SUPPORTING THE DEVELOPMENT MIDDLE GRADE LEARNERS' SPATIAL SKILLS WITH MINECRAFT

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BACKGROUND

- Interdisciplinary STEM-focused effort rooted in the Montana Engineering Education Research Center (MEERC) :
  - Nick Lux (Education)
  - Brock LaMeres (Engineering)
  - Shannon Willoughby (Physics)
  - Bryce Hughes (Education)
  - Barrett Frank (Physics)
  - Sheryl Sorby (University of Cleveland Engineering Education)
  - Chris Miko (CSULB & Advanced Learning Project)
  - Preservice teachers

NSF-FUNDED 3.5 YEAR PROJECT – CURRENTLY IN YEAR 3

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INTRODUCTION AND BACKGROUND

WHAT ARE SPATIAL SKILLS?

- Spatial judgment and visualization abilities have been shown to be predictors of middle school students' future achievement in STEM-related courses (Sorby, Casey, Veurink, & Dulaney,2014; Sorby 2000)

WHY FOCUS ON SPATIAL SKILLS?

- However, spatial skills are one of the few cognitive skills showing gender differences (Hill, Corbett, & St. Rose, 2010; Hsi, et al., 1997; Hungwe, Sorby, Molzon, Charlesworth & Wang 2014; Maeda & Yoon, 2013, McGee, 1979)
- Differences emerge around middle school (Wang & Degol, 2013)

WHY FOCUS ON SPATIAL SKILLS?

- Even abbreviated interventions (< 10 hours) can improve spatial skills (Hill et al., 2010; Hsi et al., 1997; Sorby, 2009)

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WHY MINECRAFT?

- Leveraging interest in game play
- Easily scalable & remotely delivered
- Aligns w/ research on role player games (1st person shooter) (Clark, Tanner-Smith & Killingsworth, 2016; Green & Bavelier, 2003 and 2007; Martin-Dorta et al., 2014; Nguyen & Rank, 2016)

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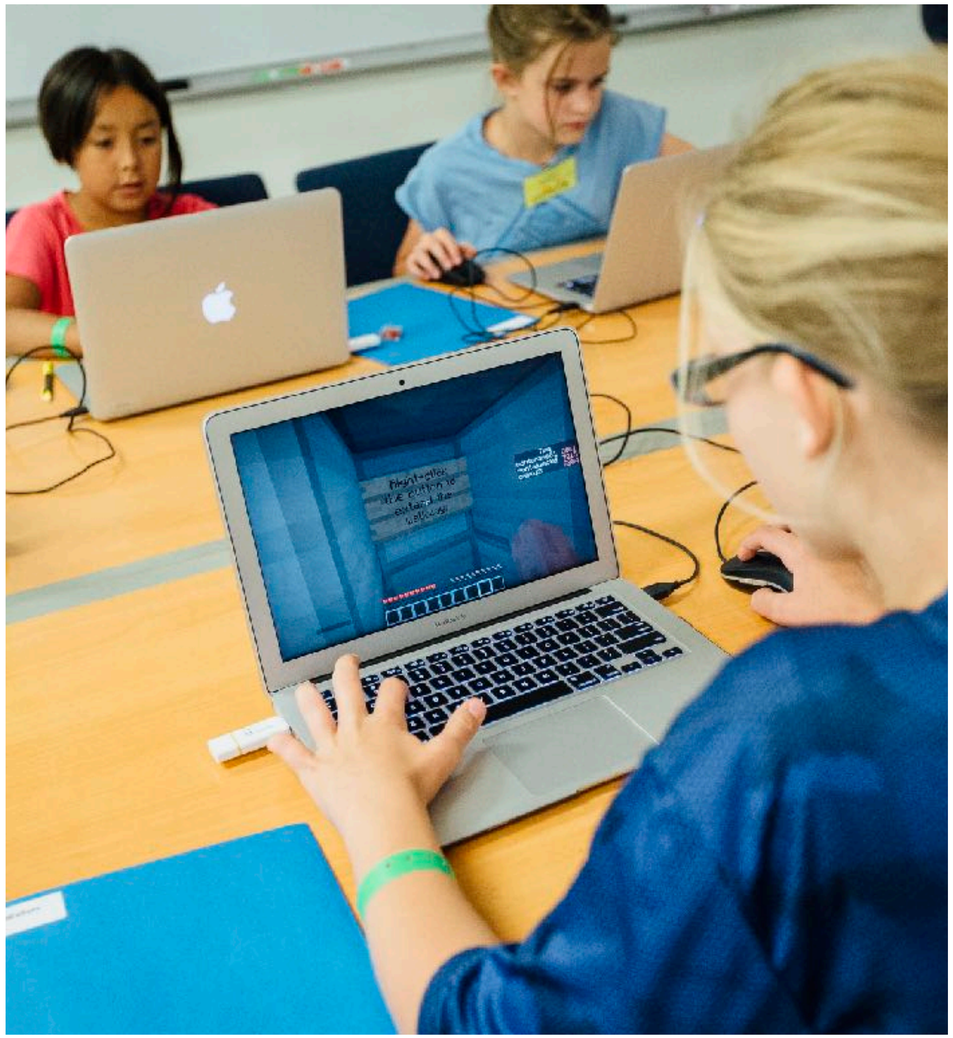
WHY MINECRAFT?

- Sketching 3D objects has been shown to substantially assist development of spatial skills. (McKim, 1980; Sorby & Baartmans, 1996; Sorby & Gorska, 1998; Field, 1994; Bowers & Evans, 1990)



MINECRAFT EXAMPLE: CALIFORNIA MISSIONS

THE STUDY

PROBLEM STATEMENT

- Despite what is known about game play in 3D environments, little research has been conducted how Minecraft can be used to address spatial skills.

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PURPOSE

- Investigate if Minecraft-based activities that target specific spatial skills influence learners' spatial abilities, and how that skill growth differs across genders
- Measure which design challenges most positively influence spatial skills, and **how growth varies by gender**.

RESEARCH QUESTIONS

1. Does a Minecraft-based intervention that targets specific spatial reasoning tasks influence middle grade learners' spatial ability?
2. Does spatial skills growth differ by gender?

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INTERVENTION DESIGN

SPATIAL SKILLS AND MINECRAFT

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TIMELINE

Three-year project…

- Year 1: Team development, planning, intervention design
- Year 2: Summer Camp #1 (August 2018)
- **Year 3: Summer Camp #2 (August 2019)**

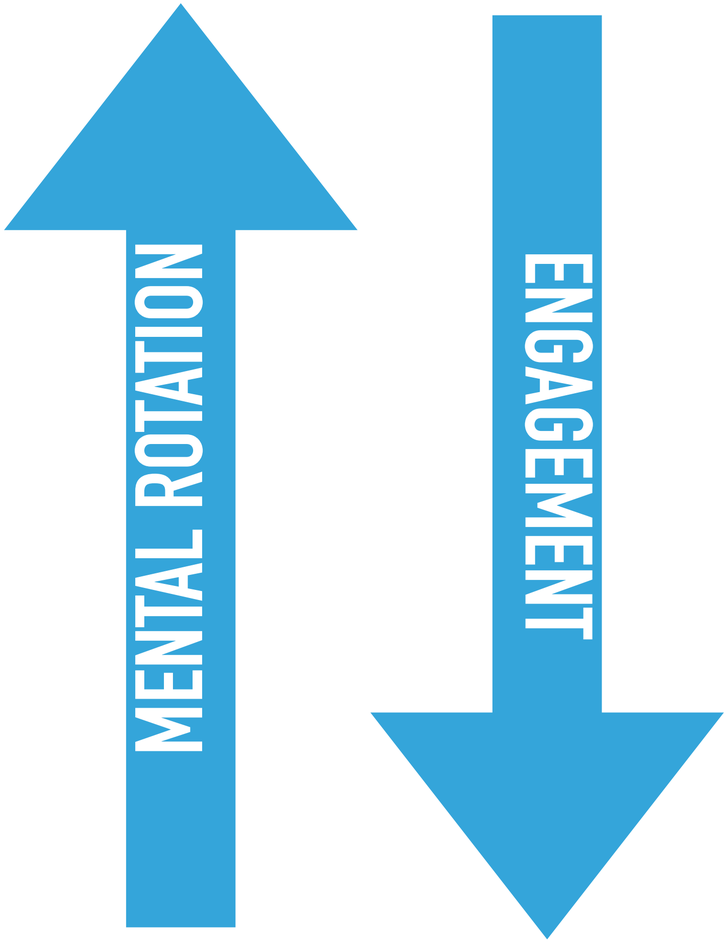
DESIGN: DAY CAMPS IN 2019

- **Day One**
  - Spatial skills pre-tests (puzzles);
  - Minecraft basics;
  - Spatial skills problem solving intro
  - Storyline Intro & Fortress Design Challenge
- **Day Two**
  - Maze challenges and puzzles
  - Fortress Design Challenge
  - Boss Battle

About 10 hours total

SPATIAL SKILLS ACTIVITY DEVELOPMENT

- Spatial skills activities were originally highly structured activities that students completed in the Minecraft environment
- After Year 1, mental rotation measurement data indicates a statistically significant increase of 1.0625 (95% CI, -1.6114 to -.5135) km, $t(31) = -3.9473$, $p < .0005$ (Cohen's $d = .59$)
  - But anecdotal evidence suggested the tutorial/ drill & practice design influenced engagement



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SPATIAL SKILLS ACTIVITY DEVELOPMENT

- In Year 2, we worked with partner teachers to develop an **engaging** narrative drive the game
- Pilot tested the design concepts with three classes of students (*n* = 58) and arrived at a final storyline in the form of a graphic novel
- Preservice teachers participated in the research, wrote the storyline, and pilot tested it
- **Winner: Post Apocalyptic Zombie World**

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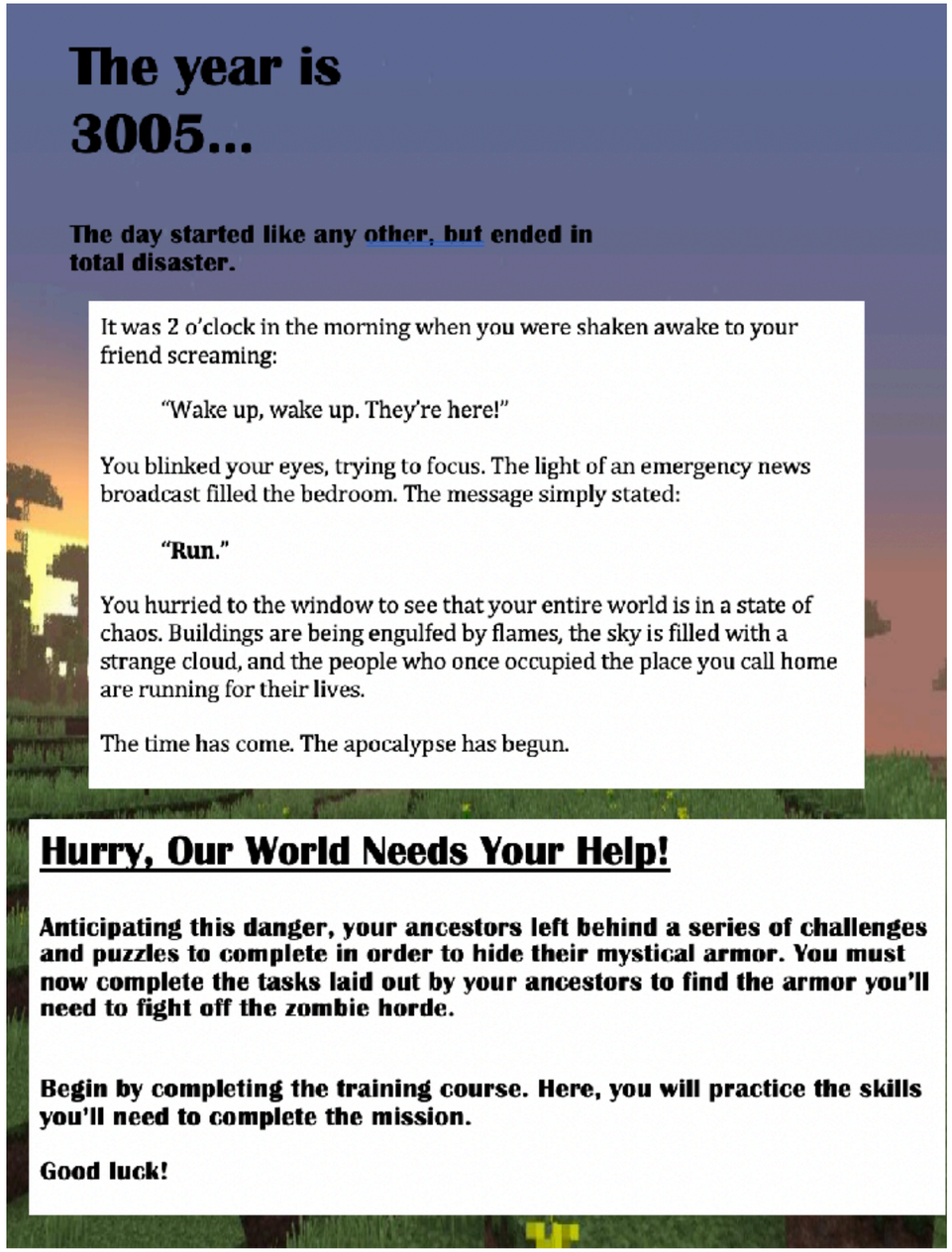
THE STORYLINE

- Must complete series of spatial skill puzzles to obtain the armor needed to beat the Zombie boss
- Complete a Minecraft training course
- Complete intro rotation and 2d3d transformation puzzles to obtain a map
- Design a fortress for your team
- Complete puzzles to earn armor for final battle



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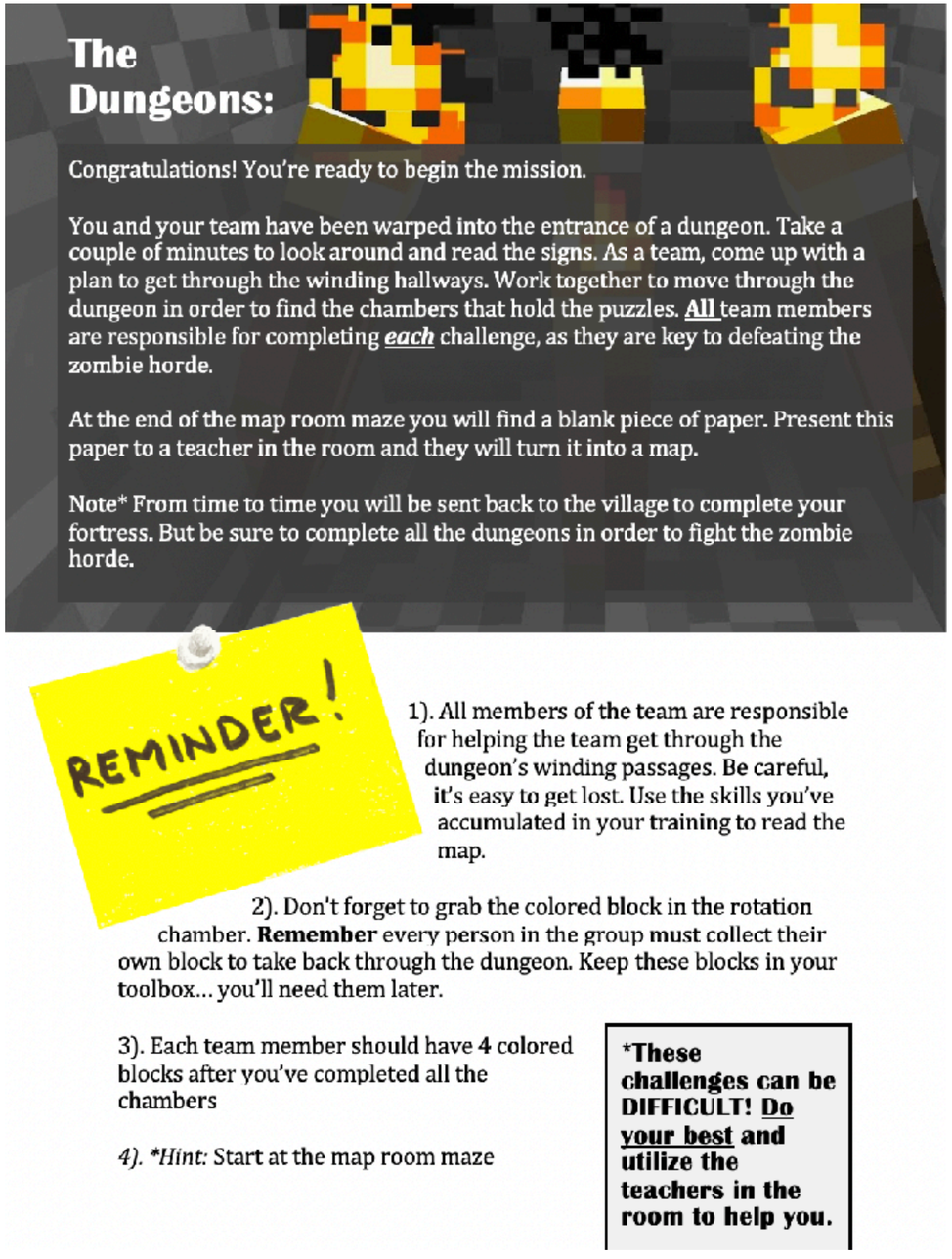
THE STORYLINE

- Student use a paper-based map to navigate a maze in Minecraft
- At the end of the maze, students complete a variety of rotation and 2d3d puzzles
- When successful, system “checks” the answers and advances students to next maze
- Beat all 4 mazes (with 2 spatial puzzles each) to earn the armor to fight the zombie boss



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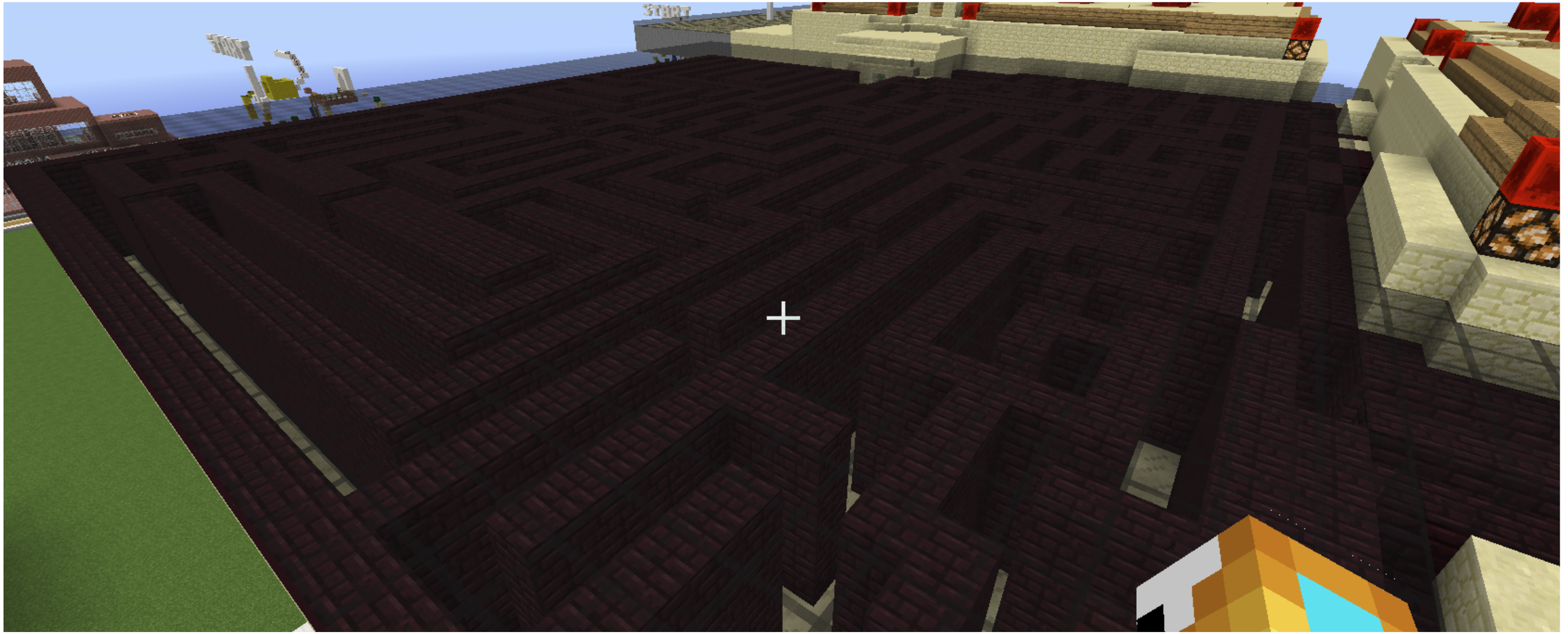
GAME PLAY & SPATIAL SKILL PUZZLES

MAPS, MAZES, AND PUZZLES

Dungeon 1 Map Maze Directions

1. Upon entering the map room maze, take the path to the left.
2. Continue on this path past another path to the left.
3. The path will then turn left, left, then right.
4. You have now arrived at a T. Turn right.
5. The path turns left and then you will arrive at another T. Turn right.
6. Continue on this path for many twists and turns.
7. Once you have been traveling for a while, the path will turn left. Then, there is a dead end directly to your right. Pass this dead end and take the next path to the left.
8. After a couple more turns, you will come to a T. Turn right.
9. Continue on this path. At one point there is a new path to the left. DO NOT TAKE IT! Your current path will lead you to the Map Room.



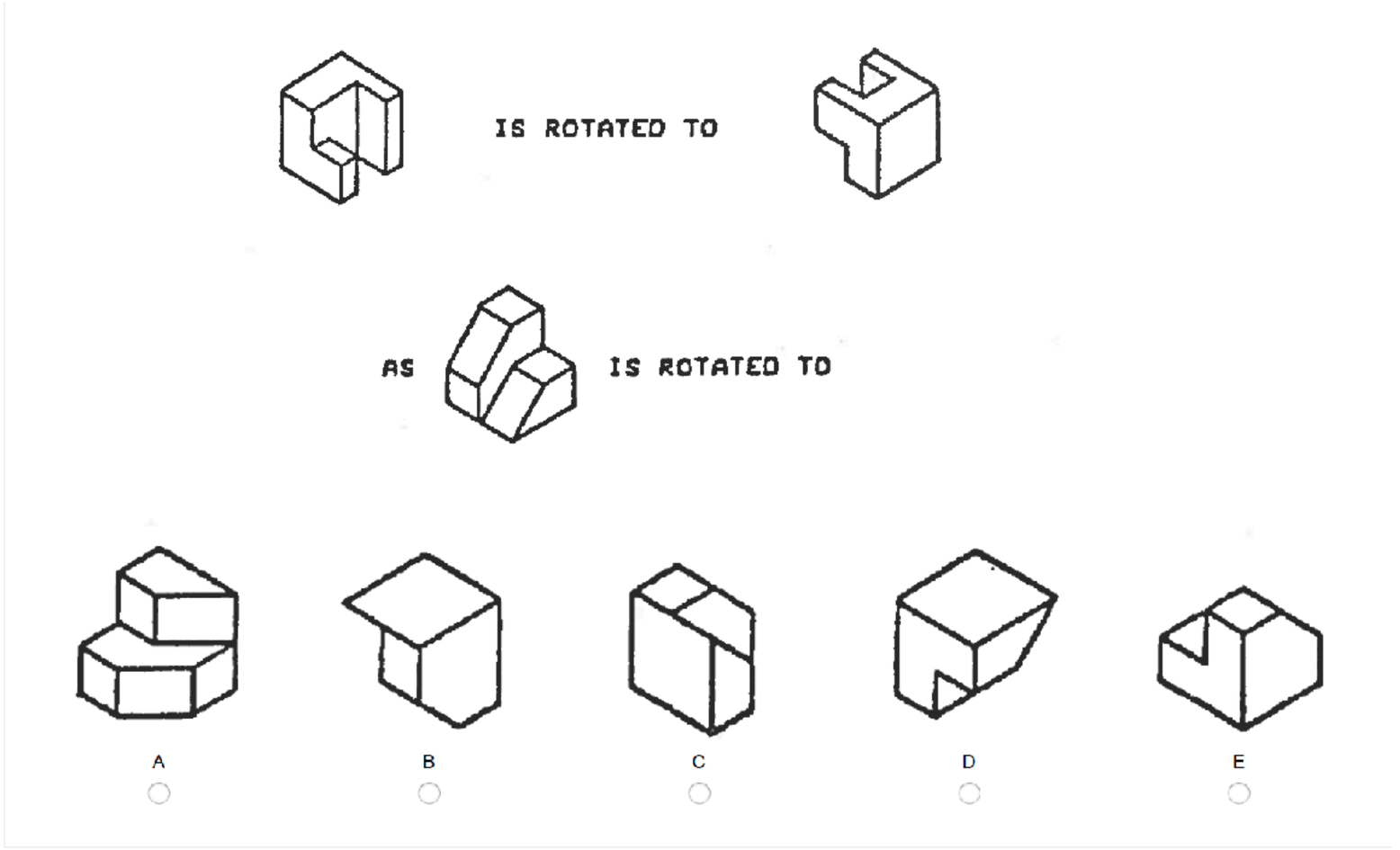
Maze from above

DATA COLLECTION & ANALYSIS

- Pre- & post-test spatial skill measurements
- Qualitative data (observations, focus groups)
- For small sample size, ANOVAs and paired samples t-test with effect size calculation

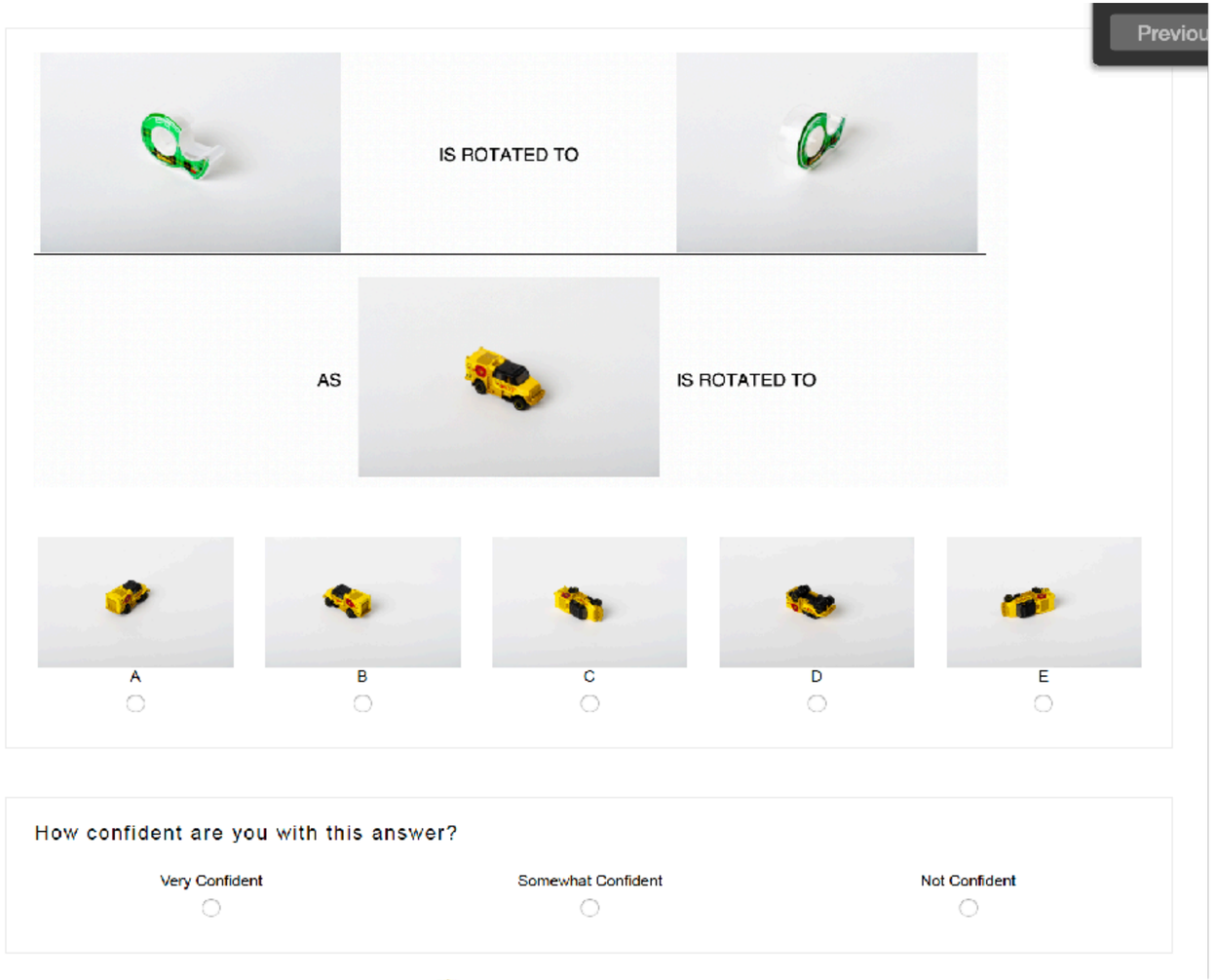
DATA COLLECTION

SPATIAL SKILLS INSTRUMENTS: ROTATION (PRE & POST)



Adapted from Purdue Spatial Visualization Tests: Visualization of Rotations (PSVT:R) (Guay, 1977; Sorby, 2009, Yoon, 2011).

SPATIAL SKILLS INSTRUMENTS: ROTATION (PRE & POST)



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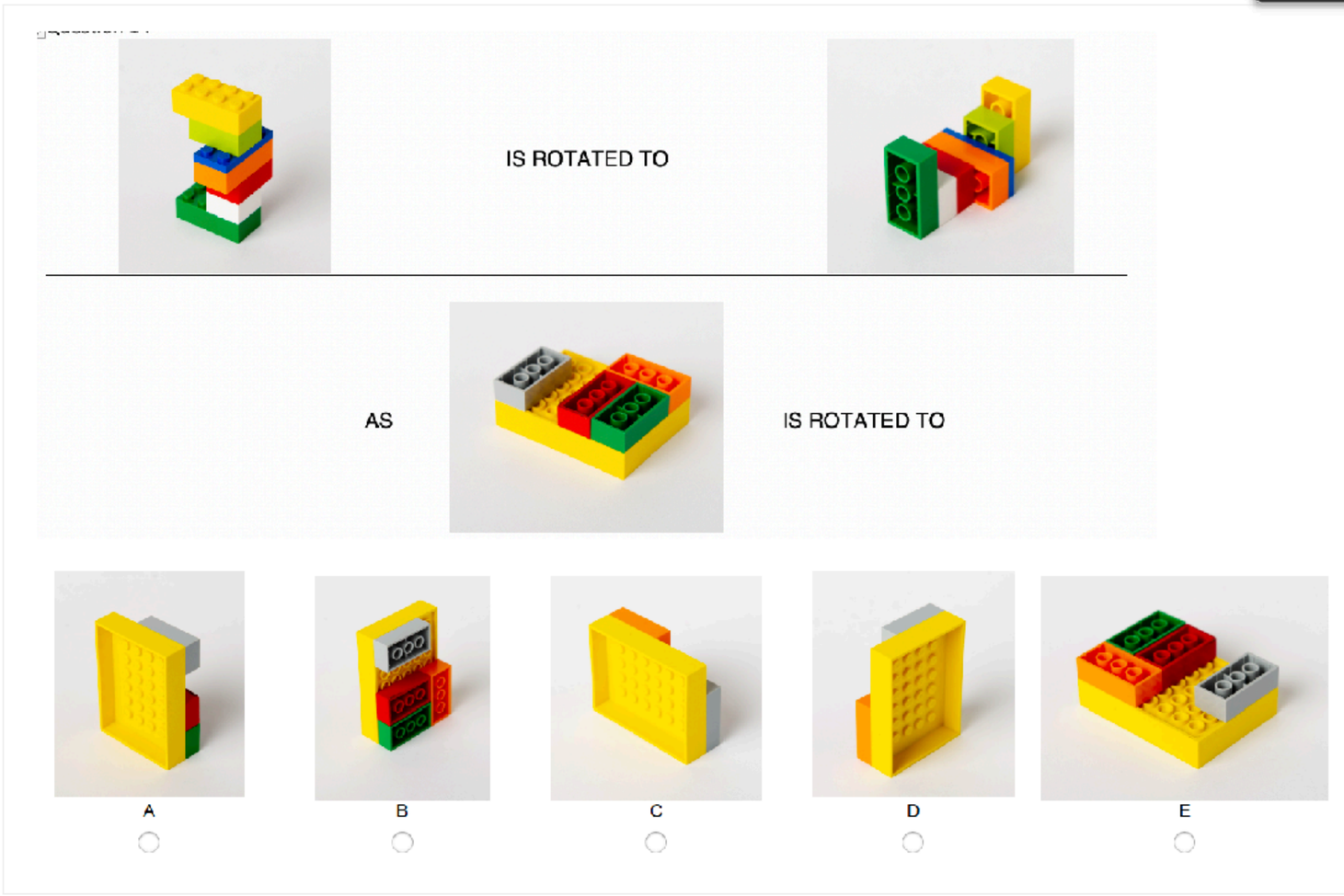
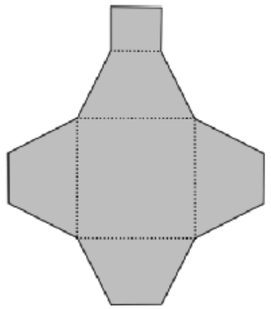
SPATIAL SKILLS INSTRUMENTS: ROTATION (PRE & POST)



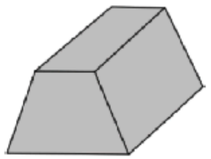
SPATIAL SKILLS INSTRUMENTS: 2D TO 3D TRANSFORMATION

1. The diagram below represents the net of a box.

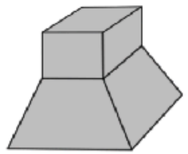


Which one of the following figures represents the box when the net is folded?

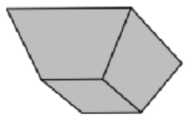
A.



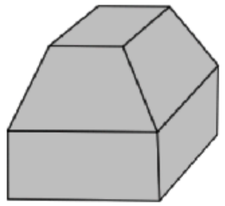
B.



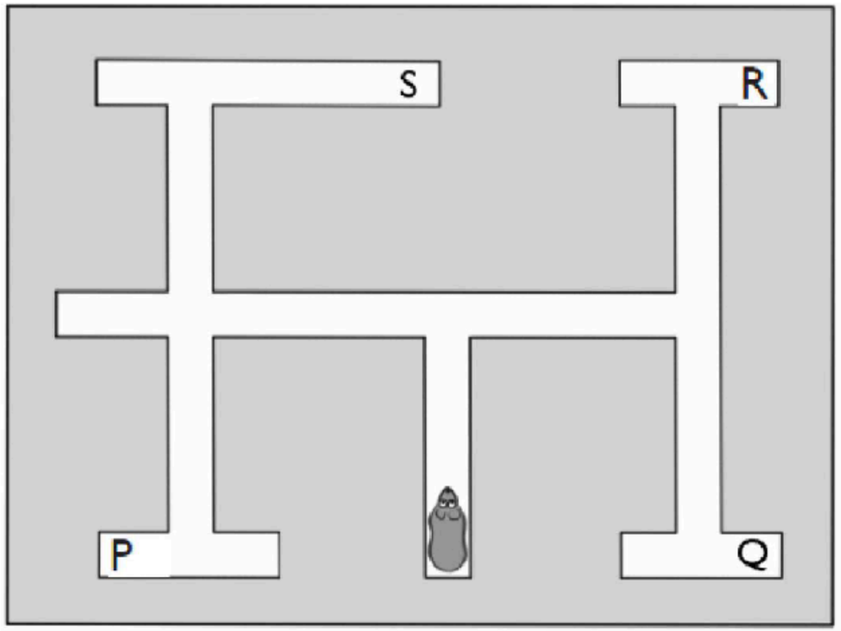
C.



D.



2. Briana placed a hamster at the start of a maze as shown below.



The hamster ran through the maze. It turned to its right, then turned left, then turned right.
Where did the hamster finish?

P
Q
S
R

Ramful, Lowrie, and Logan's (2017) Spatial Reasoning Instrument;
Lappen's (1981) Spatial Visualization Test

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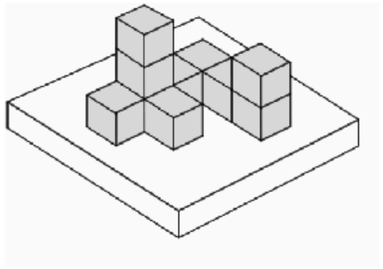
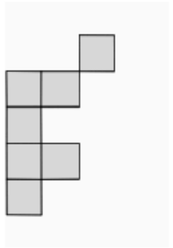
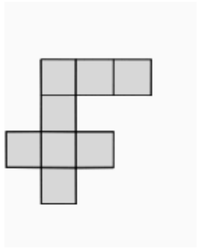
SPATIAL SKILLS INSTRUMENTS: 2D TO 3D TRANSFORMATION

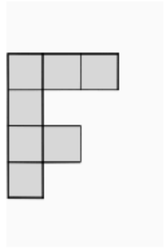
8. The diagram below represents a model made of cube blocks.

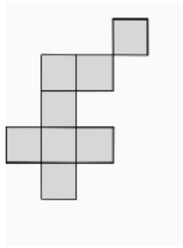


Which one of the following represents the model when viewed from above?

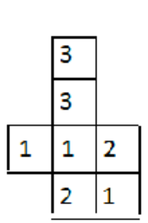


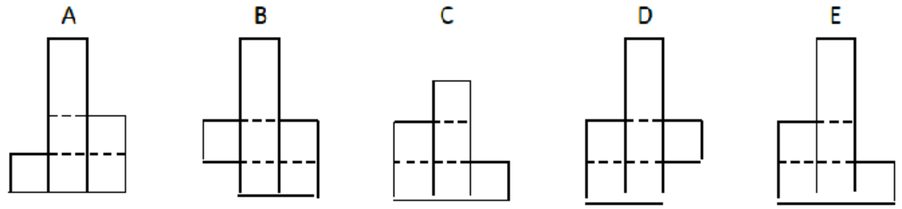




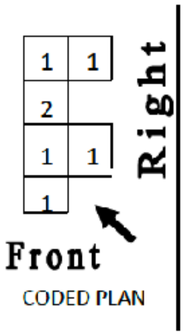


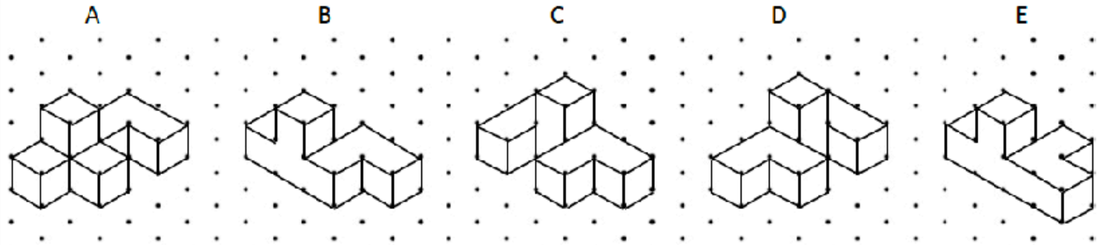
9. You are given the coded plan of a building. Find the BACK VIEW.





10. Find the view from the FRONT-RIGHT corner.





Ramful, Lowrie, and Logan's (2017) Spatial Reasoning Instrument; Lappen's (1981) Spatial Visualization Test

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FINDINGS

SAMPLE

- All camp participants that provided research consent (*n*=28)

Demographics	*n*	Percent
Gender		
Male	14	50
Female	14	50
Grade in Fall 2019		
4th	10	36
5th	8	29
6th	4	14
7th	6	21

MINECRAFT EXPERIENCE

Participants' Experience Playing Minecraft	*n*	Percent
I have no experience.	5	18
I have a little experience.	7	25
I have some experience.	12	43
I have a lot of experience.	4	14
I am an expert.	0	0

COMPUTER GAME EXPERIENCE

Participants' General Computer and Game Experience	*n*	Percent
I have no experience.	1	4
I have a little experience.	9	32
I have some experience.	10	36
I have a lot of experience.	6	21
I am an expert.	2	8

ACCESS

Access to Technology or Gaming Console at Home	*n*	Percent
No access	0	0
Little access	4	14
Some access	8	29
A lot of access	4	14
I own a computer or gaming console	12	42

FINDINGS

- Although the mean **rotation** post test scores were higher than the pre test, no significant differences were detected.
- Although the mean **2d to 3d transformation** post test scores were higher than the pre test, no significant differences were detected.

NO GROWTH IN EITHER SPATIAL SKILL

Year 2

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HOWEVER…

- Confidence: Learners' **higher confidence** when it came to mental rotation
  - Rotation test confidence measurement data indicates a statistically significant increase of 293 points (95% CI, 173.7806 to 346.9601 km, $t(26) = 6.1809$, $p < .0005$.
- Speed: Learners' were **quicker** with their 2d to 3d skills after the intervention
  - 2d to 3d measurement data indicates a statistically significant faster time at 293 seconds quicker to complete (95% CI, 1192.1054 to 394.8546 km, $t(26) = 5.9750$, $p < .0005$.

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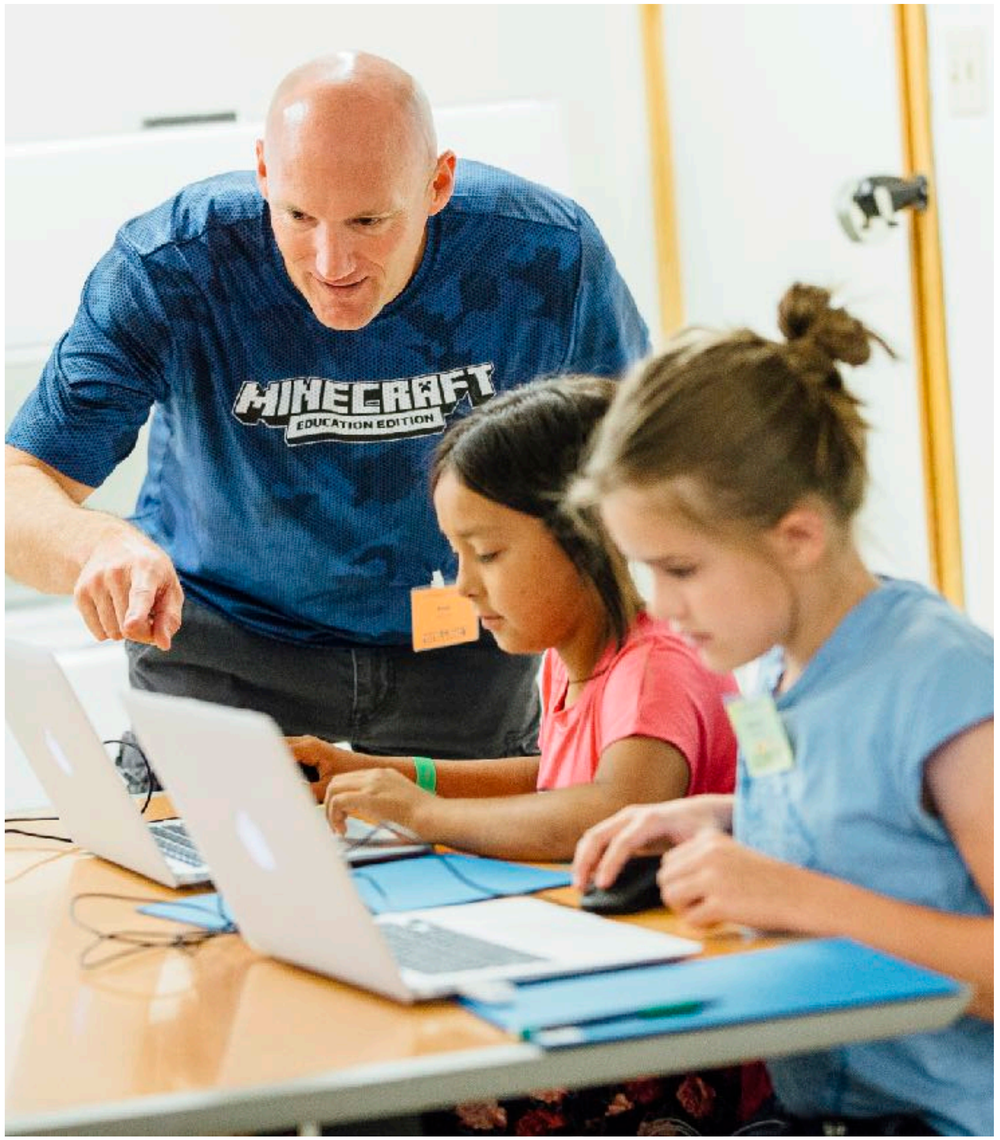
FINDINGS

- No significant growth detected when analyzed across:
  - Gender
  - Experience
  - Access
  - Speed
  - Confidence



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FINDINGS

- In summary…
  - No growth in spatial skill scores (pre to post)
  - Higher confidence reported with mental rotation skill
  - Quicker at 2d to 3d transformation
  - Much more engaging

CONCLUSIONS

LIMITATIONS AND CONCLUSIONS

- Small sample size
- Lack of experimental design
- Test/retest concerns & self-report (confidence)
- But findings do indicate that students' speed and confidence did increase
- Qualitative data indicates storyline was a success and learner engagement was high

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CONCLUSIONS

- Although no growth in total score, growth in **speed** and **confidence** is promising
- Currently working with engineering educators to better understand the role of speed and confidence in engineering

CONCLUSIONS

- Too many teachers needed!
  - Several Minecraft experts and upwards of 5 preservice teachers needed in the room to support students
  - Alternative design and delivery mechanism needed

NEXT STEPS

- Summer Camp 2020 and AY 19/20 partner school implementations
- Continue to refine storyline and game play with assistance of partner teachers, preservice teachers, spatial skills expert, and Minecraft expert
- Study possible other predictors (math scores, STEM self-efficacy, STEM identity)
- Exploring move to Minecraft Education for ease of distribution

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MINECRAFT EDUCATION POTENTIAL

- Alignment to NGSS and state math and ELA standards
- Easy distribution
- Easily managed/facilitated

MINECRAFT EDUCATION

Minecraft Education home page

QUESTIONS AND COMMENTS?

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