

City of Minecraft: Introducing middle school students to the construction industry through gaming.

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This project provided a unique opportunity to introduce middle school students to the construction industry through the use of the video game, Minecraft. The four day summer course, City of Minecraft, combined the video game Minecraft with educational activities related to the construction industry. This allowed the program to communicate about career and educational opportunities within the construction industry in a format that was appealing to middle school aged students. The program has goals for future implementation at the high school and collegiate level.

Key Words: K-12 Education, Construction Careers, Minecraft, STEM

Introduction

Department of Defense Education Activity Grant

In 2013, the Kansas Unified School District 383 for Manhattan and Ogden submitted a grant application to the Department of Defense Education Activity (DODEA) Military-Connected Academic and Support Programs (Adams & Ward, 2013). Within the grant application the school district identified a need to expose K-12 students to STEM programming. The justification provided for the need for additional STEM programming was based on four indicators where military dependents students were less successful than the district average. Indicator 1 addressed the lower rates of student success in Algebra I by the end of 8th grade. 45% of students across the district had completed Algebra by 8th grade and 26% of military dependent students had achieved the same level. Indicator 2 addressed the level of student participation in STEM coursework beyond the minimum requirements for graduation. 35% of students across the district had completed additional coursework, and 30% of military dependent students. Indicator 3 addressed the college and career readiness of the student population. 67% of students across the district were identified as not ready for college based on their composite ACT scores, and 70% of military dependent students were identified (Adams & Ward, 2013). Although the grant specifically focused on military dependent students within the school district, the indicators provided in the grant application indicated a need for future exposure to STEM programming for all students within the district.

STEM Programming

The DODEA Grant provided funding for three specific STEM education goals. External STEM programming was directly related to one goal:

> Goal 3: Provide enhanced, ongoing opportunities for STEM engagement for all military related students in the form of intensive STEM summer institutes and other school based STEM activities of significance. (Adams & Ward, 2013, p8)

The implementation of this goal involved the creation of a Summer STEM Institute. The institute was a four week summer program offered to USD 383 and surrounding school districts for students who had completed fifth, sixth, seventh or eighth grade. The students would enroll in a different course for each of the four weeks. The development of the courses offered during the STEM Institute were a collaboration between USD 383 and Kansas State University. The Summer STEM Institute would be hosted by Kansas State University. As the host, the university provided classroom and lab space for a majority of the courses offered. Additionally, many faculty university participated in the planning and teaching of the courses. Each course was instructed by a USD 383 teacher, a Kansas

State University faculty member, and one to two Kansas State University College of Education students. The topics for the courses vary across all areas of STEM, with the intent to provide a broad exposure to STEM fields to all participating students (Adams & Ward, 2013). In an attempt to expose students to the STEM education opportunities available at Kansas State University, a construction industry related course was developed using the computer based game, Minecraft, as the catalyst.

Minecraft

The game Minecraft was first released in 2009 by the Swedish company Mojang, which was founded by Markus Persson. Persson's concept was to create a digital sandbox with virtual blocks that players could use to create with. The basic premise of Minecraft is when each new game is started, Minecraft generates a new world filled with different terrains. Players use blocks to build structures within these worlds. The available blocks are representative of the materials available in the real world, i.e. stone, sand, brick, wood, etc. Additionally, players can combine specific blocks to create or "craft" new items. (Thompson, C., 2017) The game can be played in two modes, creative and survival. In the creative mode of the game player are able to create freely. In survival mode, players must protect themselves from monsters and other creatures while creating their structures. (Tromba, 2013).

In 2011, Santeri Koivisto, a Finnish school teacher, had the idea to create an educational version of Minecraft. He collaborated with Aleski Postari, an IT student to modify the code within the original Minecraft game to create MinecraftEDU. This collaboration was aided by support from Mojang's Carl Manneh. Minecraft agreed to permit the pair to create and distribute the education version under one condition, the experience remain fun for the students. Koivisto and Postari partnered with Joel Levin, a teacher from New York City to create TeacherGaming. TeacherGaming became the distributor of the MinecraftEDU software and provided support tools for teachers (Goldberg & Larsson, 2015). The MinecraftEDU platform allows for teacher control of the Minecraft world. The education version is a platform that allows for students to engage with their classmates, learn visually, and explore the world through a virtual platform, while in a safe, teacher supervised environment. One key feature is that instructors do not need to be trained experts in the game. Students are able to peer teach the basics of the game and explore independently to learn new aspects of the game. (Larson, 2014).

City of Minecraft Outcomes

Course Outcomes

For each STEM Institute course, the instructors used the 5E Model of Instruction lesson plan. The 5E model uses hands on methods to accomplish course outcomes. The components of the 5E model are engagement, exploration, explanation, extension, and evaluation (Bybee, et al, 2006). For the City of Minecraft course, this lesson plan model was used and several anticipated learner outcomes were developed as shown in Table 1. These outcomes were directly related to the exposure of students to different aspects of the construction industry.

Table 1

City of Minecraft Anticipated Learner Outcomes

Outcome 1	Students will have an understanding of construction materials.
Outcome 2	Students will explore concepts of engineering, science, and math while building models of real world buildings virtually.
Outcome 3	Students will have an understanding of the impact of natural disasters on buildings.
Outcome 4	Students will be able to identify construction and engineering materials in the real world though exploration.
Outcome 5	Students will explore possible future studies and/or careers.

Math/Science Standards

In the State of Kansas, students are assessed using state standards. The standard used for assessing math in K-12 was the "Kansas College and Career Ready Standards – Mathematics Grades K-12 with Kansas 15%" standard. This standard was adapted from the Common Core State Standards. Within the City of Minecraft course the math standard for Middle School that was applied to the course was, Geometry 7.G. This portion of the standard relates specifically to drawing, construction, and describing geometrical figures (Thompson, D., et al, 2010). . This standard was directly related to the virtual designing of buildings within Minecraft and the creation of models.

The science standard adopted by the State of Kansas was the "Next Generation Science Standards: For States, By States". The middle school level physical science standards addressed topics such as, structure and properties of matter, forces and interactions, and energy (NGSS Lead States, 2013). Table 2 shows the standards from the categories that were implemented in the course, and how they were applied within the course.

Table 2

City of Minecraft Science Standards

Standard	Description	Application
MS-LS2.1	Analyze and interpret data to provide evidence for the effects of resource availability on organisms or populations or organisms in an ecosystem. (NGSS Lead States, 2013, p50)	Students evaluated the Minecraft world to determine what resources were readily available for use in construction their buildings.
MS-PS2-4	Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. (NGSS Lead States, 2013, p43)	Within the Minecraft game there was no gravity. Students discussed the challenges of applying their virtual design in the real world.
MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solution. (NGSS Lead States, 2013, 63)	Students were provided with "land" and budget constraints which required them to evaluate their virtual environment to develop a solution.
MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. (NGSS Lead States, 2013, p63)	During the engineering application activities, students evaluate the success of their design and made corrections.
MS-ETS1-3	Analyze data from test to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. (NGSS Lead States, 2013, p63)	During the engineering application activities, students evaluated other classmate's designs and used those to make corrections to their own designs.
MS-ETS1-4	Develop a model to generate data for iterative test and modification of a proposed object, tool, or process such that an optimal design can be achieved. (NGSS Lead States, 2013, p63)	Students created physical models and tested them with regards to the weekly topic area.

(NGSS Lead States, 2013,

Methodology

Course Development

The City of Minecraft course was developed as a cooperated project between USD383 8th grade science teacher, Stacy Harris and Kansas State University construction science faculty member, Katie Loughmiller. The direction provided to the pair was to develop a construction science related course for the STEM Institute. Loughmiller proceeded to talk with students in the department and gather ideas for the course. One suggestion that seems ideal for this type of course was the use of Minecraft. The college students shared examples of projects they had

constructed and how the game was related to their coursework in construction science. From there, the team began researching existing applications of Minecraft as a teaching tool. The research resulted in the school district purchasing 25 networkable licenses of MinecraftEDU for use the course.

In addition to the video game component of the course, it was important to both Harris and Loughmiller that the students be exposed to practical applications in the construction industry. This results in the inclusion of activities related to material selection, budgeting and estimating, and exploration of construction sites throughout the one-week course.

Course Format

As a course within the USD 383 Summer STEM Institute, City of Minecraft followed the same overall schedule as the institute. Each session was four half days, Monday through Thursday, from 8:30am to 11:30am. The partnership with Kansas State University allowed the course to be hosted by the Department of Architectural Engineering and Construction Science. This allowed for easy access to departmental resources throughout the course.

Day One

The first day of each session of City of Minecraft started with an engaging activity that allowed students to introduce themselves to the group and be paired up with another student for the course's first project. After introductions were completed, the Kansas State University faculty member would introduce the students to different construction materials. Materials were shared with the students that could be directly related to materials available in Minecraft. Additionally, the students discussed the impact of gravity on the real life materials. Because there is modified gravity in Minecraft, the students would be able to use materials within the game in ways that would not work in real life.

The next activity for the students was a short introduction to the Minecraft game. Many students were already very familiar with the basics of the game. For this course, the MinecraftEDU module was used, so students were introduced to the aspects of the MinecraftEDU that were different from the standard game. The MinecraftEDU game was setup on an internal server. All students were provided a laptop that was connected to the server. This allowed the students to interact with each other in the world they were building in (Figure 1). Within the game, the students interacted in a world that was pre-designed with a city street grid.

Figure 1: Students working on their City of Minecraft buildings

The first day was completed with the start of the student's first project. The students, working with their partners, started the process of designing, estimating, and building their first building in MinecraftEDU. Each pair of students were randomly assigned a building type (school, office, restaurant, etc.). Once they had received their building type, students were given time to sketch a basic floor plan for their building and complete a building permit (Appendix A). Their floor plan and building permit were then reviewed by one of the instructors. If all of the required information was provided, they were provided a lot within the MinecraftEDU world to build their building.

Students were then provided a pricing sheet identifying the cost of materials within MinecraftEDU and a project budget. Students developed a project cost estimate (Appendix B) based on their floor plan. Once each group had completed their cost estimate, they were allowed to start building their project in MinecraftEDU.

Day Two

The schedule for the second day involved several activities outside of the MinecraftEDU environment. The first activity of the day was a discussion with the students about the weekly topic. Each week a different topic was selected for the students to incorporate into their MinecraftEDU projects. Those topics included, natural disasters, types of architecture, and environmental sustainability. As an example, earthquakes were the topic of one session. In the discussion, students learned about how earthquakes impact buildings and in what ways they could modify the design and construction of their buildings within MinecraftEDU to minimize the impacts of earthquakes.

The middle portion of the day was designated for the students to complete their group building projects in MinecraftEDU. Any changes to the original design and cost estimate for their projects were tracked by the students. After completion, they submitted a final cost summary for their building.

One of the goals of this course was to expose students to different aspects of the building industry. At the end of the second day, students were taken to an area of campus with buildings of several different styles of architecture. The students are broken up in to partners and provided a list of architectural terms and an iPad. Each group was required locate the architecture terms on the surrounding buildings and take a photo of one of the team members interacting with the item. The terms provided to the students were related to different aspects of buildings, including terms associated with landscaping, masonry, doors, and windows, and mechanical, electrical and plumbing systems.

Day Three

Because the STEM Institute was hosted on a university campus that was experiencing a large volume of construction, the students were given the opportunity to take tours of different ongoing projects. Each week the students toured a different area of campus and learned about the construction projects in that area. During several sessions, the students were escorted on a formal tour of new construction projects (Figure 2). Other weeks the tours were conducted from outside of the construction fence due to ongoing construction activities. These tours allowed the students to have the opportunity to see first-hand the complexity of the building industry and meet with industry professionals working on those projects.

Figure 2: Students posing for a photo after their construction project tour

After the construction tour, the students started their second project. This project was an opportunity for the students to work individually on the design and construction of their own home within the MinecraftEDU environment. For this project the students were also required to incorporate the information that was provided about the weekly topic into their project. For example, during one the topic was earthquakes, students had to incorporate design elements they had learned related to earthquake design into their second project.

The third day was completed with an engineering application activity. Each week the students would conduct an engineering application activity related to the weekly topic. During earthquake week, the students constructed toothpick and marshmallow structures. For this activity, the students were partnered with a new partner and provided a bag of marshmallows and toothpicks. To make the activity more challenging, the students were only allowed to use their non-dominant hand during construction of their structure. After completing their structure, the students used a shake table to test the stability of their design. As a class, a discussion was held regarding what was successful and unsuccessful about each groups design.

Day Four

One of the goals of the STEM institute was exposing students to the career and educational opportunities related to each course. The fourth day of the City of Minecraft session was started with a discussion about possible careers in the building industry. This discussion was facilitated by the use of the construction career trading cards produced by the National Center for Construction Education and Research's BYF program. These cards provide information related to educational requirements, salary potential, and a brief description of the job duties for a large number of construction and design careers (BYF, 2017).

The main focus of the last day of the session was student presentations and awards. The interactive MinecraftEDU world was brought up on a projection screen for the entire group to view. Each student took the group on a "walking" tour of their completed building (Figure 3). Students were asked to explain how they came up with their design, what materials they used during the construction of the building, and share any interesting details about their

buildings. The students were very enthusiastic about sharing their designs, so the presentations took up a large majority of the day.

Figure 3: Students presenting their completed Minecraft buildings

After the students completed their presentations, the instructors presented awards for the students. During the week, while observing the students in their different activities, the instructors had created a list of achievements. Each student was provided an award based on their personal achievements during the week. Additionally, they were all given the opportunity to select a prize. These prizes were a combination of items donated by different industry and university groups. The intent of the prizes was to provide each student with a take-away that would spark a conversation with their parents about what they learned about the construction industry during the course.

Discussion

Assessment

Assessment of the STEM Institute is conducted via two surveys. The students attending the STEM Institute and their parents are surveyed during the final week of the institute. The survey was generalized for the entire STEM Institute, but it did provide some data related to the success of the City of Minecraft course. The results of the 2017 survey showed that 86.5% of students responding would like to attend the institute again next year. Of the parents who participated in the survey, 93.5 % stated that the courses offered were appealing to their child (Houk, 2017). The only specific data collected that relates to the City of Minecraft comes from the career portion of the student survey.

When asked about what careers they learned about during their experience with the STEM Institute, civil engineering and construction were in the top 10% of student responses (Houk, 2017).

The assessment process for this course should be expanded to address specific components of the course and its impact on students and not rely solely on the assessment of the STEM Institute program. This expanded assessment would allow for better improvement of the course and potential expansion of the course to high school or collegiate programs.

Challenges

There were several challenges during the initial implementation of this program. One of the major challenges was the creation of a temporary network for the students to use MinecraftEDU. Because this program is offered during the summer, there was not a standalone computer lab for the students to use. The team worked with the technology staff at the school district to create a temporary computer lab for the course to use. This allowed the course to be taught in any classroom space.

Another challenge the team faces was developing activities outside of the game to engage the students. The first year, one of the activities the students completed was a scale model of the city made from cardboard. Although the instructors enjoyed this activity a great deal, the students did not find this activity to be as engaging. In subsequent years the activities have been adjusted to better match with the interests of the students. In the upcoming summer 2018 course, the students will be constructing a chair from newspaper that must hold the weight of 50 pounds.

Implementation

The adoption of programs like this, have the opportunity to exposed students and parents to the opportunities available in the construction industry. Although the course focused on construction education, it could be adapted or expanded to include other areas of the building industry. Programs like City of Minecraft have the potential to be adapted and implemented in other school districts or universities. With increased support from the local construction and design industry, this course could be expanded to provide additional opportunities for students.

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Appendix A

City of Minecraft
Application for Permit to Build

Date: _____

Contractor: _____

Types of Use:

_____ Residential (Lot size = ½ block)

_____ Commercial (Lot size = 1 full block)

_____ Industrial (Lot size = 1 full block)

Approximate size of building:

Width: _____

Length: _____

Height: _____

Materials to be used:

Exterior Walls: _____

Foundation: _____

Roof: _____

Description of proposed building:

_____
_____
_____
_____

Appendix B

City of Minecraft – Construction Estimate

Total Budget = _____

Material	**Quantity (indicate units)**	**Cost/Unit**	**Total Cost**
Grass		$ 1.00	
Dirt		$ 2.00	
Sand		$ 2.00	
Gravel		$ 5.00	
Clay		$ 5.00	
Diamond		$ 500.00	
Quartz		$ 100.00	
Redstone		$ 5.00	
Glass Block		$ 20.00	
Glass Panes		$ 50.00	
Brick		$ 30.00	
Doors (any kind)		$ 100.00	
Brick Stairs		$ 50.00	
Wood Block		$ 20.00	
Wood Slabs		$ 20.00	
Wood Stairs		$ 40.00	
Stone		$ 30.00	
Cobblestone		$ 35.00	
Stone Slabs		$ 25.00	
Cobblestone Slabs		$ 30.00	
Stone Stairs		$ 50.00	
Ladders		$ 100.00	
Bookshelves		$ 250.00	
Carpet		$ 15.00	
Paintings		$ 150.00	
Signs		$ 75.00	
Sponge		$ 5.00	
Chests		$ 500.00	
Crafting Tables		$ 250.00	
Total Project Cost			