describe a slice of an on-going project that centers on two questions: 1) What spatial reasoning skills might be exhibited through building in Minecraft? and 2) In what ways might these skills be generative for growing the field's conception of spatial reasoning in context?

2 Methods

This study took place in a laboratory at a private university in the Midwestern region of the United States of America. Twenty participants completed the study, but data from 3 of them was lost due to computer and human error. Our analysis is based on a dataset that includes 17 participants. All participants were enrolled as undergraduate or graduate students at the university.

Participants were given unlimited time to build three structures (Fig. 1- Fig. 3) within the Minecraft virtual world on a computer. Some students were shown the structures in a digital portfolio, while others had access to the structures in the virtual world. Each computer collected a screen recording, audio data, eye tracking data, mouse movements and keyboard logging as students completed the task. The eye-tracking data was combined with the video recording for human video analysis. The data analysis followed an iterative process that was guided by looking for spatially-relevant actions based on knowledge of previous spatial categories (e.g., perspective taking and mental rotation), and the affordances of Minecraft (e.g., the ability to fly). The categories presented in this paper are the most recent iteration of this on-going work.

Fig. 1. Structure A

Fig. 2. Structure B

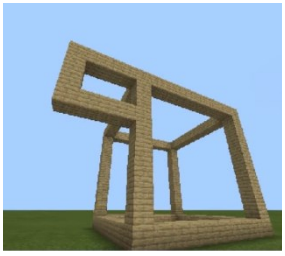

Fig. 3. Structure C

3 Results

Our analysis has surfaced four classes of actions. The first two, spatial representations [4] and perspective-taking [3], bear similarity to existing spatial skills, while the final two, building and place-marking, and error checking and correction, represent a deviation and a combination, respectively.

3.1 Mental Representation

One common practice we observed was the various ways users worked to form mental representations by counting blocks (inferred from eye-tracking data) or otherwise fixating on a single subcomponent of a given structure. For example, when building any of the three structures, individuals would often select a single point, normally at a corner, and use that as a reference point to develop a usable representation of that structure. This approach is in lieu of what may take place within the material world by using a yardstick or other measuring device. The discrete blocks within Minecraft make this process possible. In the language of Newcombe & Shipley[5], this process of looking at the sub-components (i.e., combinations of discrete blocks) may help students discern the intrinsic properties [7], and perhaps, identify relevant symmetries or noticeable asymmetries. Put differently, we can think of the process of counting, or establishing a visual-spatial anchor as a means for making what is ultimately a dynamic [7] process (i.e., building with blocks) seem more static.

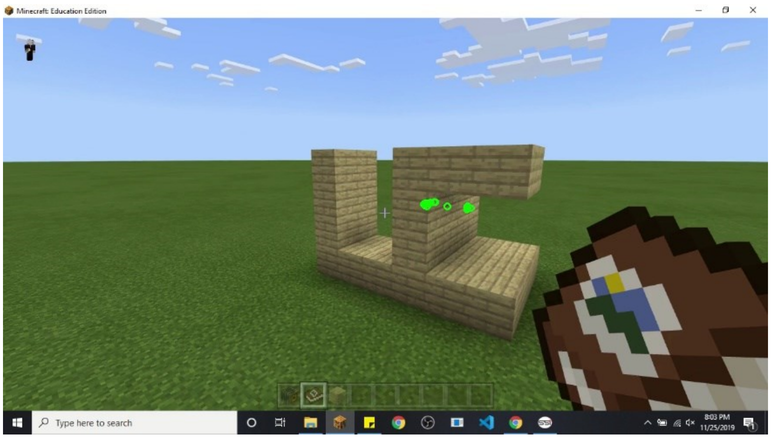

Fig. 4. Student positions their avatar at time 00:06:30 to match portfolio angle. Green dots are eye gaze data points.

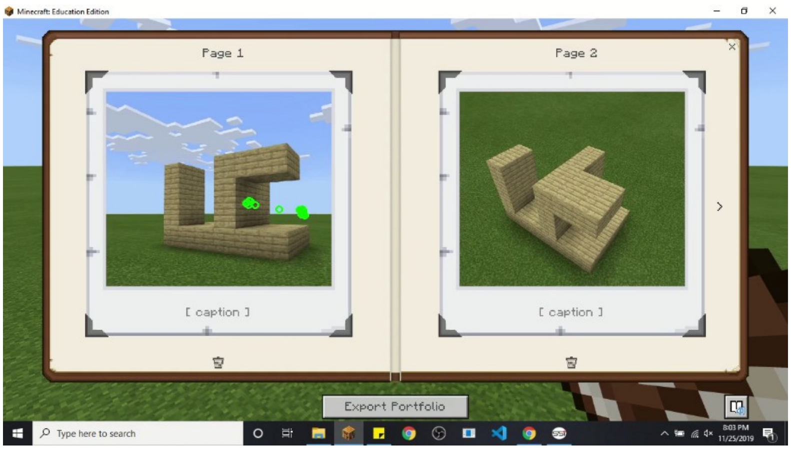

Fig. 5. Student views structure in the portfolio at time 00:06:35. Green dots are eye gaze data points.

3.2 Perspective Taking

Perspective taking [3] was also a common approach. One example of perspective taking was students intentionally viewing their built structure at the same angle as the reference structure. This was common for students whose reference structures were in a digital portfolio. In viewing the structure from one or more perspectives, students are dealing with extrinsic representation, as they reconcile the relationship between their avatar and the Minecraft structures [7].

3.3 Building and Place-Marking

Whereas perspective taking involved the user thinking about the structure in relation to their avatar, building and place-marking has more to do with the relationship between the reference object and the object that they are building. A prime example is when students carefully built their structures right next to the reference structure (Fig. *6*). In many ways this eliminated the need for them to explicitly count the structures size, because they could use the nearby reference building as a visual cue. Another example is when students build row by row and can use visual cues to know where to start and stop each row. Frequently, the use of building and place-marking reduces the overall complexity of the building process.

Fig. 6. Example of building next to the reference structure

3.4 Error Checking and Correction

As students built their structures, some took steps to determine the correctness of their design. We suggest that this process integrates elements of perspective taking and forming a spatial representation. Students positioned their avatar (perspective taking) so they could easily compare corresponding features (derived from their mental representation) of the reference structure and the built structure (Fig. 7). This is similar to the encoding and comparison process discussed within the mental rotation literature [4].

Fig. 7. Example of student checking their built structure against the reference

4 Discussion and Conclusion

Our analysis includes four practices that we argue are closely tied to spatial reasoning. Two practices include perspective taking and building mental representations through counting and identification of salient features. At the same time, some of the affordances of the game seem to point to opportunities to circumvent certain spatial practices. For example, building and place-marking, eliminated some of the need for students to count the size of the structures being created. Depending on the context, we could see ways that this could serve as being beneficial or deleterious for learning but leave this as a mere observation within the current study.

More broadly, we are intrigued about using Minecraft as a platform to better understand spatial reasoning practices in context. When combined with eye tracking technology, it could be very feasible to have students complete a diverse set of spatial reasoning tasks all while remaining within the comfortable and contextually motivated Minecraft environment. In line with this implication is the realization that additional research is needed to determine the types of Minecraft activities that promote the use of spatial reasoning, and their alignment with different types of spatial practices.

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