Board 96: Designing a Middle Grades Spatial Skills Curriculum in Minecraft

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Designing a Middle Grades Spatial Skills Curriculum in Minecraft (Work in Progress)

Introduction

Many researchers maintain that spatial skills, or the collective and diverse set of cognitive abilities that involve generating and manipulating mental representations of objects, provide a critical foundation for intellectual ability and learning [1-9]. Further, researcher also suggests that spatial abilities are critical to success in STEM fields and STEM learning [10, 11]. Despite recognition of the critical role these skills play in STEM learning, research continues to indicate spatial abilities are one of the few areas of cognitive skills with gender differences, where females do not perform as well as males [12]. These differences seem to often emerge in middle school years. Some researchers have concluded that these difference might be a contributing factor to the under representation of women in engineering fields [10].

However, research on spatial skill interventions has indicated that precisely targeted trainings, even very brief interventions, can significantly improve younger learners' spatial abilities [13-17]. It should be noted that cognitive psychologists and researchers often use spatial skills, spatial intelligence, and spatial skills interchangeably. To lend precision to this investigation, we have operationalized spatial *abilities* to be the innate abilities with which we are born. Spatial *skills*, on the other hand, are representative of what can be learned [18]. Consequently, we use the term *spatial skills* to frame this research.

Interacting in 3D environments, and sketching 3D objects, can assist development of spatial skills [19-22]. Couching our approach in this research, we have hypothesized that interacting in a 3D gaming environment like Minecraft [23] might be one solution for developing these precisely targeted spatial skills interventions. In Minecraft, users "sketch" using 3D objects in a virtual space, building 3D objects through the virtual manipulation of blocks. Although some empirical research does exists on this approach [24], exploring ways to leverage learners' interest in 3D gaming environments in an effort to build spatial skills seems prudent given the excitement around electronic gaming in youth. Therefore, leveraging funding from the National Science Foundation (Award # DRL-1720801), the purpose of this study is to investigate if the process of virtually building and manipulating 3D objectives in a digital context like Minecraft can result in similar growth in spatial skills.

Research Design

In an effort to investigate if Minecraft can be used as an effective intervention to support learners' spatial skill growth, we designed a series of Minecraft-based puzzles and challenges that target specific spatial skills influence learners' spatial abilities. Our team then offered a spatial skills-focused and Minecraft-based summer camp in Summer 2018 for upper elementary and middle school learners. Although all camp participants that provided research consent (*n*=32), only 27 participants completed a background survey prior to the camp. Findings from the background survey all camp participants completed before the start of camp indicate that 74% (*n*=20) of participants identified male, and 26% (*n*=7) identified as female. In terms of the grade participants were entering in the fall of 2018, a large majority (52%, *n*=14) were entering 4th, whereas 11% (*n*=3) were entering 5th grade, 18% (*n*=5) were entering 6th grade, and 18% (*n*=5) were entering 7th grade. And lastly, a majority of participants were beginner or novice Minecraft players with little to no experience playing the game (50%, *n*=13). Thirty-one percent (n=8) of participants had some experience with Minecraft, and only a small portion of the participants had considerable Minecraft experience (19%, *n*=5).

To measure the effect of the Minecraft-based activities on learner's spatial skills, a pretest/posttest design was used that focused on the mental rotation and 2D-to-3D transformation skills. On day one of the camp, participants completed pre-tests on each spatial skill. These measurements were designed to less than 10 minutes to complete and were adapted from previous instruments used with similar populations and found to be valid and reliable. We recognize that the instrument adaptation process invalidates the original instruments. Consequently, further research plans include a closer examination of these new measurements to examine instrument validity and reliability. The mental rotation instrument was an adapted version of the Purdue Spatial Visualization Tests: Visualization of Rotations (PSVT:R) [17, 25]. The 2D-to-3D transformation measurement was adapted from Ramful, Lowrie, and Logan's [26] Spatial Reasoning Instrument. With the help of a spatial skills expert, those items from the Spatial Reasoning Instrument that specifically align with 2D-to-3D transformation skills were selected. Those items were combined with several items from Lappen's [27] Spatial Visualization Test. Data was analyzed using a paired-samples t-test. Given the small sample size (n=32), more sophisticated analyses were not prudent at this time. A power analysis indicated a much larger sample size would be needed. However, in the future, once the spatial skill activities are completed by more learners, an analysis of covariance (ANCOVA) methods to test for significant differences between gender groups on changes in spatial skills will be conducted.

Preliminary Findings

Preliminary findings suggest that learners' mental rotation skills did increase, but no growth was found in their 2d-to-3d transformation skills. Analysis of the mental rotation measurement data indicates that, across all learners, participants scored higher on the post-test than on the mental rotation pre-test; a statistically significant increase of 1.0625 (95% CI, -1.6114 to -.5135) km, $t(31) = -3.9473$, $p < .0005$. The Cohen's d was approximately .59, suggesting a medium effect of the treatment.

Analysis of the 2D-to-3D transformation measurement data suggests learners did score higher on the post-test than on the pre-test, but the difference was not statistically significant (0.40625 (95% CI, -.9391 to .1266) km, $t(31) = -1.5549$, $p = .1301$. Combined, these paired-samples t-tests suggest that learners, when gender is not used as a covariate, scored significantly higher on the mental rotation post-test, but not on the 2D-to-3D transformation post-test. As indicated, once the research team is able to increase the sample size with further academic year implementations of the spatial skills activities coupled with summer camps in 2019 and 2020, ANCOVA will be used to determine if any differences exist between gender groups. Data analysis is currently underway and additional findings will be shared in the full paper.

Preliminary Conclusions & Implications

Notwithstanding the small sample size, coupled with the lack of experimental design, results from this small study indicate that learners' mental rotation spatial skills did increase from pre-test to post-test. In addition, we intend to refine the design of the 2D-to-3D transformation Minecraft activities in an effort to arrive at a design that might better influence that spatial skill. We have plans for academic year pilot testing and pending summer camps to increase the sample size, as well as provide opportunities to test other Minecraft-based activities targeting additional spatial skills like mental slicing and perspective taking. Ultimately, we intend to assess the effectiveness of those new activities with the results from refined mental

rotation and 2D-to-3D transformation activities, intent on developing a cohesive Minecraft-based intervention that most effectively grows a variety of spatial skills in middle grades learners.

Funding

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