CHAPTER 9.

TEACHING EARTH SCIENCE WITH MINECRAFT

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Minecraft is a video game extremely popular with children and teenagers. It is an open sandbox game that allows players the freedom to create anything they can imagine (see Figure 1). So far, more than 21.5 million people have bought the desktop version of the game.[1] I aimed to tap into the popularity and unique style of *Minecraft* to engage high school students in a series of lessons about earth science. *Minecraft* is a perfect fit for the Earth Science topic in the *Australian Curriculum* for Year 8, which covers rocks and the rock cycle. My two Year 8 classes used *Minecraft* alongside traditional teaching techniques to learn about earth science. The students were surveyed before and after the program on their attitude, motivation, and engagement toward earth science. I want to share my story with you to encourage you to see video games as a medium through which meaningful learning can occur. I hope this will also inspire other teachers to create engaging, transformational classroom experiences using video games.

1. Mojang. (2015). Home. Retrieved from Minecraft at https://minecraft.net/

Figure 1. Screen shot from the game Minecraft.

BACKGROUND

I am an Australian high school science teacher and I enjoy playing video games in my spare time. Before becoming a teacher I worked in the field of science communication. This involved communicating complex ideas through exhibits, hands-on activities, written articles, and live-action science shows. Working in informal learning environments such as science museums and children's museums highlighted how powerful learning through play can be. Why does high school seem to lose that feeling of "play" and become boring, hard work? After reading online about other teachers' using video games in the classroom I decided to do some experiments myself. I am lucky enough to work at a great school that supports my "experiments." I am still testing the most effective ways of weaving video games into the classroom. What I have learned so far is shared in this chapter.

I work in a private, all-girls secondary school in an inner-city suburb in Australia. For this particular "experiment" I used my two Year 8 science classes as guinea pigs (12–13-year-olds). In Australia all students in both primary and secondary school follow the *Australian Curriculum*. The whole country follows the *Australian Curriculum* for all subjects, making sharing resources easy to do. The Year 8 Earth Science topic spans one school term (about 10 weeks) and looks at rocks, the rock cycle, and mining.

The general content description found in the *Australian Curriculum* is "Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales."[2]

This content description is then expanded (click on "ACSSU153") into the following learning goals:

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2. ACARA. (2014). Science. Retrieved from Australian Curriculum: http://www.australiancurriculum.edu.au/science/Curriculum/
F-10?layout=1#level8

- representing the stages in the formation of igneous, metamorphic and sedimentary rocks, including indications of timescales involved

- identifying a range of common rock types using a key based on observable physical and chemical properties

- recognizing that rocks are a collection of different minerals

- considering the role of forces and energy in the formation of different types of rocks and minerals

- recognizing that some rocks and minerals, such as ores, provide valuable resources.[3]

At my school each student is required to "lease" a laptop computer from the school. The students are fairly tech savvy and use their laptops for schoolwork every day. The school Information Technology (IT) Department provides technical support for the laptops. Teachers are provided with a laptop by the school instead of a desktop. Teachers at the school are expected to use technology within their classrooms and provide learning materials online through the school intranet.

PREPARING FOR IMPLEMENTATION

While looking online for resources related to using video games in the classroom I found the *MinecraftEdu* website.[4] I had previously played *Minecraft* and loved the open-ended gameplay and possibility for creativity.

The school gave me permission to buy two class sets of *MinecraftEdu* (about US$14 per copy) and one copy of the server software (US$41). The school's IT Department was invaluable in setting up and testing the school server. *Minecraft* doesn't require a high-powered computer, which meant students could use their laptops instead of going to a computer lab. Booking in to use the computer labs at my school is a headache because of timetabling issues, as we have very few computer labs (since students have their own laptops) and they are often in use by technology classes. This severely restricts when other teachers can use the computer labs.

The benefit of using the student laptops was that I could use *Minecraft* in class at a moment's notice. We played on a local server hosted at school, which meant students could play together in the same *Minecraft* world. The *MinecraftEdu* software makes it really easy to set up a server even for first timers such as myself (see Figure 2), and there are many YouTube tutorials out there to step you through setting up your own server (also see Wilmot, this volume).

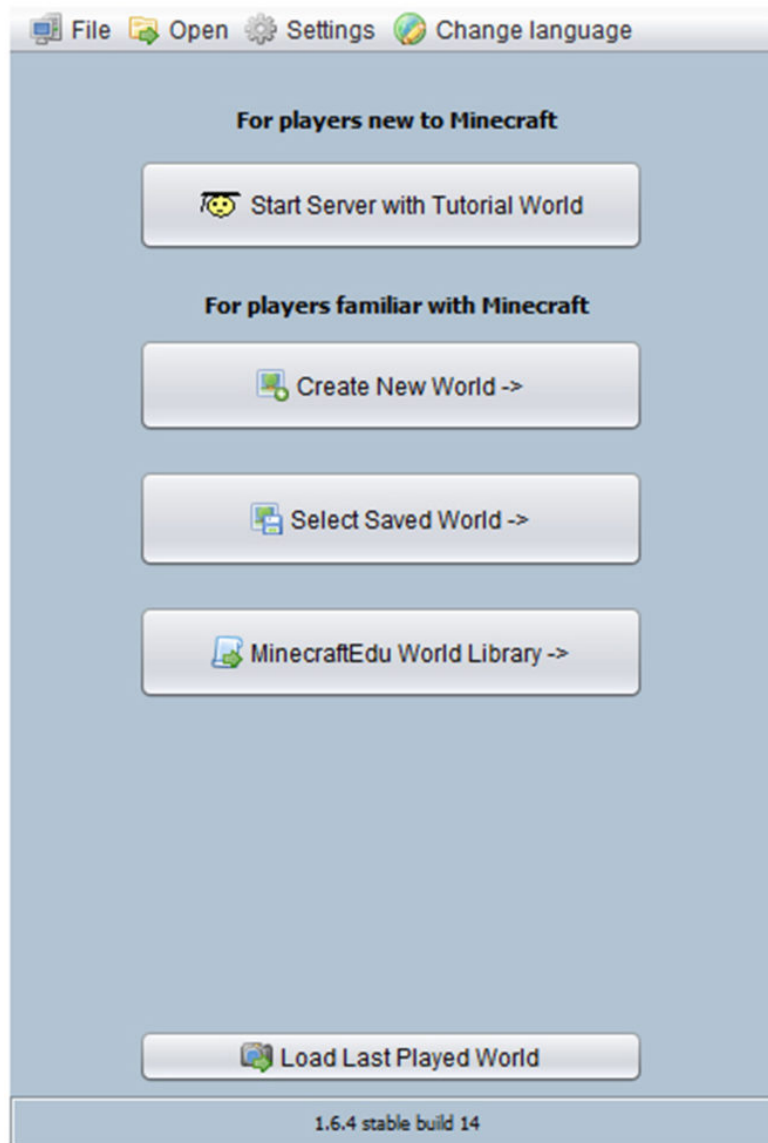3. ACARA. (2014). Click on "ACSSU153."
4. www.minecraftedu.com

Figure 2. Screen shot of the MinecraftEdu server software.

I originally wanted students to be able to access the school server while at home. This would allow me to set homework to be completed in *Minecraft* so we could then build on concepts and discoveries in class. Unfortunately, because of potential security issues the IT Department did not allow students to log in from outside the school network, but students could still access the single-player version of the game at home.

Designing for Earth Science

I found designing quality science lessons to be the hardest part of the whole experience. Before beginning the "experiment" I was unsure of how familiar the students were with *Minecraft* and earth science. Consequently, I wasn't sure about what type of activities would run well, be engaging, and stimulate learning. I looked at the library of premade maps on the *MinecraftEdu* website. There are a lot of good quality resources there; unfortunately, only a few of them were about science. Out of

the few resources that were actually about science, there was only one about earth science, which involved digging up a fossil. I struggled to find any premade worksheets or pre-prepared activities on the Internet as the use of *Minecraft* in the classroom is still relatively new. I believe this will improve through time as the use of *Minecraft* in schools grows and more teachers start sharing their resources.

I wanted to create worlds students could explore at their own pace while solving problems related to earth science. The tutorial map that comes with *MinecraftEdu* (and available as a download online) is a good example of what I wanted to achieve. However, creating Minecraft maps from scratch is very time intensive and unfortunately, the Earth Science topic coincided with important school reporting deadlines. This meant lesson planning for *Minecraft* took a back seat at times. Because of these time restrictions I tried to plan activities that could be done in any randomly generated map instead.

MinecraftEdu has been designed with teachers in mind and has some added features that make building maps and running lessons very straightforward (see Figure 3). The "freeze" and "mute" student's options were vital for controlling the flow of the lesson. Turning on "student respawning" was useful for allowing students who got lost or stuck to teleport themselves back to the spawn point. However, I found myself using the teleport function often to teleport students who were lost, or not where they were supposed to be.

Figure 3. Screen shot of the MinecraftEdu teacher menu.

The teacher menu also allows you to easily change what mode the game is in. I usually used "MinecraftEdu" mode when I wanted students to collect and craft resources without worrying about hunger and fighting off monsters (see Figure 4). For activities in which students had to build something substantial (say a model of a sedimentary rock) I used "Creative" mode so students could focus on building rather than collecting and crafting.

Figure 4. Screen shot of the MinecraftEdu teacher menu.

For most of my activities I would often give students the equipment they needed to start with. For example, with the "Classifying Blocks" activity, I gave students an iron pickaxe, four treasure chests, and four signs (see Figure 5). This was to avoid time wasted in collecting and crafting materials.

Figure 5. Screen shot of the MinecraftEdu teacher menu.

When I did set up a map I made only simple alterations, such as inserting a few strategically placed teleport blocks next to important landmarks (e.g., cave entrances) for students to use (see Figures 6 and 7). These blocks allow students to instantly teleport to any other teleport block on the map. This

meant students didn't waste too much time exploring and trying to find ores or other equipment needed for the activity.

Figure 6. Screen shot from MinecraftEdu showing a teleport block.

Figure 7. Screen shot from MinecraftEdu showing the teleport menu (as it appears to teachers).

The "Classifying Blocks" activity assessed students' understanding of the terms *rock, mineral,* and *ore,* which addressed the learning goals of "identifying a range of common rock types using a key based on observable physical and chemical properties" and "recognising that rocks are a collection of

different minerals."[5] For this activity students had to fill out a physical worksheet (see Figure 8) while completing the task in *Minecraft.*
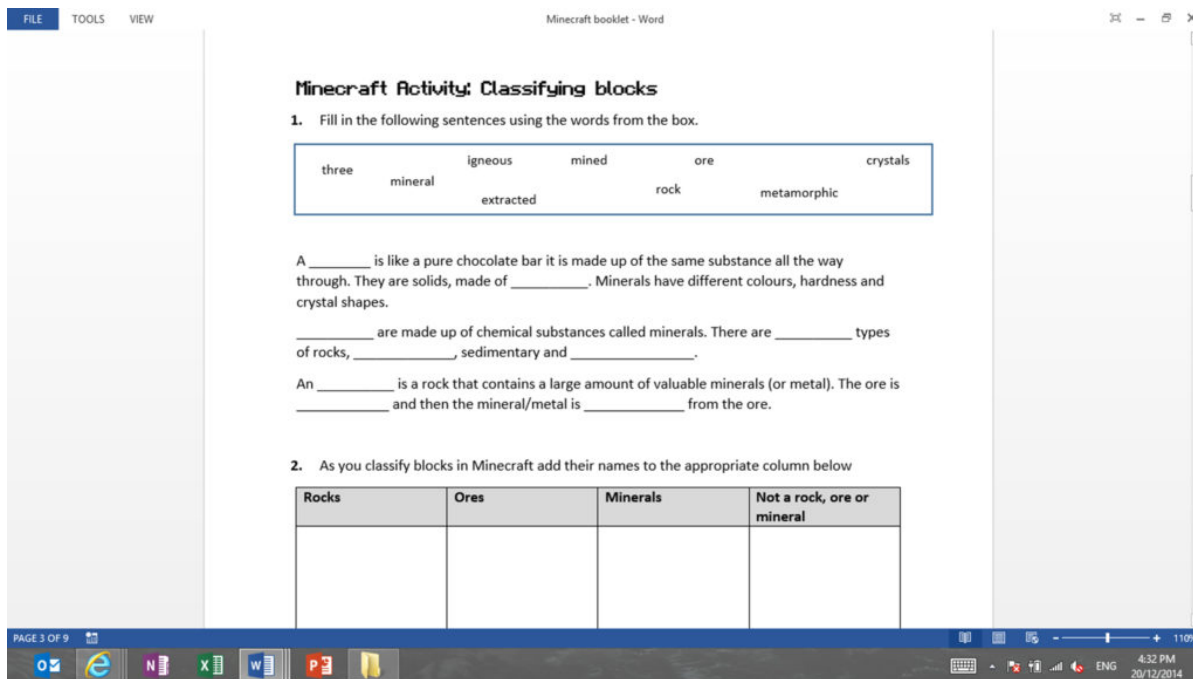

Figure 8. "Classifying Blocks" activity worksheet.

The "Rock Formation" activity required students to apply their knowledge of the three types of rock (igneous, sedimentary, and metamorphic) and how they are formed. This addresses the learning goals "representing the stages in the formation of igneous, metamorphic and sedimentary rocks, including indications of timescales involved" and "considering the role of forces and energy in the formation of different types of rocks and minerals."[6] For this activity students filled in a digital worksheet (see Figure 9) with screen shots from *MinecraftEdu.*

5. ACARA. (2014). Click on "ACSSU153."
6. ACARA. (2014). Click on "ACSSU153."

Figure 9. "Rock Formation" activity worksheet.

Both physical and digital worksheets worked well, and I liked how students had to collect evidence from inside the game to prove that they had completed the activity. With the physical worksheet, however, it was easier to see how far along students were in the activity and who was having trouble. The worksheets helped keep students focused on the task at hand and gave them something to refer back to when studying.

IMPLEMENTING IN THE CLASSROOM

The first time I used *MinecraftEdu* in the classroom I dedicated the whole lesson to helping students learn how to play the game. This involved downloading and installing the software, logging into the local server, and playing through the tutorial world. Many students had not played many video games on the computer so they were quite new to using the keyboard and mouse at the same time. The tutorial world slowly steps students through how to move, how to collect resources, how to build, and finally how to craft objects.

The first earth science lesson in *Minecraft* was the "Classifying Blocks" activity, which required students to classify blocks into four categories—rock, ore, mineral, or none of the above. Working in pairs, students were required to sort blocks they had collected from around the map into four labeled treasure chests. Here you can see some examples of blocks students collected (see Figures 10 and 11).

Figure 10. Different types of blocks found in Minecraft, from left: Lapis luzuli ore, diamond, emerald ore, emerald, stone.

Figure 11. Screen shot of one student's labeled treasure chests in MinecraftEdu (from far left: not a rock, ore, rocks, mineral).

Students had to use the physical appearance, name of the block, and their prior knowledge from class to help them make a decision. The students had a physical worksheet in front of them to record their results and help keep them on track. After sorting their own blocks, students looked at another group's classification system and discussed whether they agreed with the classification or not. Sorting and discussing their reasoning helped students gain a deeper understanding of the meaning of the words *rock, ore,* and *mineral,* rather than just memorizing a definition.

Toward the end of the Earth Science topic I ran the "Rock Formation" activity in *MinecraftEdu*. This activity required students to fill in a digital worksheet by taking a series of screen shots of locations in *MinecraftEdu*. Students had to take screen shots of locations where different types of rock form. For example, intrusive igneous rocks are formed by cooling magma under the ground. Students had to find a location in *Minecraft* where there was magma under the ground, take a screen shot of it, and paste the screen shot into their worksheet (see Figure 12).

Figure 12. Screen shot from a student worksheet, showing where intrusive igneous rocks are found.

Students pressed either the "Print Screen" button on their keyboard or F2 to take a screen shot, and it is easy to switch between the worksheet and *MinecraftEdu* by using either the toolbar or Alt + Tab. This activity really tested the students' understanding of the rock cycle and how each type of rock is formed. The activity generated a lot of discussion, as when students were unsure of where to go they asked their friends for help. The act of explaining and justifying their choices through discussions and the worksheet helped to cement their understanding of how the rock cycle works.

Surprises

The biggest surprise for me was the increased collaboration among students. During class students would be talking about the task and how to complete it as well as helping each other. This was a big difference from the usual "social" chatter.

The other surprise for me was how popular *Minecraft* is! After our second *Minecraft* lesson the word had spread like wildfire through the Year 8 group. A few of my students had shown other students how to log into the school *MinecraftEdu* server. I found out about this when during our lesson three students from another class logged in. When I discovered they were imposters I "froze" and "muted" them so they couldn't play, and they quickly logged out.

A small group of students began to play on the local school server at lunchtime. I found out when the

students who were playing at lunch had messed with an area I had set up for a lesson. I had to quickly reset the map before the class started. This involved loading a previously saved version of the map. Many students, both experienced and inexperienced *Minecraft* users, would come to school and show me amazing things they had built in their own time. Even as I write this chapter, many weeks after the earth science lessons, there are still students playing *Minecraft* together at lunchtime, building a replica of Hogwarts together on their own server.

RESULTS

The students who used *MinecraftEdu* were surveyed before and after the Earth Science topic. Out of the 44 students surveyed, 81% of students said they enjoyed using *MinecraftEdu*, 15% said the experience was OK, and 4% said they disliked it. In my short time as a teacher I haven't found any activity that absolutely every student enjoys, so taking into consideration that just under half of the students were first-time *Minecraft* users, I believe the activity was a success. As this was a trial run to see if using *Minecraft* increased student engagement in science, there were no set "deliverables." The students were not graded on any work they completed using *MinecraftEdu*; their learning was assessed through observation, worksheets, and questioning. I found that activities that required the students to apply their knowledge and had clear objectives resulted in the best learning.

The students who enjoyed the experience had this to say:

"I just liked that it was a more interactive way of learning and it was hard to get bored."

"I loved *Minecraft* because we were having fun on it while learning about all of the different rocks, minerals and ores."

"I liked the aspect that we could all participate at the same time."

Of the 18 students who said they had not played *Minecraft* before, 11 said they would play the game again. "I never played *Minecraft* until the day we played in class and now I love it! It is so much fun especially creative!"

I was interested in why some students didn't enjoy the experience or said it was just OK. The most common response was that students were not used to playing first-person video games and found the gameplay disorientating.

"It was really fun; I loved the activity where we had to find where different types of rocks were formed in the *Minecraft* land. But using *Minecraft* made me feel a bit motion sick, because of the weird movements."

In the presurvey many students reported playing video games regularly on their mobile phones/ tablets; however, fewer than half reported regularly playing video games on a PC or games console. Some students found having to learn how to play *Minecraft* hindered their learning of earth science.

"I didn't really like lessons that we used it because finding the different types of rocks and minerals was tricky for girls who don't usually use *[Minecraft]*."

"I liked it when we got to find rocks. I didn't like when I got lost and it took a long time to get back."

"I feel that using *Minecraft* was difficult to use and that we didn't really use it that much to learn about it."

One student in particular was an avid *Minecraft* fan and had some useful advice. "I love *Minecraft,* but I didn't really see the educational advantage. It would be much more beneficial if more realistic 'mods' were used, like Terra Firma craft. I'm just saying unmodded *Minecraft* doesn't really have much to do with real processing."

I am interested in exploring the use of mods to make the gameplay more "scientific." Using mods would allow a lot of customization and help teachers design worlds to meet a wide array of learning goals. *MinecraftEdu* shows a lot of promise as a teaching tool to be used alongside other teaching resources and methods.

PLANS FOR NEXT TIME

I didn't achieve as much as I planned to, but it's a starting step. I found my enthusiasm for the project waning in the face of all the hard groundwork and small setbacks experienced in class (e.g., maps being changed unexpectedly, students not having laptops in class). Things such as report writing and the other demands of teaching also kept creeping in. In the future I would love to spend more time developing quality maps like the tutorial map. I would also like to try using some mods to do more "accurate" and in-depth science. For example, the Technic mod has a lot of mining equipment and extra ores with different properties.

I am not a game designer but many principles of good learning align with good level design. I think that's why the idea of learning through video games appeals to me so much. Even so, I found there was a lot for me to learn about how to create good *Minecraft* worlds/levels for learning. I found it useful to look at other maps designed by teachers, even if not in the same subject area, as they highlight aspects of good map design. Next time I want to try designing activities that require more problem-solving, collaboration, and creativity skills. I would also like to try teaching different areas of science, such as physics.

CONCLUSION

For teachers wanting to experiment with *Minecraft,* I recommend becoming familiar with the game before using it in the classroom. Knowing how to play will allow you to help students if they get stuck. It is worth setting up a map (even if it's just adding teleport blocks) and testing your planned activity before using it in the classroom. This will help you pick up on little things that need to be fixed or improved before the lesson. By removing this friction you can help your students get on with learning. I recommend having access to the server so you can control things such as which map is selected. It is extremely difficult to plan and run classes without access to the server.

Check out the myriad of resources online to help you become familiar with *Minecraft.* Wilmot (this volume) has a good selection at the end of his chapter. A quick search on YouTube will also return countless helpful tutorials.

Give students time to become familiar with the game. Some of my students had never played a first-person video game before, so using a keyboard and mouse at the same time was very alien to them.

They needed time (one to two lessons) to get used to the game and how it works before genuine content learning could take place.

Direct the learning. You can't expect students to achieve your intended learning goals by just playing *Minecraft* without any support. Students aren't going to notice things such as lava cooling into obsidian (an igneous rock) unless you help them see it. Look at the *MinecraftEdu* collection of teacher-made maps; if you can find a map that suits your purposes it will save you a lot of time. A more "controlled" map where certain areas are restricted (such as the tutorial map) helps keep students focused. A worksheet also helps tie the activity to the learning goals and gives the students something for later study.

Minecraft is an extremely popular and widespread game with teenagers, so it seems silly not to tap into this popularity and take advantage of it to help engage students in learning. With added mods and a growing list of premade downloadable maps designed by teachers it is an extremely versatile and engaging tool. It doesn't require much "computing power" or high-tech equipment, or even an Internet connection once it's up and running. I believe *Minecraft* brings a sense of play into the classroom that can sometimes be missing.

APPENDIX

How to Load and Save Worlds Using *MinecraftEdu*

Google search "MinecraftEdu library." It will appear as a list like so (see Figure 13).
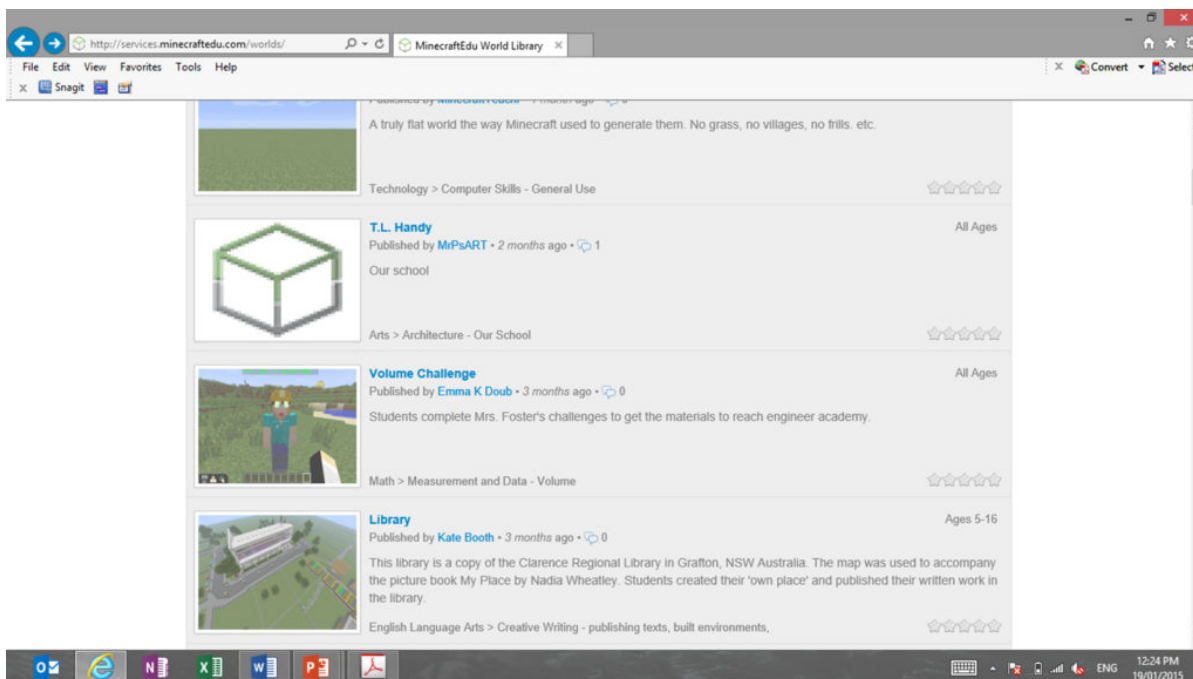

Figure 13. Screen shot of the MinecraftEdu library.

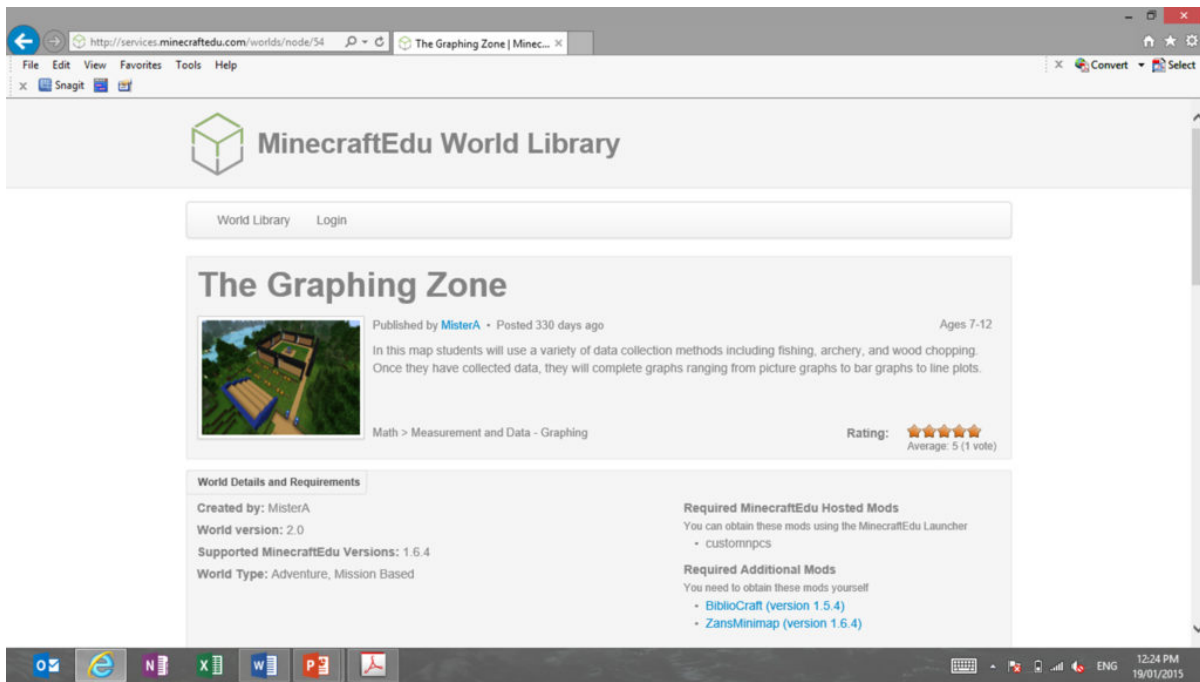Click on the map you wish to download (see Figure 14).

Figure 14. "The Graphing Zone" map information.

Option 1: Download With Server Launcher

Open the *Minecraft* server launcher and then return to the *MinecraftEdu* webpage. When on the map information page, scroll down and click on the link "Download with Server Launcher" (see Figure 15). It's as simple as that.

You should then be able to select the downloaded world from the server launcher by clicking on "Select Saved World" and selecting the world name from the list (see Figure 16). Click on "Start Server with Selected Saved World" and you're done!
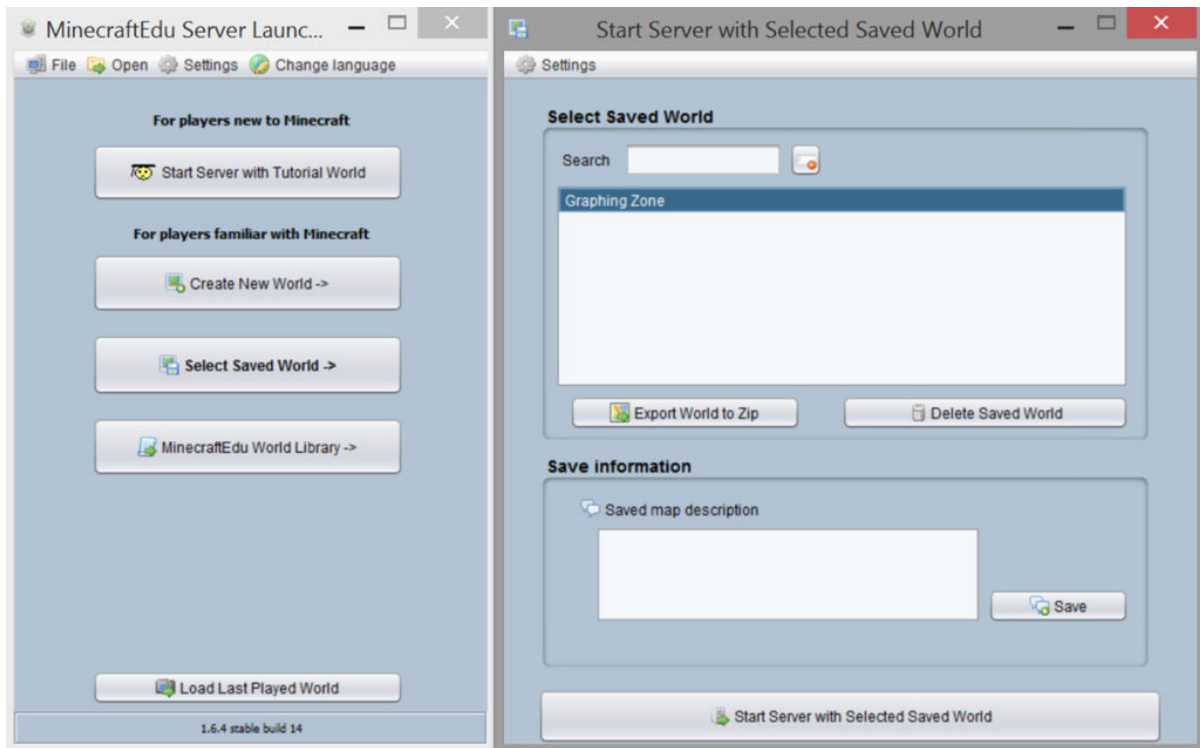
Figure 16. How to select a saved world on the MinecraftEdu server software.

Option 2: Download World Manually

If the "Download with Server Launcher" button doesn't work, you will have to do things manually (see Figure 17). This option is a little bit trickier.
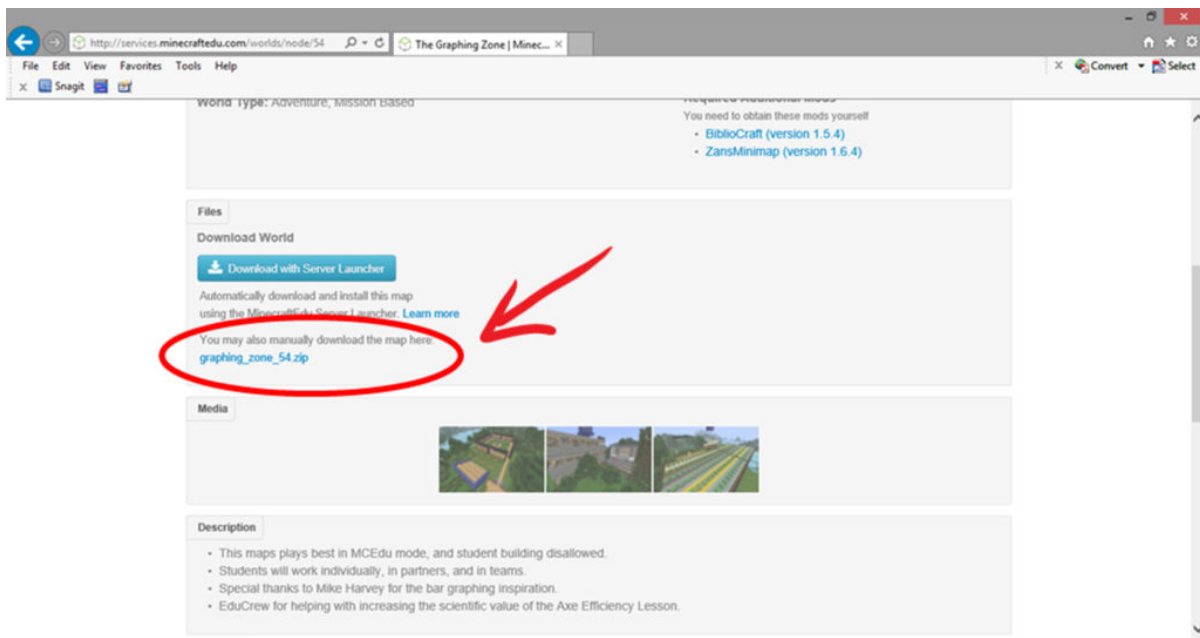

Figure 17. Where to find the manual download link on the MinecraftEdu library.

On the *MinecraftEdu* library website click on the link below the words "manually download the map

here." This will save a zip file in your "Downloads" folder on your computer. You then need to open the zip folder (if your computer can't do this you will need some free software such as WinZip [http://www.winzip.com/] or CAM UnZip [http://www.camunzip.com/]).

Then you will need to find where the *MinecraftEdu* file is saved on your computer. If you can't find it, a quick search for "Minecraftedu" will help (Windows button + F will bring up the search function on PCs; use Command + F for Macs). Once you have found the folder open:

"Minecraftedu > servertool > worlds > saved worlds"

Once in the "saved worlds" folder, create a new folder with the name of the world you just downloaded (e.g., "Graphing Zone"). Click and drag the unzipped downloaded folder across to the "saved worlds" folder (see Figure 18).
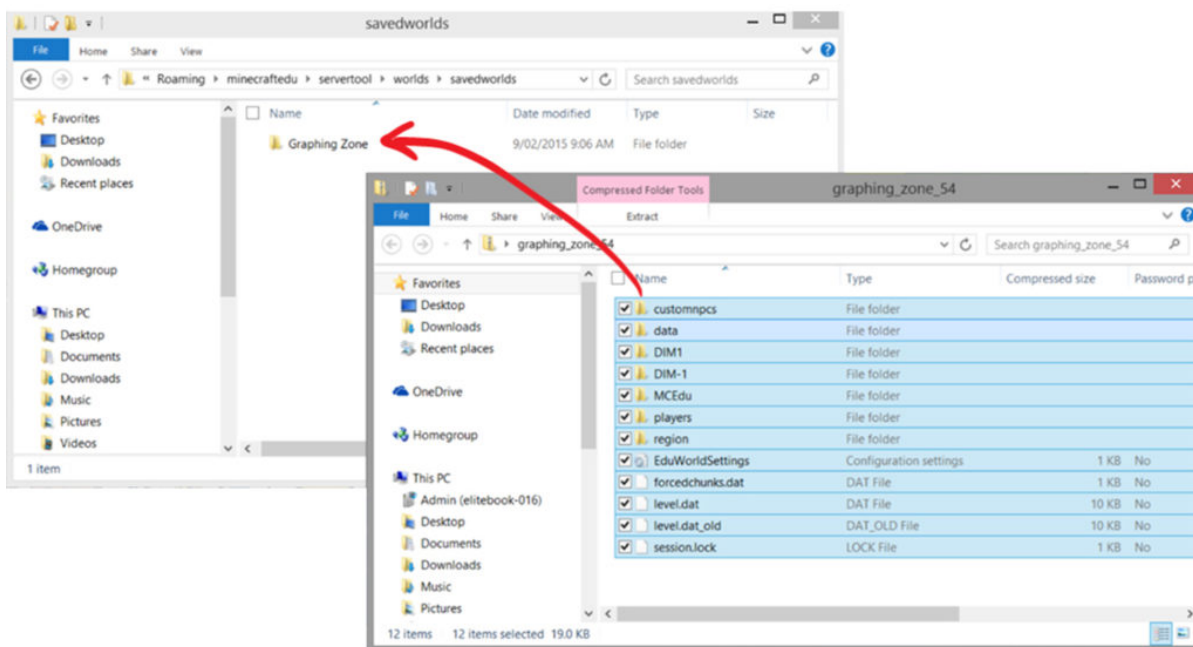

Figure 18. How to transfer unzipped world folders to the "saved worlds" folder.

Reopen the server launcher, go to "Select Saved World," and you will see the name of the downloaded world. Click on the name and then on "Start Server with Selected Saved World" and you're done!

Saving Worlds

If you have created a *MinecraftEdu* world or altered an existing world, you can save it and share it with others. While using the *MinecraftEdu* server software, click on the "Save map" button at the top right (see Figure 19).
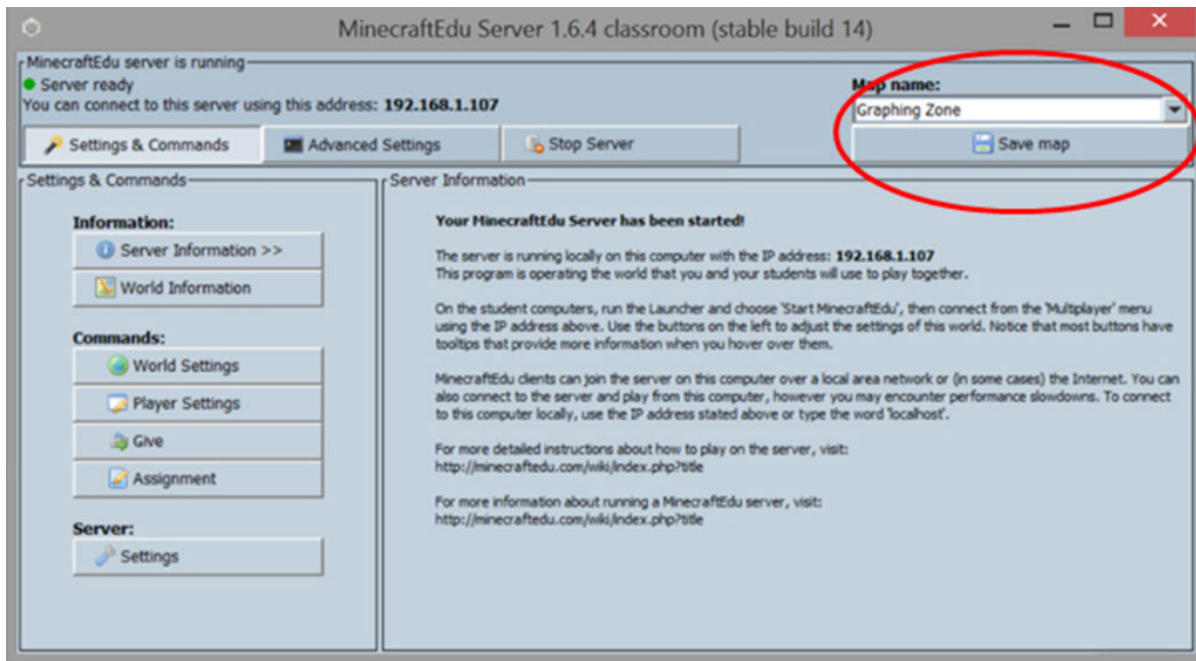
Figure 19. Where to find the "Save map" option on the MinecraftEdu server software.

Your world will then be saved in the same "saved worlds" folder described above. If you want to share your world with others you will need to zip the folder (using WinZip or CAM UnZip) and upload it on the *MinecraftEdu* library.