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DESIGNING EDUCATIONAL GAME EXPERIENCES FOR k12 STUDENTS IN CONTEXT OF INFORMAL MINECRAFT CLUB.

Kasvatustieteen pro gradu -tutkielma
KASVATUSTIETEIDEN TIEDEKUNTA
Teknologiapainotteinen luokanopettajakoulutus
2016

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UNIVERSITY of OULU

Kasvatustieteiden tiedekunta | Tiivistelmä | opinnäytetyöstä
Faculty of Education | Thesis abstract

Luokanopettajankoulutus	Tekijä/Author Ruotsalainen, Hannu		
Työn nimi/Title of thesis Designing Educational Game Experiences for k12 students in Context of Informal Minecraft Club.			
Pääaine/Major subject Kasvatustiede	Työn laji/Type of thesis Thesis	Aika/Year May 2016	Sivumäärä/No. of pages 55+23

Tiivistelmä/Abstract

In current times schools are facing new kind of problem. Students are physically present but their minds are wondering. To answer this problem teachers have searched new ways to inspire students to learn. Many teacher believes that video games could be the answer to this problem. This design based research goes in detail how Minecraft learning areas were created and made better during one school's afternoon club. Research questions for this thesis were: 1.) How iteratively design learning areas for the Minecraft club? 2.) How did design of the learning areas change during the Minecraft club? 3.) Were there a change in test performance at the end of the club compared to start of the club?

This afternoon Minecraft club was held once in every week for 8 weeks and in it there were 16 participants aged between 10 and 12. Researchers would create new learning area in the game world every week and students would play through it. After the club meeting researchers reflected upon the results and decided if there was need for change. Every learning area had its own theme and it was used to teach students topic from the Finnish curriculum.

In the results it was discovered that Minecraft learning areas had positive effect for most students test performance. This test performance was measured with pre-club and post-club conceptual tests. The design of the learning areas changed much during the Minecraft club and reason for this change was mostly student behavior and researcher's attempt the counteract it. Researcher found a model which allowed them to iteratively develop the learning areas. This was a cyclical process which kept going for the whole 8 weeks. In the week 7 design was perfected for this club. The turtle world is the fines specimen of the results. In it crystalizes whole of the development which was done during the Minecraft-club.

Asiasanat/Keywords Minecraft, gamification, serious games, design based research

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1 Introduction

A new problem has risen schools in Europe and USA. Students are less interested in their studies and find lectures more boring than before. More and more students are physically present in classrooms but their minds wonder somewhere else. Teachers find themselves in situations where they are more trying to stimulate students to learn than they are actually teaching. (Steinberg, Brown & Dornbusch, 1997)

Curtis Chandler (2013) has also noticed this same problem and is proposing that video games could be used to counteract this in schools. Video games and gaming as a whole has become big part of our western culture and this is not likely to change any time soon. This is why teachers and schools around the world need to start learning how to use this new medium as a teaching and learning tool.

This topic is very important to me as a person. I have always been very keen gamer and I have played video games from the young age. When I was a child video games were always seen as bad things and catalysts for aggressive behavior but I have always thought that video games can and should be used to do well.

This thesis is going to show case one way to use MinecraftEDU as a teaching tool in a primary school's afternoon club's context. This have been done before (Schifter & Cipollone, 2013; Short 2012; Køhrsen & Misfeldt 2014; Overby & Jones 2015; Scarlett 2014; Schifter & Cipollone, 2013; Uusi-Mäkelä 2014)

) but as a new angle in this club students are able to continue playing from home in the same game world which they were playing during the club. In this thesis we will graze the history of video games and gaming as a whole. After this terms “Gamification “ and “ Gamifying education “ will be explained. After this focus will be put on Minecraft and its’ educational extension (mod) MinecraftEDU. Both basics of the game will be explained and its’ role in this thesis will be described. Second, theoretical concepts of the game design and design based research will be introduced. Third, aims of the study and research questions will be introduced in the fourth section, which is methodological framework, both research design and data collection techniques will be presented. Fifth part of this study includes presentation of the results. After that this section thesis continues with discussion and conclusion chapters.

2 Theoretical Framework

In this chapter the theoretical ideas on which this research is based on will be presented and discussed. Firstly we open the term video games and gaming as a whole. From there we move on to the serious games and after that we cover video games in schools and gamifying education. From there we move on to the earlier studies and Minecraft-game. After this we will lightly touch on the subject of video game design and lastly the design based research will be explained.

2.1 History of video games

According to Wolf (2002) defining term "video game" is more complicated than it seems at first. To define video game one have to look at the definition of both game and video. In this thesis video games are defined to be digital games which are played for entertainment.

Video games as a medium despite of their popularity is very new. First video game was created in Cambridge University in 1952. This game was developed by A.S.Douglas as a part of his research project. The game was computer programmed version of the tic-tac-toe which was played against the computer. This during the 50th was a grand achievement. Even though this grand achievement this game did not reach the consciousness of the big audience due to the fact that the machines it worked on were not available. (Egenfeldt-Nielsen, Smith & Tosca, 2013)

Video games and video games industry started to grow during the 1960 due to development of technology. Although video games were at the start of their life cycle and even to this day developers don't know how to fully utilize the power of video games. If we compare video games to other forms of mass media for example to movies the history of video games was really short. First movie show was year 1895 and first time movies were used in education was at the beginning of 1900s. (Egenfeldt-Nielsen, Smith & Tosca, 2013)

After the first tic-tac-toe game videogame industry started slowly develop. In nowadays videogame industry is huge International business where billions of euros are made every year. This is due to development of technology and educated work force has made it possible to develop even more complex games. Due to this development specialized study programs have been developed to meet the requests of the gaming industry. In Finland this

kind of specialized study program can be found in Kajaani. (Egenfeldt-Nielsen, Smith & Tosca, 2013; Kajak3d.com/fi/)

The popularity of video games has climbed considerably in fifty years. First video games were directed towards teenaged boys because videogame industry thought them as a natural audience for the video games. This was due to the fact that teenaged boys before the videogames had played a lot of table top games. So it would be natural them to switch from table top games to videogames. (Egenfeldt-Nielsen, Smith & Tosca, 2013)

First video games were popular amongst teenaged boys and young adult men, this was because of originally video games were directed to this demography. But when come to start of year 2000 popularity of video games grew explosively in all age groups. To explain this phenomenon the biggest reason is that availability of video games was greatly improved. Nowadays almost every shop sells video games and if person cannot bother to go to the shop this person can buy virtual copy of the game or just order it home from the internet. Also the new innovations like smartphones and tablets with their appstores have greatly increased the sale of video games. (Egenfeldt-Nielsen, Smith & Tosca, 2013)

As said before in early years of video game industry video games were directed at small group of people. But during the last decade video game industry has found new demography for their games. In early years video games usually were about conflict or war but in year 2000 company named Electronic Arts published a video game which changed many things. This video game was named “The Sims “and it was very different from the “normal” video games. The Sims was life simulator. This means that goal of the game was to take care of your sim and guide him/her through their everyday lives. This video game introduced countless new persons to the video games. To this day “The Sims “have sold over 20 million copies. (The Sims Franchise celebrates Its Fifth Anniversary and Continues to Break Records, 2005; Egenfeldt-Nielsen, Smith & Tosca, 2013)

2.2 Gaming

Marc Prensky (2001) says that one of the biggest reasons why video games are becoming so popular is that the children who spend their childhood playing video games are growing up now and they don’t want to give up their hobby. So they will spend their money on video games. This puts more money into the industry and more investors get interested in vid-

eo game market. Marc Prensky calls these persons “digital natives”. These persons have spent whole of their lives surrounded by digitalized world. Prensky highlights that video games is digital native’s mass media. They have taken it for themselves and it’s theirs. This generation and its mass media is different from the former generation in many ways. (Prensky, 2001)

Video games have been elevated by this new generation. Video games are no longer considered as playthings for kids but as an art. This nonlinear experience can be experienced in many ways unlike the mass Medias that have come before it. (Egenfeldt-Nielsen, Smith & Tosca, 2008) Prensky (2001) tells us that video games by nature are better suited for the digital natives. Digital natives think differently than the former generation and this why this new nonlinear medium fits their need better.

2.3 Serious Games

Tarja Susi, Mikael Johannesson & Per Backlund (2007) define serious games as such " most agree on a core meaning that serious games are (digital) games used for purposes other than mere entertainment."

The definition of serious games seems to be rather universal. Same as Susi et. Al.(2007) Also Connolly, Boyle. E, MacArthur, Hainey and Boyle, J. (2012) define the serious games in same manner in their systematic literature review. "Digital commercial games were developed primarily for fun, entertainment and recreation, while the main aims of the games-based learning and serious games are learning and behavior change." (Connolly et.Al, 2012, p.2)

The game MinecraftEDU which was used during this research is a serious game. MinecraftEDU was created as a teaching tool but it has the components which make it also entertaining. This means that the way the game is used determines if the game is serious game.

One of the biggest problems in nowadays schools is that many of the students are physically present but mentally they are somewhere far away during the classes. (Steinberg, Brown & Dornbusch, 1997) Steinberg at al. also write that even 40% of the students study just to meet expectations. Students aren’t interested in the subjects. Steinberg at al. raised a valid problem and Curtis Chandler (2013) arguments that video games could be the answer for

this problem. While students are playing video games they end up solving much more difficult problems that they usually would in school and they focus on their assignments far longer. (Steinberg, Brown & Dornbusch, 1997; Chandler, 2013)

Gee (2003) states that popular video games have one thing in common. According to Gee all good video games are also good teaching machines. These teaching machines are conceived in such a way that player can learn to master them. Gee also states that easy and short game is not interesting and the biggest problem that game designers face is that how to get young people to enjoy learning the mechanics of the video game. (Gee, 2003)

It seems that all these researchers think that video games could teach the teachers how to get students excited about learning a difficult subjects. Video games not only has succeeded getting students' excided but to enjoy studying and time used on studying. (Gee, 2003; Steinberg, Brown & Dornbusch, 1997; Chandler, 2013)

2.4 Gamification

Gamification as a term is quite new. Knowledge about this term has risen to the consciousness of the professional educators in past few years. In the article " Gamification: Using game design elements in non-gaming context." Gamifications term is defined as an unofficial hypernym for using videogame design in a non-gaming context. Also Domínguez, Saenz-de-Navarrete, de-Marcos*, Fernández-Sanz, Pagés & Martínez-Herráiz (2012) in their article " Gamifying learning experiences: Practical implications and outcomes " define gamification same way as Deterding, Sicart, Nacke, O'hara & Dixon (2011) did. (Deterding, Sicart, Nacke, O'hara & Dixon, 2011; Hechinger Report, 2011)

2.5 Gamifying education

As the name suggests gamifying education means situation in which game designs are used in educational situations. Deterding at.all (2011) tell in their article that game design should be used in education to improve student experiences and make students more engaged to the topic which is being studied.

Gamification could fix many problems in schools. For example Sipilä (2012) ponders on the schools numerical evaluation of students. She interviewed teachers and students about this and found that many of the teachers and students found the numerical evaluation prob-

lematic or demoralizing. Teachers said that it was hard to make sure that the numbers they gave to the students were right or fair. (Sipilä, 2012)

Introducing videogame design to this problem. It's not necessary to change the numerical evaluation but teacher only change the way they come up with the number for the student. Courses could be though as a roleplaying videogame. At the start of the course students are level zero characters and all the assignments that teacher gives are worth points. When student completes enough assignments and collect enough points he/she will "level up". The higher student's level is at end of the course, the higher student's number from the course is.

This way is both good for the students and the teachers. Just by looking what level student is on they instantly know that what number that certain student is going to get. Students are more motivated to work towards goal than just work not to get bad number. Alfie Kohn (1993) dictates that fear of failing destroys motivation.

This what was presented here was tested in north-America by man called Lee Sheldon. According to Hechiner report (2011) Sheldon while he was working in university of Indiana renovated one of his courses to be a MMO (Massive multiplayer online game). At the start of the course students created their own "avatar" and formed guilds. During this course students didn't write essays or school assignments as in other courses. They went on "raids", "quests " and "solo quests". For each of these assignments accumulated experience point. When student had enough experience points he/she would then rise a level. At the end of the course Lee would give student grades according to the level of their avatar. (Deterding, Sicart, Nacke, O'hara & dixon, 2011)

2.6 Minecraft and MinecraftEDU

In this chapter major differences between Minecraft and MinecraftEDU will be presented. In addition to that, essential feature of Minecraft, blocks, are presented and educational value of such items will be elaborated.

2.6.1 Minecraft

Minecraft's history starts from year 2009. At that time game developer Markus Persson decided to quit his job and start game studio of his own. The idea for

Minecraft came from game called "infiniminer". This Infiniminer was developed by Zachtronic Industries. Infiniminer was never published but Persson saw potential in the game's idea. Persson started the development of the Minecraft just few weeks after the Infiniminer was cancelled. At that time Minecraft had work name ”Cave Game ". (Minecraft.net/game)

Minecraft has come a long way since those days when Persson was developing it as ”Cave Game”. Although it can be said that Minecraft is created from the same DNA that ”Cave Game" was made. The idea in both games is to break, collect and place cubes in a randomly created 3D game world. In Minecraft player doesn't have any predetermined mission that he or she should accomplish. Game cannot be won and there is no end of the game. It's more of an activity tool in which player makes up goals for itself. This gives the players lots of freedom to do whatever she/he wants. Players can choose to just explore the game world or player can build the castle of his/her dreams. Almost everything you can imagine you can build. (Minecraft.net/game)

2.6.2 MinecraftEDU

MinecraftEDU is official extension (mod) for the game Minecraft. Mods are program code modifications for a digital games that are usually made by the fans. Such changes can change the game in many interesting ways, for example: 1) players can get more content to play or 2) physical power or other abilities can be changed and 3) new enemies can be presented. Basically this list is endless and it’s only restricted by the imagination. (Postigo, 2007)

MinecraftEdu is designed by TeacherGaming[1] for teaching and learning purposes. It is based the normal Minecraft game, but TeacherGaming has added many functions for making game easier for the use of teachers. Their modification enables teacher(s) to have more control over the gameworld(s). This is done by adding graphical user interface for teachers instead of using console commands which is feature in normal Minecraft game. One major

[1] http://services.minecraftedu.com/wiki/Main_Page

change in MinecraftEDU when compared to normal Minecraft is division of the players into two roles students and teachers:

Role 1. Teacher Player

Teacher players are the admins of the server (game world). They can e.g. freeze players, give items, teleport players and much more. These functions (see Table 1) are useful during the game for orchestrating the learning activities and assignments. For example, they can freeze the players while instructions will be given or if some improper activities are noticed during the gameplay.

In the teacher role player can use functions, which are very useful for designing the physical learning contexts (game itself). For example, in teachers' role player can add or destroy large amount of blocks. In practice, this does mean that teacher players can build large structures easier and faster than students.

Table 1. Functions while MinecradfEDU is played in teachers' role

Feature	Description
Fill and clear tool	Teacher can fill or clear area in the game. This is useful while teacher is building the physical learning context.
Long distance building	Teacher can place blocks from extremely far away.
Build mode	Allows teacher to fly, move through objects and have infinite resources to build.
Freeze students / Freeze player	Players who are students cannot move while this is on. Can also be used with one student only. Extremely useful for controlling student behavior.
Mute students / mute student	Students cannot write in the chat. Can also be used with one student only. Useful while you have frozen students and all they can do is spam the chat with messages.
Set time	Player can decide what time is it in the game.

Spectate mode	Teacher player will be invisible and no one can see him/her. Useful while observing students in game.
Give items	Teacher can give items to the students. This is very useful when player(s) need(s) certain items to work in the learning areas.
Teleport self	Teacher can teleport himself to player's location or to a teleportation block (physical, designed, location target)
Teleport student	Teacher can teleport student(s) to teacher's location.
Set assignment	Teacher can write assignment(s) which are visible to the students through student interface

Role 2. Student player

Student player's role in MinecraftEDU is almost identical to normal Minecraft gameplay. Their version of MinecraftEDU's interface doesn't include any special functions. Only teacher players can grant special abilities to them like flying or infinite amounts of building materials. Students players' only MinecraftEDU related function is the list of the assignments to be solved during the gameplay.

2.7 Earlier studies of using Minecraft and MinecraftEDU for supporting learning

In this chapter previous research on the use of the MinecraftEDU will be presented.

The focus on these studies is how video games can be used in education especially those studies which used Minecraft for educational purposes. Problem here is that there is not that many studies about educational use of Minecraft. Short (2012) and Scarlett (2014) focuses on coming up with ideas how Minecraft could be implemented in education.(see Table 2.). KØhrsen & Misfeldt (2014) were looking into how children engaged in playing Minecraft in afterschool program. Uusi-Mäkelä (2014) and Schifter & Cipollone (2013) were looking into what kind of learning environment does game world provide while teaching students languages. Overby & Jones (2015) were researching how Minecraft could be incorporated into art education curriculum.

Table 2. Earlier Minecraft studies

Name of the study	Aim of the study	Results	Reference/Link
Teaching scientific concepts using a virtual world - Minecraft	Show ideas how teach scientific concepts with Minecraft.	Study's results yield different kinds of ideas how Minecraft could be used in education. Short gives examples in following subjects: physics, chemistry, ecology, biology, geology and geography	Short, D. (2012) https://civicadigibase-public.sharepoint.com/Minecraftedu%20resources/Short-2012-science-teaching-minecraft.pdf
An Ethnomathematical study of play in Minecraft	Paper explores how children engaged in playing Minecraft in an after-school program develop for mathematical approaches.	Study's research question is left open. Researcher noticed that first person view point provided challenges for the students.	KØhrsen, L. & Misfeldt M.(2014). An Ethnomathematical study of play in Minecraft. In Sifverberg, H., & Hannula. M.S (2014, june) Nordic research in mathematics education. Proceedings of NORMA14, 205-214
Virtual LEGOs: Incorporating Minecraft Into the Art Education Curriculum	This study investigated if Minecraft could be incorporated into art education curriculum.		Overby, A. & Jones, B. (2015) http://www.tandfonline.com/doi/pdf/10.1080/00043125.2015.11519302
Gaming Geography: Using Minecraft to Teach Essential Geographic	This study tries to explore the possibilities to use Minecraft as a teaching tool for elementary/middle		Scarlett, M. (2014) http://www.editlib.org/noaccess/150098

Skills	school students.		
Minecraft as a teaching tool: one case study.	This paper presents a case study of one English teacher – how he engaged his students with Minecraft and how the students did or did not engage back.		Schifter, C. ,Cipollone, M. (2013) Temple University, United States http://www.editlib.org/noaccess/48540
Immersive Language Learning with Games: Finding Flow in MinecraftEdu	Aim of this study is to describe what kind of environment games provide for communication and their effects on communication.	Biggest challenges for the study were to provide authentic communication environments for the target language and to find a balance between free play and teacher controlled play.	Uusi-Mäkelä, M. (2014) http://www.editlib.org/noaccess/148409

2.8 Designing video games

In this chapter basic ideas of designing video games will be presented. In the context of this master's thesis design was based on Design Based Research which will be described as design approach next to this chapter. Before discussing the design of the video games it is crucial make difference between entertainment games, edutainment games and serious games. This is important because when we are aware of what kind of game we are designing we know the goal of it. Entertainment game's point is some way to entertain the player. In edutainment the goal is a bit mixed. Its point is to teach something while keeping the enticement of entertainment game. (Buckingham & Scanlon, 2005). Serious games were described in the earlier phase of this theoretical framework, but to put it into brief description, these are games which are used for something else than mere entertainment. (Connolly et.Al, 2012)

Jesse Schell (2008) defines Game design in his book ”Art of Game design" simply that designer has to answer a question: " What this game should be? ". Schell itself argues that its very simplified definition, but basically it is the question which game designer is asking from himself while he is designing the game. In practice, game design does cover all aspects of the game under development. Some central design targets are: 1) game mechanics i.e. Game rules, 2) what player can do in the game, and 3) how player is allowed to do those things? Other important parts of the game design are 1) storytelling, 2) music, graphics and other art related things 3) level design and much more. All these parts need to be completed before the game is ready. (Schell, 2008) Designing serious games is not the exception, teachers or instructional designers does need to understand core concepts of the game design. What does it mean in the context of this thesis? In practice, when educational experiences were designed in the context of this thesis, it was important to decide which blocks were be put into which positions and how to (continuously) change layout of the blocks (game world itself) according to experiences from the gameplay itself. And these block related design decisions had to follow certain instructional ideas and decisions. To conclude, educational games are designed so that these follow instructional principles, but at the same time follow guidelines and practices of the good game design.

2.9 Design-based research as tool for designing serious game activities in the context of this thesis

In this thesis game itself, learning tasks and all other issues in pedagogical design were (re-)designed iteratively so that experiences from the club meetings were used as a source for next design round. The main aim of the design was to develop Minecraft club as whole. In this chapter design-based research approach is introduced and described.

This study follows ideas of the design-based research. According to Edelson (2007) it is research method in which development and research combine within theoretical and empirical phases in cyclical process

Design-based research can be defined as methodology, in which aim is to develop education in real contexts systematically, flexible and iteratively. With ongoing evaluation and development various stakeholder groups are used as source because of their expertise. (Wang & Hannafin, 2004)

As a research method design-based research is not old. In educational research design-based research has been used as an approach only from beginning of 1990s. Need for this research method arose from the need to further develop education and learning environments from the empirical perspectives Also recent developments in the technology enhanced learning has increased a need for new kind of research methods. (Brown, 1992)

During the early years of the design-based research few articles have been published. In research literature scholars have discussed about history of the method, methodology, reporting and different kinds of operating models. Commonly agreed view is that design-based research is all iterative and development is usually contextualized. Most discussions have been about executing design-based research and its reliability criteria. (Sandoval & Bell, 2004)

According to Barab and Squire (2004) design-based research is made up by collection of different kinds of approaches. Design is based on theory and it creates also new theory. This separates it from pure formative approach. Development is validated by pragmatic solutions which are made in naturalistic context. (Barab & Squire, 2004)

Also Juuti & Lavonen (2006) are proposing for design-based research approach that combines action and theory. This is pragmatic approach. According to Juuti & Lavonen design-based research has three features: 1) alliterative design is born from need of change, 2) Designs will produce usable outcome, 3) design creates information that furthers education. Collins et al. (2004) suggest that ethnographical mixed methods fit design-based research in which quantitative and qualitative research methods are mixed.

Design-based research can have as its theory base or development goal, many theories which all have their own possibilities and challenges. For example diSessa and Cobb (2009) bring up four different theory categories. These are 1) grand theories, 2) orienting frameworks, 3) frameworks for action and 4) domain specific instructional theories.

Grand theories usually deal with the phenomenon in so universal level that design within these theories focuses on certain small areas. These kind of grand theories usually stay useful for long time. Known grand theories: evolution or Newton's mechanics
Orienting framework: these theories make it possible to conceptualize development of learning and education. Their challenge is generalization because information only apply to certain group of people.
Frameworks for action: usually these kinds' theories can be theatrical bases for design-based research because goal of the design-based research is to create practical applications. Problem with these theories is that theories are multifaceted. Frameworks which are guiding the action hold in them many different factors. This makes it hard to factor them in the development.

Domain specific instructional theories: these theories make it possible to develop and test educational procedures of certain concept.

As reported by DiSessa and Cobb (2009) these four theory categories are not sufficient goal to overall design-based research. As a development objective they suggest paleontological innovation by which they mean new category of understanding. Paleontological innovation makes possible to connect theoretical thinking to empirical data and also makes it possible to develop, test and generalize working thinking designs. Paleontological innovations problem is that it's hard to find genuine paleontological innovations and most of them are already found in some form.

In research literature design-based research has been criticized about its reliability. According to Deden (2004) design-based research approach doesn't have set of coherent research techniques. Because aim of the method is to understand and describe phenomena, DBR approach produces a lot of data which makes it hard for the researchers to analyse it objectively. Deden (2004) states that biggest problem for the design-based research is to coordinate extensive and long research projects, reinforce theory base and standard research methods. He suggests that design-based research should be developed with the same tools that it uses.

Design Based Research has been critiqued because it doesn't have universal models about how to implement design-based research activities. But according to Edelson (2007) its possibilities can be evaluated by rising up few core fields. With design-based research researcher can hope to find answers to three kinds of questions: 1) how does the development process proceed 2) what kind of possibilities and needs does the developed thing have 3) what kind of result does the development yield. Answering to these three questions separates design-based research functions in three categories: 1) development process, 2) problem - analysis, 3) development creation. (Edelson, 2007)

Development process category**:** In this category research personnel and processes which are needed in research planning, preparation, implementation, development of research process, testing of the creation, evaluation and refinement are decided. (Edelson, 2007)
Problem - analysis category: within this category design-based researches challenges and needs are sorted out and goals are decided. Problem - analysis can be theoretical or empirical and be made up with for example necessity analysis, testing and evaluation (Edelson, 2007)
Development creation category: in this category are the solutions to the challenges and developments processes possibilities which came up in the problem-analysis category. Development creation develops iteratively during the development process. (Edelson, 2007)

All the development process categories create different kind of data:

- Development process category: this category observes whole design-based research. With this can be detected what kind of problems the research has. How individuals work as a part of the entirety or what fields of expertise are needed in certain kind of development contexts. Development process category creates directive theories. (Edelson, 2007)
- Problem - analysis category: this category creates context bound theories. These theories describe how the conclusion was conceived. (Edelson, 2007)
- Development creation category: this category creates context bound models. Context bound model can be for example model that can be used to teach some certain topic. This model is concrete and explains how some topic is taught or some lecture given. Development creation category creates directive models. (Edelson, 2007)

Implementing design-based research differs from the traditional quantitative research. In design-based research phenomenon is studied in its natural environment and examinee are used in the development process. While in traditional quantitative research researchers try to monitor certain variables and handle examinee purely as examinee. Design-based research is open therefore it has more variables than traditional research methods. (Collins, 1999)

Design-based research processes iteratively trough empirical and theoretical phases. Because of this core factors in design-based research are strongly connected. According to Edelson (2007) design-based research at its core is adaptive research method. During the research formative evaluation is conducted, problem-analysis is deepened, and challenges become new goals and creation is tested time and time again.

In design-based research development is usually conducted in collaboration with different kinds of stakeholder groups. This kind of community brings to the table possibilities and problems. If the community works together, has the same view of the goal and trust each other the change of research producing what it was supposed to produce increases. On the other hand if the development community is completely opposite to this the development will most likely fail. This is due of the mistrust in the community which makes harder to criticize the work and develop it further. Furthermore if the development group grows it will take more work to communicate and inform. Also the experience of the developers effects the outcome of the research. (Chao, Saj & Hamilton, 2010)

According to Collins et al. (2004) reporting in design-based research shouldn't be done the same way as in traditional research. Design-based research report should have fife parts: I) theory and development goals which are linked to context, ii) detailed description of the

research layout, iii) cyclical development reports from which you understand why and what was changed, iv) cyclical development results, v) discussion part

While using traditional research methods reliability is evaluated with validity and reliability. This does not apply straight to design-based research. This is due to a fact that design-based research contains qualitative parts and all of these aren't measurable with quantitative methods. (Tuomi & Sarajärvi, 2009)

2.9.1 Reliability and validity in design-based research

Reliability in design-based research is measured with measurement system developed by Lincoln and Guba (1985). This measurement system consist of four classes: credibility, portability, reliability and reliability. (Tuomi & Sarajärvi, 2009)

From the stand point of reliability analysis design-based research is difficult research method. But still it can be evaluated by using design-based research collective (2003) created criteria for good design-based research and reflect those findings to Lincoln's and Guba's (1985) categorization.

In design-based research openness and complexity are the most important things when evaluating design-based research reliability. These factors make it difficult to define the research. Usually there is huge amounts of data collected and that data comes from many sources. It becomes difficult to decide what to report and how to define the research. Generalization of the research is also challenging and errors are easily made due to unique nature of social events and unique development environment of the design-based research. (Kelly, 2004)

Those who defend design-based research are augmenting that the advantage of design-based research is that research results can be generalized and results explain researched topic well even though research's reliability cannot always be verified. Critics on the other hand are saying that the weakness of the design-based research is that usually made by using a small sampling size. This means that it doesn't describe the universe as well as quantitative research methods. (Edelson, 2007)

3 Methods

This method section will start with the description of the context and continue with the description of the subjects. After that tools used in this thesis will be explained. At the end of this chapter data collection and analysis approaches will be described.

3.1 Research question(s):

The aim of this study was to design and implement learning activities for using MinecraftEDU as a tool in MinecraftEdu game club. .

1. How to iteratively design learning areas for the Minecraft club?
2. How did the design of the learning areas change during the Minecraft club?
3. Were there change in test performance at the end of the club compared to start of the club?

3.2 Participants and research setting

The participants were 16 (11 boys, 5 girls, average age ≈11) K-12 students in the primary school in Northern Finland. The total amount of participants was reduced by the size of computer classroom where MinecraftEDU game was being played during the club meetings.

All of students participated in informal afternoon club which had 8 x 90 minutes of meetings. Students were chosen to club voluntary basis, it was advertised to students between 10-12 years old in their school. Age limitation was chosen to guarantee homogenous skills among the population.

From the methodological point of view, participant selection followed random sampling procedures, which means that presentative sample is selected by using chance selection to minimize biases that would alter the sample. (Fraenkel, Wallen & Hyun, 1993)

3.3 Tools

In this thesis MinecraftEDU computer game was used as a tool. Minecraft and MinecraftEDU are presented in the theoretical framework (see chapter 2.4) in order to bridge game design and pedagogical functionalities of the game.

In this tool section basic functionalities MinecraftEDU will not be described, instead focus will be put on game extensions (mods) used in this thesis project which enhanced game-play and made the game more compelling to play.

One topic chosen to be included into club activities was electricity. How to design activities which supports learning electricity? It was known that Minecraft doesn't have blocks for creating complex circuits, energy sources and devices. Solution was to choose appropriate mod which enables such functionalities. In addition to that MinecraftEDU itself is extension to Minecraft game so it is included here into the list of modifications. Furthermore, there is also WorldEdit extension which helps teacher for designing game worlds. All used mods can be found from table 3 (below), but are also are explained in their respective chapters below.

Table 3. List of used extensions (mod) which were used for adding new features to the game

Extension	Description
MinecraftEdu	Default extension which adds educational functions into Minecraft game (teachers' and student's interfaces). This modification turns Minecraft into EDU version.
ElectricalAge	Extension which can be used for crafting and placing electrical devices and networks (e.g. generators, batteries, lamps, windmills)
Worldedit	Extension which helps game world designer (teacher) to build big structures and geographical elements easier and faster than normal building tools
ComputerCraft	Extension which is adds programmable turtle blocks and computers to the game

3.3.1 MinecraftEDU MOD

Game which we used is actually Minecraft's mod. It defies the term "mod" because it's made by professionals and it's sold to the schools. But in a sense it's a mod. MinecraftEDU adds features to the Minecraft which makes it easier to use for the

teachers. Mod adds blocks that allows teachers to control players' actions and gives teachers powers to build very fast with unlimited resources. This was the mod we based everything on.

3.3.2 ElectricalAge MOD

ElectricalAge is a mod created by team of people called Electricalage team. This mod adds 150 new items to the world of Minecraft and allows more realistic electrical simulations. Minecraft has very basic electrical simulation with the "Redstone" and it was not enough for club's purposes. Electricalage mod was the most stable mod that we found which covers electricity this realistically.

Table 4. Functions of ElectricalAge-mod

Function	Explanation
Electricity simulation	This mod simulated electricity very accurately compared to Minecraft's own Redstone (Appendix I.)

3.3.3 Worldedit-mod

This mod allowed teachers to use varied commands to shape the game world as they saw fit. With this mod teacher could create mountains or islands just by typing in a command. This mod was used mostly before the club started. While teachers were shaping the game world.

Table 5. Functions of Worldedit-mod

Function	Explanation
Add blocks	Player (teacher) can add large quantity of blocks with command.
Brush tool	Player can shape the game world.

3.3.4 ComputerCraft-mod

This mod is included with the MinecraftEdu game. It adds programmable computers and robots (Turtle) to the game. Both computers and Turtles can be programmed using simple JavaScript statements. Computers and Turtles also have preprogrammed programs which can be used by the player.

Table 6. Functions of ComputerCraft-mod

Function	Explanation
Programming	Players can program computers and Turtles in the game world.
Turtle	Little programmable robot that can run simple programs. Can place and remove blocks.
Computer	Can be used to write programs to control Turtles and doors etc.

3.4 Data Collection

Data for this study was collected during the club meetings. Video material was collected. This video material was gameplay videos inside the game world. First one was from the students' point of view, second one was from the teachers' point of view and the third was stationary camera. Data holds about 20 hours of gameplay footage. Researchers also kept research diary about the events which took place during the club meetings. In this diary there was thoughts about what didn't work and what did. This diary was used in tandem with the gameplay footage to pin point reasons to make changes to the learning areas.

3.4.1 Research diary

According to Hardy, Phillips and Clegg (2001) reflexivity associates reflecting on how the research is conducted and understanding how the process of doing research shapes the yield of the study. This notion is based upon the knowledge that research is interpretive activity. Research process is regarded as being subject to variety of influences which effect

upon the analysis generated by the researcher. This is the reason why it's important for the researcher to reflect upon his own work and for this research diary is an excellent research tool.

In this study researchers kept a research diary about the events which took place during the club meetings. This notebook contained notes about what didn't work in the learning area and other interesting events. With this diary researchers could easily pin point what had happened during certain club meeting.

3.4.2 Gameplay videos

In this thesis gameplay videos were used to point researcher's reason to change the design of a learning area. Research diary was used in tandem with the gameplay videos it made finding the right spots in the video easier.

Gameplay videos: students' perspective

These videos were filmed by my research partner. He approached this club from ethnographic perspective and was interested in student/player experience of the club. These videos show how he proceed through the learning areas.

These videos give good perspective on the student side of things. These videos shed light on the assignments and the functionality of architecture.

Gameplay videos: Teachers perspective

Point of these videos were to give the teachers perspective during the club meeting. From these videos it's possible to verify why certain aspects of architecture and assignments were changed. Teacher would prioritize filming of "misbehaving" students. From these videos the functionality of assignments and architecture can be seen.

Gameplay videos: passive camera

This camera was passively filming the work done by students in the learning areas. Its point was to provide information what students do in the working areas. Do the students work as intended or do they do something else, if so what? While student's and teacher's perspective cameras were going around and doing various actions this camera was stationary. It shows all the actions done in the working area from the start of the meeting to the end.

3.4.3 Conceptual knowledge test

To analyze the learning of the students pre- and post-tests were conducted. From this a paired samples t-test was done and learning gains were calculated. (Hake, 1998)

In the club pre-test was conducted on the first club meeting and the post-test was conducted during the last. This test was done by using Google forms. Students would get an internet link which took them straight to the test and they would just fill in. Students answered two identical set of questions which were as follows: a) How do you understand teamwork?; b) What is the society?; c) How does electricity work?; d) How is area calculated?; e) How is volume calculated? f) How does trading work? g) What are maps for? h) What are coordinates for?

3.5 Data Analysis

3.5.1 Conceptual knowledge test

In this thesis both pre- and post conceptual tests were conducted in order to answer question: were there change in test performance between pre- and post tests. From one questions student could get 2 points max if he or she could answer the question correctly. If the answer was somewhat right student would score 1 point and if they didn't know anything about the question they would score 0 points.

There was also few students that were removed from the data. This was due them not being present when post-test was conducted or their answers were clearly not done seriously. There were five persons like this.

3.6 Reliability and validity of the study

When talking about reliability and validity according to Tuomi & Sarajärvi (2009) while estimating the reliability of a DBR such as this study. Normal method of evaluating validity and reliability cannot be applied. This is due to the fact that DBR contains qualitative parts which cannot be measured by quantitative methods.

3.6.1 Reliability of the study

Firstly it needs to be stressed that with group size this small this study cannot offer definitive results on the subject. It can be said that for this particular group benefitted from our experiment and the study yielded interesting results and many functional learning areas which can be further developed in upcoming clubs.

3.6.2 Validity of the study

Definition of validity is the measurement of how well the methods measure or data represents what they are supposed to measure or represent. (Newman & Benz, 1998) Validity can also be separated into two different categories internal validity and external validity. Internal validity means how well data and conclusion are linked together. External validity means how well results of the study can be generalized to other contexts.

While evaluating the internal validity the results and conclusions can be linked together well. Research method fit perfectly needs of the study. Goal was to create real functional digital learning areas which can be used and for that DBR was perfect tool. By its nature DBR yields concrete products.

On the other hand what comes to the external validity, this results and learning areas can be applied in other contexts but we cannot say if they will yield the same result. Other researchers might run into different sort of student behavior than we did. It's completely possible that other researcher would like to change something completely different than we did.

3.6.3 Ethical considerations

This study was conducted to comply with the ethical principles of social studies suggested by Descombe (2010): a) Protect the interests of the participants; b) ensure that participation is voluntary and based on informed consent; c) avoids deception and operates with scientific integrity; d) Complies with the laws of the land.

Research did not cause any harm to the participants' personal safety and data collected was used in a way that participants cannot be identified from the results.

4 Results

In this chapter results of the study will be presented. Data for this research was collected by using different methods: research diaries, videos recorded during the game itself, observations, pre/post-test and game world as a data. With this data collected it was possible to create coherent pattern how and why the design decisions changed during the club.

4.1 Were there change in test performance at the end of the club compared to start of the club?

In this club both pre- and post conceptual tests were conducted in order to answer question: were there change in test performance between pre- and post tests. From the pre/post-test can be seen that most of the students increased their test score from pre- to post-test. In some cases the change was quite staggering. From this we can say that playing the created learning areas has clearly had some positive effect on students learning.

Table 7. Points of pre- and post-conceptual tests

No	Age	Pre-test	Post-test	Change (Points)	Change (%)
1	10	4	7	+3	75,00%
2	10	3	8	+5	166,66%
3	10	4	4	0	0,00%
4	10	2	2	0	0,00%
5	10	3	4	+1	33,33%
7	10	4	3	-1	-25,00%
8	12	5	15	+10	200,00%
9	11	4	7	+3	75,00%
10	11	3	6	+3	100,00%
11	11	2	5	+3	150,00%

12	11	3	5	+2	66,66%
	Average	≈3,36	6	≈2,6	76,51%

4.2 How did the design of the learning areas change in each design cycles and during the Minecraft club in general

In this section design cycles are described in order to illustrate how did the design of the learning areas change during the 8 weeks of the Minecraft club. Design choices were based on the teachers' experiences and collected data (videos, diaries etc.) and are reflected in this chapter.

Minecraft club was re-designed iteratively between each of the club meetings. There were changes in architecture, tasks and organizing the club itself which all can be seen from the figure 1. Colors represent phases: blue is first design cycle, green is second one while orange is third. If color changes back to previous one, it does mean that previous design was taken into use.

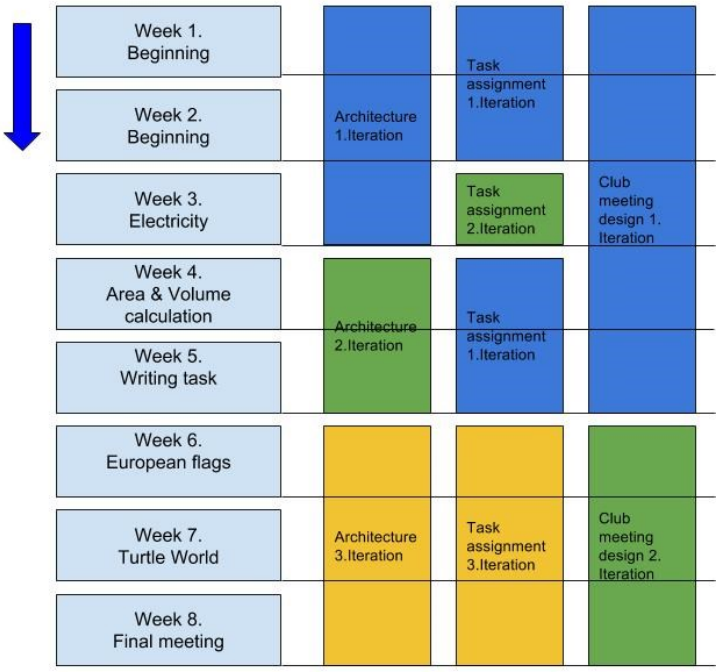

Figure 1. Club design and different iterations. Blue: First iterations, Green: second iterations, yellow: Third iterations.

4.2.1 Design cycles in the architecture of the game world (learning areas)

Design changes related architecture focuses on how the learning areas were designed and built and how the architectural design changed between the three design cycles. Two of designs were used two weeks and latest one of the game world architecture was used three weeks. All of these design steps will be explained in this chapter

First two weeks of the architectural design (first iteration)

This two weeks of the architecture included in-game practice where two researcher (author and his colleague) trained their skills for building game worlds. During two first weeks two distinct learning areas were built: a) island (arena for informal club activities), b) hall of quests (some of the tasks were given here) and c) first wing of the science center.

Next we will go in more detail on these learning areas which were created in the first week of the club.

Week 1. Architectural design of the Island and Hall of quests

Island was the first learning area that was built for the club. This area is where students can build and play on their free time and that's why there is minimalistic changes to the "vanilla" version. This build was very simple and was made by using premade map from the Minecraft's archives. Only changes that were made were: few nearby islands were deleted, ship and mountain were build and the island was surrounded with boarder-blocks in order to prevent students from escaping the club area.

Island (figure 2) was chosen as context because one design idea was to keep students close to each other for increasing collaborative learning. Teachers also wanted to have clear hub for the club. So when students would find themselves with nothing to do they could go to the certain point of the world and find extra quests and things to do - their home island as learning hub.

Figure 2. The Island - the home hub for informal learning activities

Hall of quests were created as a hub for quests (tasks). From there students could easily find new main quest and captain's quests. This hall of quests were built so only teachers could influence it or change it. Students could only interact with the info-blocks and teleporter-block.

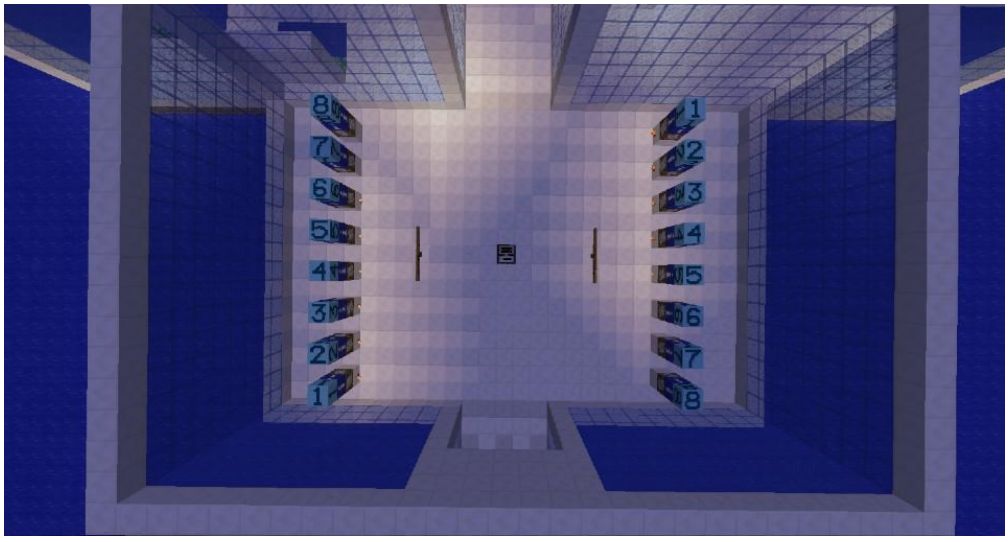

Figure 3. Hall of quests from top. (Roof removed)

Hall of quests was built by using following design recipe: a) Base layer with build disallow-blocks square a x b; b) The structure was built with quarts blocks and glass blocks; c) Room was surrounded with boarder-blocks; c) Teleporter-block was placed in the middle of the room; d) 8 info-blocks were placed on either sides of the room. Together 16 info-blocks; e) Two signs were placed to inform students in which side of the room certain quests were. (Captain's quests and main quests)

Week 2: Science Centre: Designing showroom and student working area by using Electrical Age extension

In this design activity first formal learning area was designed where aim was to support learning of the basics of the electricity. This was done by using "Electrical Age" Minecraft extension (Mod). Learning area was designed so that students were able to access into science center through hall of the quests which was designed during the week 1.

This formal learning area consisted of two different set of the rooms: 1) showroom which was like museum or science center full of different kind of electrical circuits, power sources etc. 2) Second part of the complex was students' working area where they can build their own electricity related products according to given assignments and tasks.

First section of the science center (electricity showroom and task area) was build same way as the hall of quests. In practice, science center was extension to hall of the quests (task building), because one corridor was built from the hall of quests building. This design choice enabled students to enter on their free time. After this corridor was entrance to learning area.

In practice, it was done so that first suitable area was covered with build disallow-blocks. This area was big +100blocks x+200blocks. After this build disallow-blocks were covered with quartz blocks. Then walls and ceiling were created to get that same aesthetic that hall of quests have. With these steps done we have a big hall. Next step was to divide this big hall to smaller rooms and corridors. Idea here was to make students walk through these showrooms which would show them examples about the electricity and leading them to the student working area in which they would complete assignments.

<u>Showrooms for displaying running demonstrations of the electricity</u>

In the showroom area of the science center complex there were nine smaller rooms including different kind of working examples of the electricity: a) Basic circuit and cables; b) Couplings series and parallel; c) Power sources; d) Signals; e) Voltage convertors; f) Fun Redstone applications; g) Power sources review and battery charging; h) Solar power house; i) Living room the solar power house; j) Basement of the solar power house; k) Roof of the solar power house; l) Wind power

Showrooms are described in the detail in Appendix III: Showrooms of the science center.

Student's working areas where students can build their own electricity solutions according to the assignments

This big hall is where students work on their assignments. Each student has their own working space which are all alike. These areas were built so that students can only break and add blocks in certain places. Underneath quartz floor there is layer of build disallow-blocks. On the students working places is build allow-blocks on top of the build disallow-blocks. Just outside of the walls there are boarder-blocks. This design is exactly the same as the hall of quests.

Students can move about in this hall freely and observe other students work. Hall was built like this to promote collaborative and team work. Students could easily interact with each other.

Figure 4. Student's assignment hall. Description of the areas: 1) Info-block and material area: Here students can see the instructions what to do within this hall, Here students get their items which they need to use on the assignments. 2) Student working areas: 16 work places one for each student Here they complete several assignments of varying difficulty.

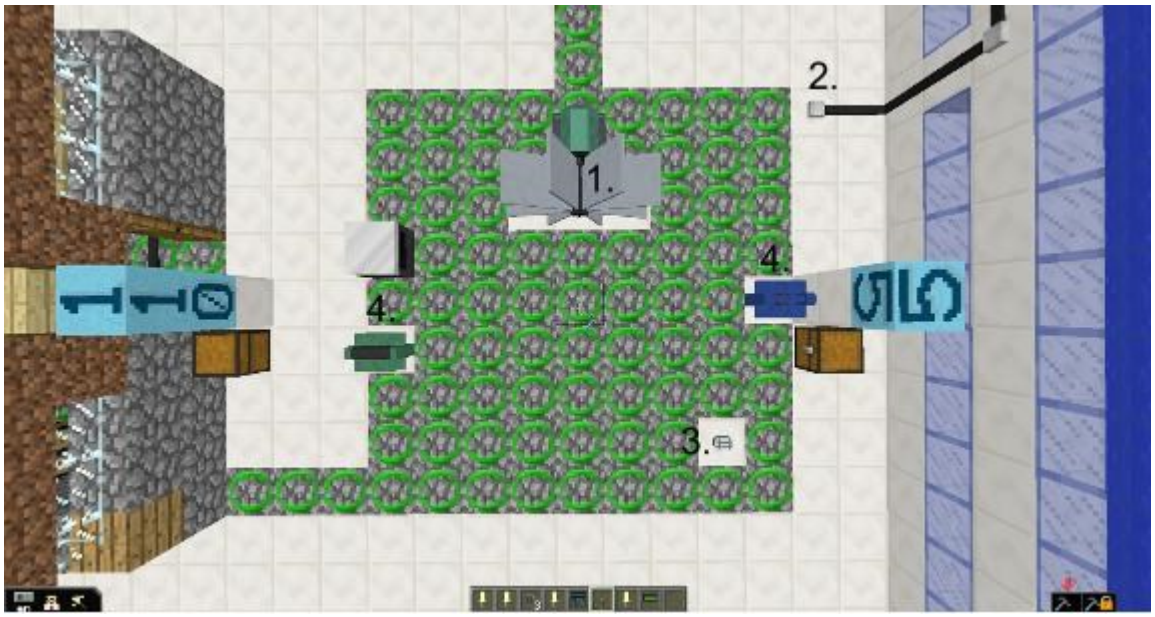

Figure 5. Student's working area bird view. 1) Water turbine: Used to generate energy for the machines; 2) 200V connection cable: Outside power outlet. Provides 200V; 3) Lamp: Students had an assignment in which they needed to light the lamp; 4) Machines (200V and 50V): Electrical furnace, plate machines 200V and 50V

Experiences from the first weeks of the architectural design. How to keep students focused on to the task? Design experiences from basic block placement

Next, basic block design of the hall of the quests and first wing of science center will be described. Pedagogical design rationale for architecture was to keep the students in the learning area and make the navigation for them as easy as possible. Restriction of the students movement was done by using build disallow and boarder blocks (see Appendix for description and figure 2 for illustration).

Figure 6 shows how students can move in the green zone but they cannot move on or through the red zone. This design allows students to move on top of the wall but not jump down from it. It keeps the students in the correct area but allows them to run on top of it due to the roof.

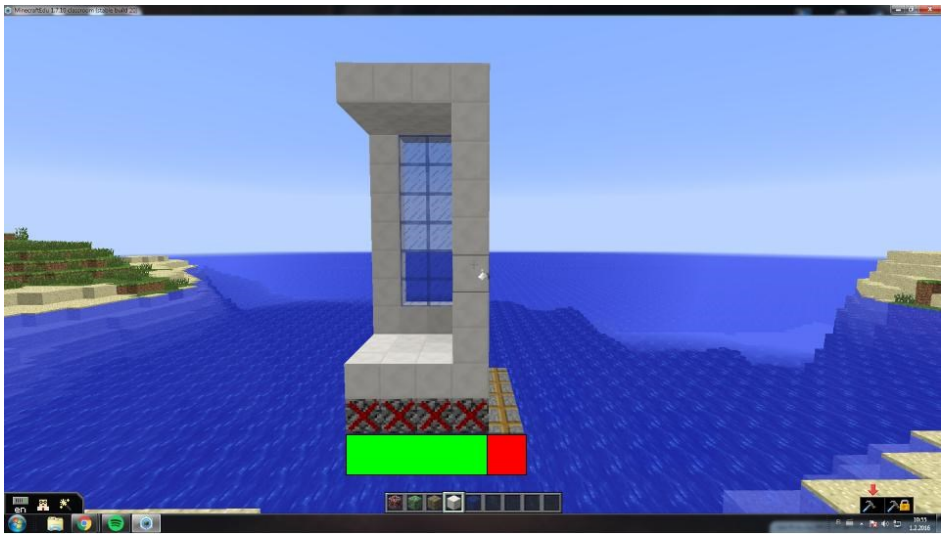

Figure 6. How to keep students inside the learning area. Side view of the first architectural design. Green area: students can move; red area: movements forbidden

Figure 7. Design flaw in the first architectural design. Students were able to move on top of structure and escape because of the roof.

First two weeks of the gameplay revealed design flaw in the architectural design. As seen in the figure 7 students can move on top of the structure without hindrance even over the dividing wall. In theory, students could be kept in the learning area quite well but if they can get on top of the building they can move freely.

Third and Fourth week of the architectural design (second iteration)

Week 3: Designing new wing to the science center: Area and volume calculation

This wing of the science center was built on the third week of the club (see the appendix IV. Mathematics wing of the science center). It was built with the same principles than the

electrical wing but with few changes. Students would follow same kind of path through the facility but now there was two working areas for students.

First one was for area calculation and the second one was for the volume calculation. In short this wing was made up by three kinds of areas: 1) Theoretical introduction with examples done by teacher, 2) well-structured tasks for understanding the topic in practice and 3) free working area for students to build different kinds of object and calculate then volumes and areas of those.

This wing is built in a very similar way that the electrical wing was. Connection corridor was built from the hall of quests. This way students could enter the new wing trough the hall of quests whenever they wanted. Basic building style is here exactly same as it was with the electrical wing. The whole area was first covered with build disallow-blocks (appendix 2.) which were covered with quartz blocks. Walls were built with glass blocks and quarts to get the same aesthetic than the other areas of the science center.

Week 4: The Island: Writing quest

Quest on the week 4 didn't give much room to examine architectural design. This quest (task) was a writing assignment in which students had to write a book about how to survive the zombie night on the island. The learning area was the student's island which hasn't changed at all from the beginning of the club.

Experiences from the third and fourth week of the architectural design. How to keep students focused on to the task?

This second iteration tried to answer the problems that came up during the first and second club meetings. This iteration is a structure with same kind of aesthetics than the first iteration but it doesn't have a roof and on top of the wall there is a wooden fence. The border blocks and build disallow blocks are in same places and allow same kind of movement as in the first iteration.

Figure 8. Second architectural iteration from the side. Notice how roof is removed in order to prevent students' escape from the science center.

As we can see in the figure 8 this architectural design allows same kind of movement for the students as the first one but obviously students cannot move on the roof although students can run on top of the fences which are on top of the walls. As same as before students can only build in student building area which is marked with build allow blocks.

Final design of the game world (learning area) architecture

This was the pinnacle point of the architectural design for this club. This design was an answer to many problems that were present in the club meetings. Design changes are again subtle but very effective. Border blocks layout was changed and the dividing walls also become inaccessible due to the use of border blocks. (Appendix 2.) Wooden fences on top of the structure were also removed because they were no longer needed.

In the figure X can be seen that the border blocks (Appendix 2.) have been changed to the place limiting the area where students can move. Students can't anymore walk on top of the walls because now border blocks are strait under the walls.

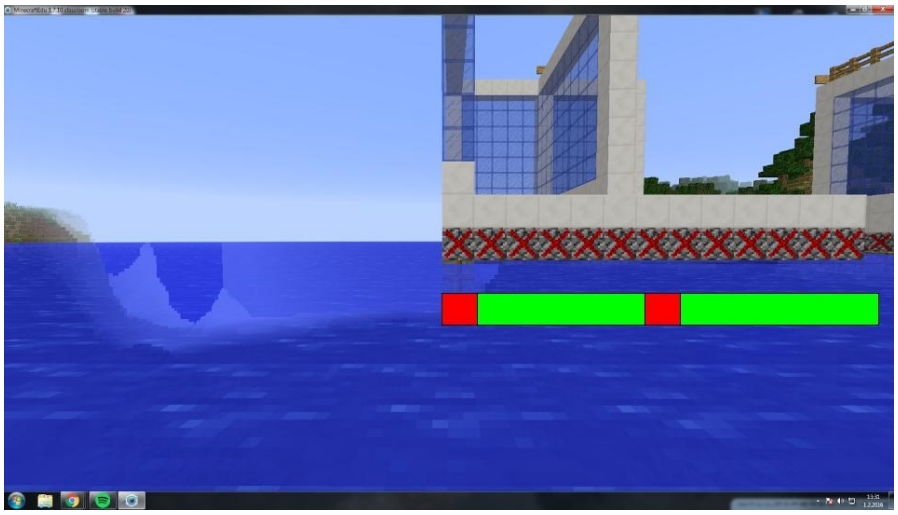

Figure 9. Border blocks (Appendix II) have been changed to the place limiting the area where students can move.

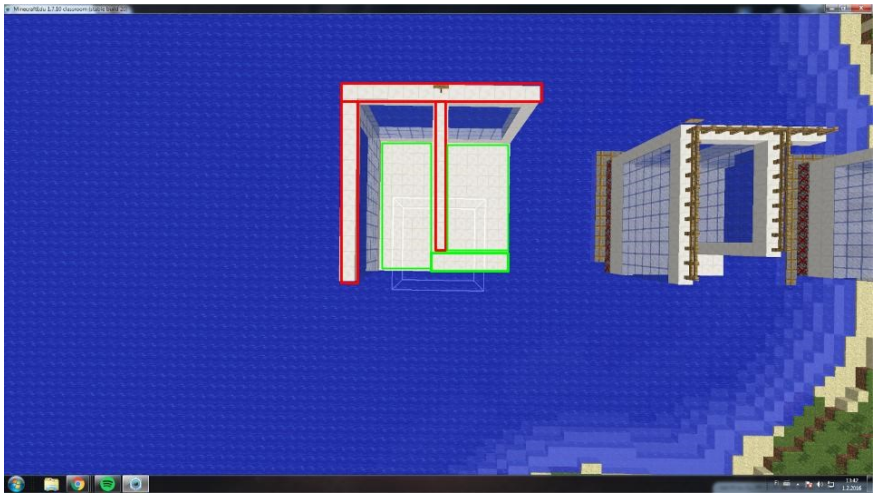

Figure 10. Same design iteration. Bird' eye view.

From this figure from the above can be seen where students can move and where they cannot. Students can move in the green zones and they cannot move on or through the red zones. This design is a bit more restrictive than those design that came before but it gives more control to the teacher.

Week 5: Designing new wing in the Science center: European flags

This particular learning area was the first one to use the final design iteration of architecture. It has been built in a same manner than the previous learning areas in the science centre. Some minor changes are going to be presented below.

Student's assignment in this particular learning area is to pick one European country and then complete assignment as it follows: a) look for a European country on the Internet; b) build it's flag in the building area; c) put a sign in front of the flag with following information: 1) the official language; 2) the area in square kilometers; 3) the size of the population; d) write a tourist guide in a chest in front of your flag

This learning area has a very basic layout. It's a big quadrangle hall with both students working area and building materials. When students enter the hall first they are met with information box. This information box contains link to the Wikispaces site which has the assignments for the students and in front of the information box there is a chest. In this chest are sign and books for every student so they can complete the assignments. Students can freely roam the hall and they can build their chosen country's flag where ever they want to provided that it's on the build allow blocks.

Figure 11. Science center: European flags learning area. The red arrow: the direction from which students enter the area; Red circle is the information box (Appendix 2.) with the chests that contain everything needed by the students; Area which is enclosed with blue lines is the students working area. Here students build their flags and erect their signs; Area enclosed with yellow lines is the building material stock. Here students can get all the building materials for the flags.

Week 6: Science center: Programming

This learning area was the last one which was designed for this club. Although this learning area follows the same architectural guidelines than the previous learning arena within same design cycle, but it has many functionalities that were not needed in European flags

assignment. Design rationale for this learning area was to teach students basics about programming. This is important because new national curriculum in Finland emphasizes the importance of the programming in the primary school context. (Opetussuunnitelman perusteet , 2014)

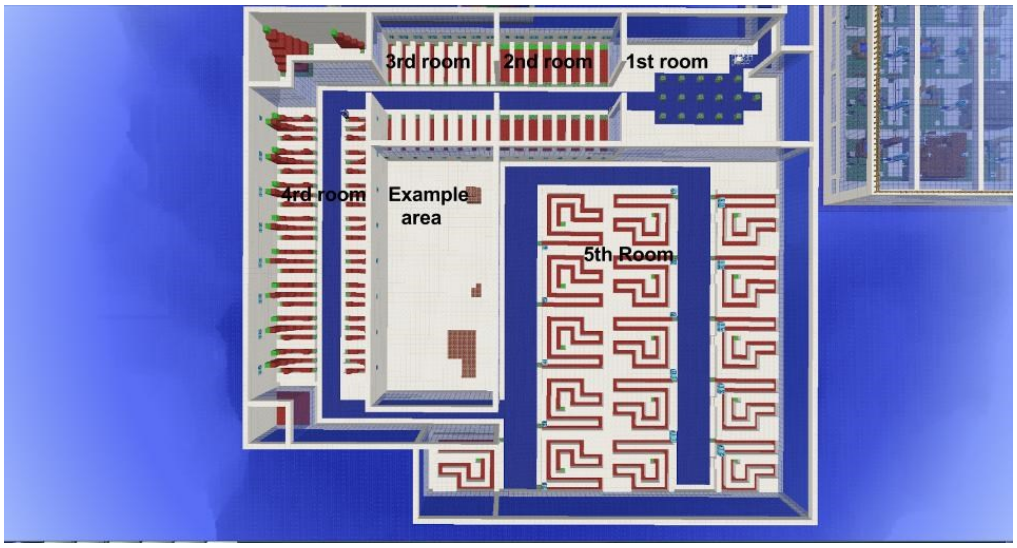

Figure 12. Turtle world overview picture

In this wing of the science center students were programming little robots called turtles. These turtles can be programmed either with module programming or text based programming language. Students would complete quests by programming the turtle to do certain things. When students have these basic skills they could learn more advanced programming on their free time.

All these following rooms share same kind of characteristics. Under the floor there are layer of build disallow blocks for both students and turtles. Students can only place their turtles on build allow blocks. (See more on the design of the programming wing: Appendix V. Programming wing of the science center).

First programming hall: learn how to customize turtle

The design rationale of this room was to offer a space for students to learn how to customize their on turtles. Students would place one turtle on top of a pedestal and then customize it as they want. After this they would place a sign on the turtle with their own name on it.

Figure 13. Room for customizing the programming turtles

Second programming hall: learn forward and backward functions

This room was designed for learning how program turtle block to move from the build allow block (Appendix 2 and figure 14 below.) To the green block and back again. Disallow blocks (under the red wool blocks) which forced students to place their turtles in one starting position. Every student have their own working areas are placed side by side so that students can easily work together.

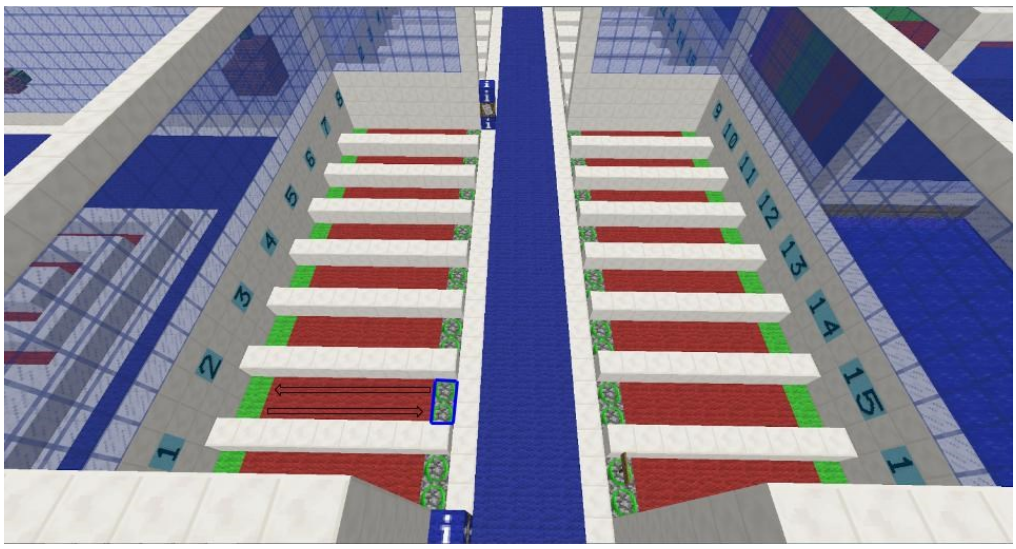

Figure 14. Second room (learn how to move turtle) of the Turtle world. Blue box: build allow block which is starting position in programming activity. Under the red wool blocks are build disallow blocks so students can only place their turtles in one starting position. The arrows in the figure demonstrate the movement directions of the turtle.

Students were given following assignments: 1) Program your turtle to move from build allow block to the green block; 2) Upgrade your program so that after the turtle has reached the green block it will come to the starting position

Third programming hall: learn how to turn the turtle

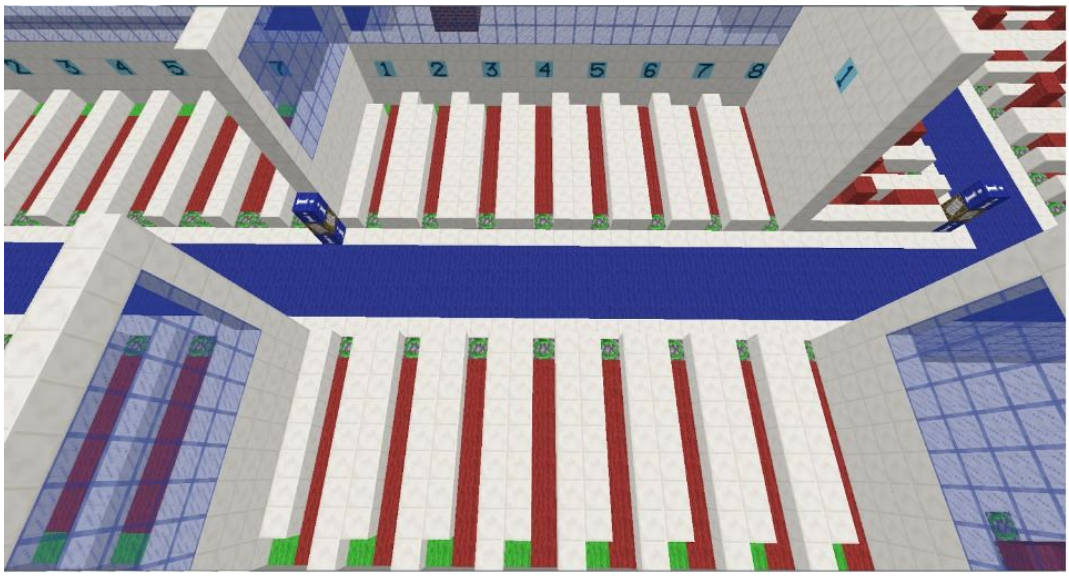

Figure 15. Third room of the Turtle world where students learn how to turn the turtle

Basic design in this hall was the similar than in the previous programming hall: students would be assigned to program their turtle to move from the build allow block to the green block by following the red path. This exercise made students to learn how to turn their turtle around. Students were given following assignment: 1) Program your turtle to reach the green block and then return to the starting position

Fourth programming hall: learn how to jump and come down with turtle

This room has the same idea as the previous programming halls. Basically students needed to place their turtle on the build allow block and program it to reach the green block. The design rationale of this hall was to teach students how to program vertical movements of the turtle (See figure X below). Students were given the following assignment: 1) Program your turtle to reach the green block. (Turtle cannot fly over the obstacles! It has to climb. 3 different tracks.)

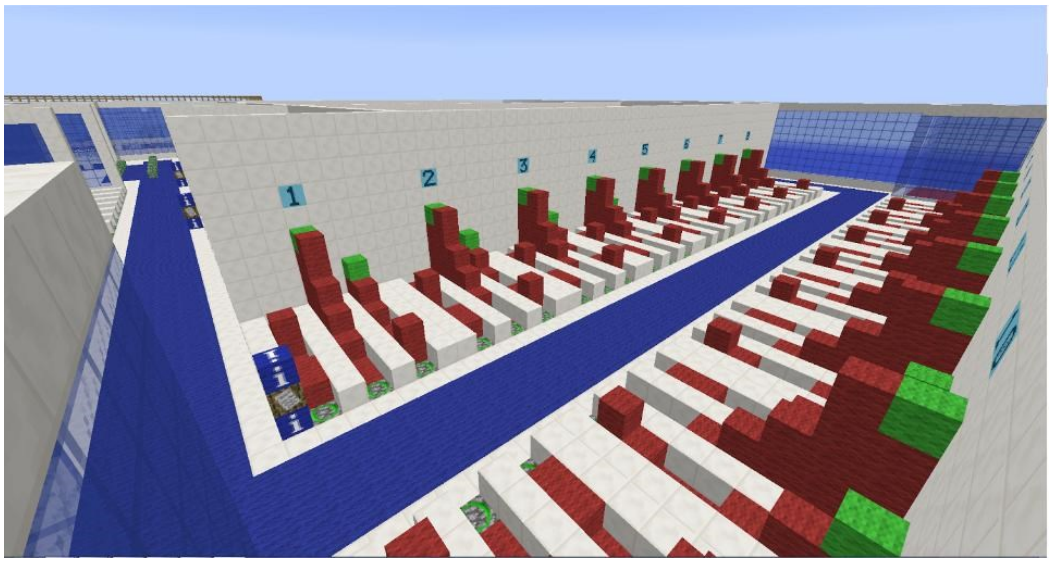

Figure 16. Fourth room of the Turtle world

Fifth programming hall: The maze (final programming task)

The design rationale for the maze was to be a final programming challenge for the students. They had to program their turtle to move through the maze (see figure 17 & 18 below) on its own and the turtle would have to follow the red path. Bonus was awarded if someone could make a turtle that keeps running the maze back and forth forever.

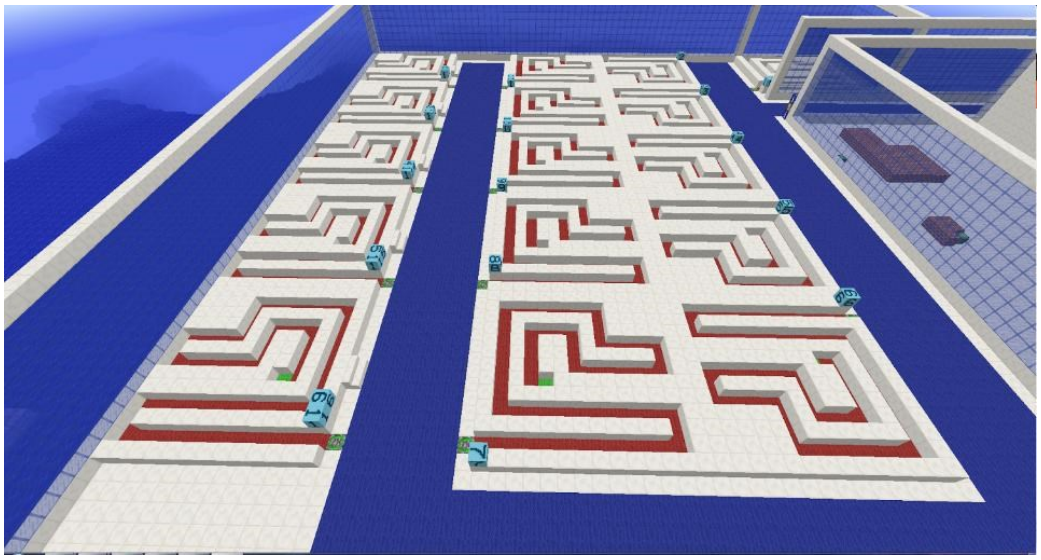

Figure 17. Fifth programming hall of the Turtle world. This was designed to be a final programming challenge for students.

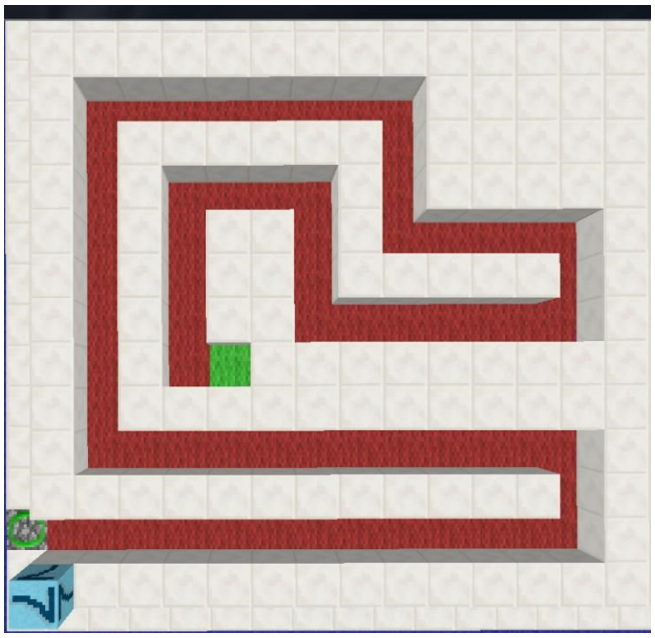

Figure 18. Fifth room's maze from the top.

4.2.2 Design cycles in the task assignments

Design cycles in the task assignments focus was put on how students were given their assignments. This includes how the assignments were given in the game world and also how teachers gave assignments in the classroom. In the club there were three iterations of this.

First weeks of the assignment distribution design (iteration 1, weeks 1-3)

Assignment were simply given with the MinecraftEDU's assignment tool. Students would connect to the game and then check their assignments by pressing "m" key (see figure X below). Also teachers had placed information blocks around the learning areas to further explain the assignments. After student had done the assignment he/she would just tick the box.

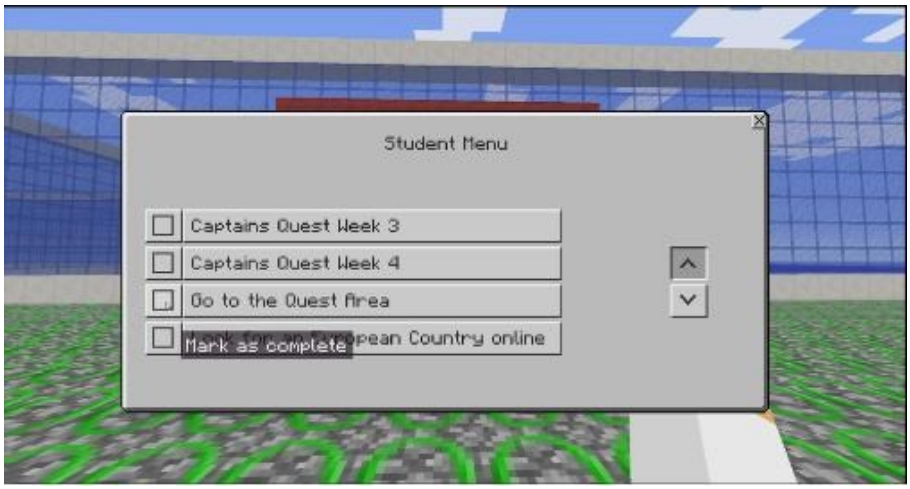

Figure 19. Student's assignments view.

Second design of the assignment distribution (iteration 2, week 4)

This iteration was only in effect for a week. In this iteration, tutorial blocks were taken into use which were a part of "electrical age" MinecraftEDU extension. This was a try to get better way to provide task related information to students, because "m" letter wasn't most convenient way to read task related information according to experiences from the first iteration. Also one design rationale was to increase the amount of the information provided to the students

It should be noted here that in both of these first iterations assignments were given purely in the game world.

Third design of the assignment distribution (iteration 3, week 5)

This iteration of the assignments came to effect during the fifth week of the club. This design iteration brought to the table teacher's demo aspect to the assignments.

Same way as in the first iteration learning area has information boxes which have the assignments and also students can check the assignment tool for their assignments. New part to this iteration was the teacher's demo. In this demo teachers shows with the video projector what kind of assignments students have for the session.

4.2.3 Design cycles in the designing the club meetings and activities

In this set of the design cycles the design of the club sessions is explained. This design activity consisted of the two iterations. First design cycle took place in weeks 1-4 and the

second one was 5-7. This activity concentrates mainly about how the sessions were structured outside of the game world.

First design of the club meetings (weeks 1-4)

In the first iteration club sessions would start with teacher checking which students are present and would solve possible problems that had come up during the week. After this students were given five minute warning to store their inventories and get ready for the teleport. After the five minutes teacher would freeze students and then teleport them to the learning area. After the teleport teacher told students about the days assignments and possible in-game rewards which were in store for those who would complete the assignments. After this teacher unfroze students and they were free to explore the learning area and complete their assignments. When students were done with the assignments they were free to go back to the island and play freely.

Second design iteration (weeks 5-8)

This second iteration was same as the first one in many ways. New thing which came with this second iteration was the teacher demo which was discussed in the chapter 5.2. After the students were teleported and frozen teacher would demonstrate what kinds of assignments the learning area held. This took five to ten minutes depending on how much the students were listening.

4.2.4 Differences between the design iterations

In this part we are taking closer look at the differences between each iterations. This part will try to explain the reasoning behind the changes and answer the questions " Why were this design changed?" The reasons behind the changes are justified by showing the reasons behind them from the research data which encases gameplay footage and researcher's own observations.

Firstly we will go through the differences between different architectural iterations. In architectural iterations we are focusing our attention towards the changes to features which are present in both iterations for example use of border-block. Next examined will be how the assignments were given to the students. Lastly we shall tackle the club meeting design as a whole.

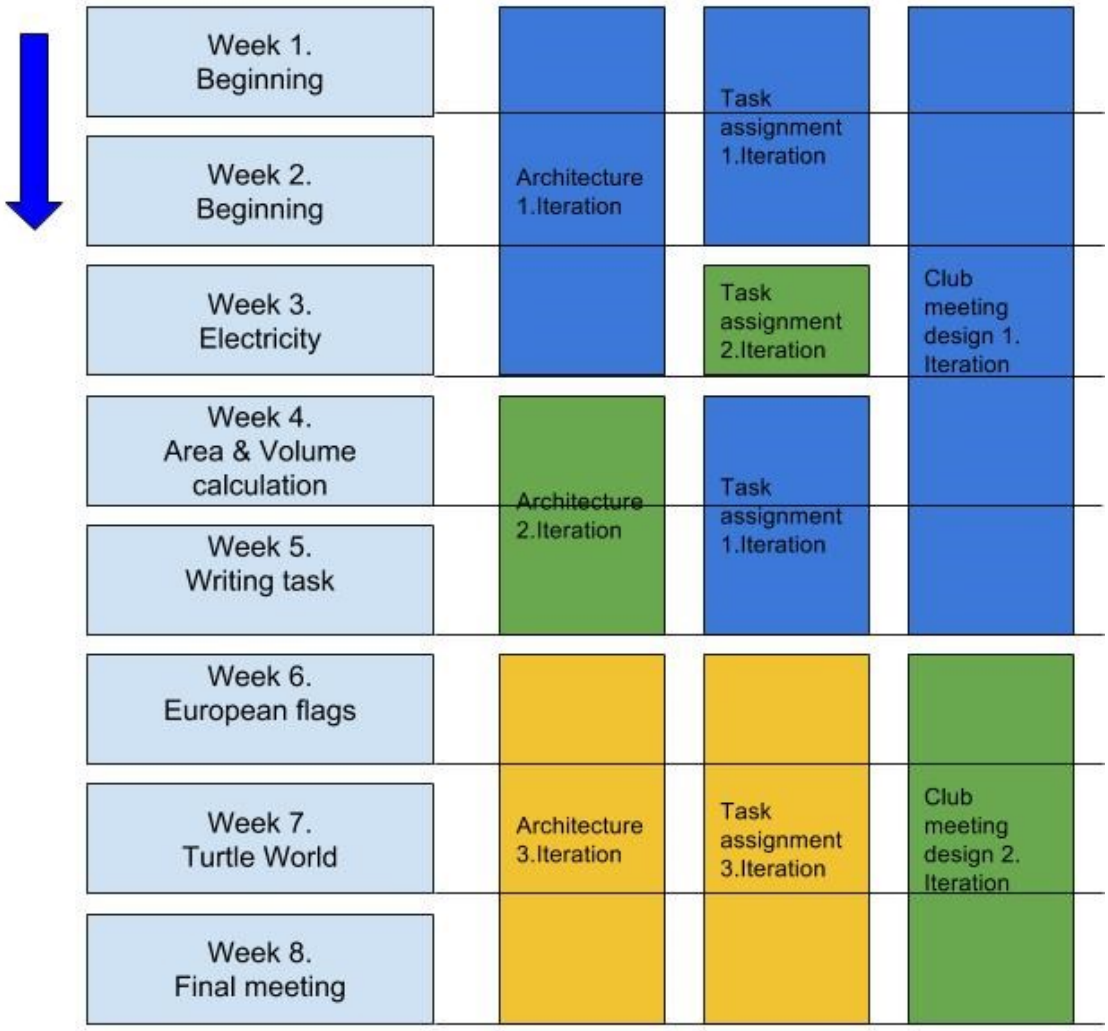

Figure 20. Club design and iterations in effect

Architectural design cycles 1, 2 and 3

In this part we take closer look at the reasons why architectural solutions were changed. Changes were aimed mostly to counter student misbehavior. This kinds of misbehavior was trying to escape from the learning area or to cause harm to other students.

Differences between design iterations 1. And 2.

The change from iteration 1 to iteration 2 happened between third and fourth meetings. Changes were quite notable. Roof was gotten rid of because some of the students were using it while they we trying to escape from the learning area as can be seen from the gameplay footage.

Figure 21. Student moving in restricted zone.

From video can be clearly heard student yelling: ”I am stuck between fence and something!” This "something" is clearly the invisible wall created by border block (Appendix II) and only place where there were fences in this design is the roof.

The roof also gave a lighting problem. It took considerable effort and time to make sure that the learning areas were illuminated properly. So the best way to get rid of these problems was just to get rid of the roof.

On the third club meeting teachers noted a problem that some of the students just ran thought the "show rooms" without a glance what were in them and this led to the problem that they did not know how to use certain in game items to complete the assignments. In the gameplay footage first player arrive at the student's working area at 2:46 after the exercise started and those who examined the show rooms arrive much later at 15:00.

So in the fourth week "show rooms" were changed so they had assignments for the students in them. While they were going through the rooms students needed to complete the assignment if they wanted to receive the reward for the week's assignment.

This change helped with the problem of student just running through the "show rooms". As can be seen from the figure 21. From the week 4. Most of the students are inspecting the examples more carefully and not just giving them a glance and moving on.

Figure 22. Students inspecting examples in the math wing.

Differences between design iterations 2 and 3

Change from the iteration 2 to 3 happened between the weeks 5 and 6 although this would have happened between the week 4 and 5 if the week 5 assignments would have needed a learning area. Second iteration had the same problem of students trying to escape the learning area. In week 4 students build high towers to jump on top of the separating walls and run on top of them trying to escape. (Figure 23.)

Figure 23. Student's building towers to escape.

This led to the change of positioning for the border blocks. (Appendix II) As can be seen from the figure 9. Border blocks were moved directly under the separating walls and as can be seen from the (Figure 24.). Student tries to build a platform to jump on top of the walls

but then notices that it cannot be done and gives up. After giving up on escaping student starts doing the assignments.

Figure 24. Up left corner: Student tries to jump on top of the wall. Up right corner: student gives up. Down: Student doing the assignment.

Task assignment design cycles 1, 2 and 3

In this part we take a look at the task assigning. How the task assigning changed during the club. We will be focusing on what was the most convenient way to assign tasks.

Differences between design iterations 1 and 2

Iteration 1 was very simplistic and it raised few problems. Teachers noticed that students would just ignore the information blocks in game and it seemed that students didn't know that they could check their active assignments by pressing m-key. (Figure 25.)

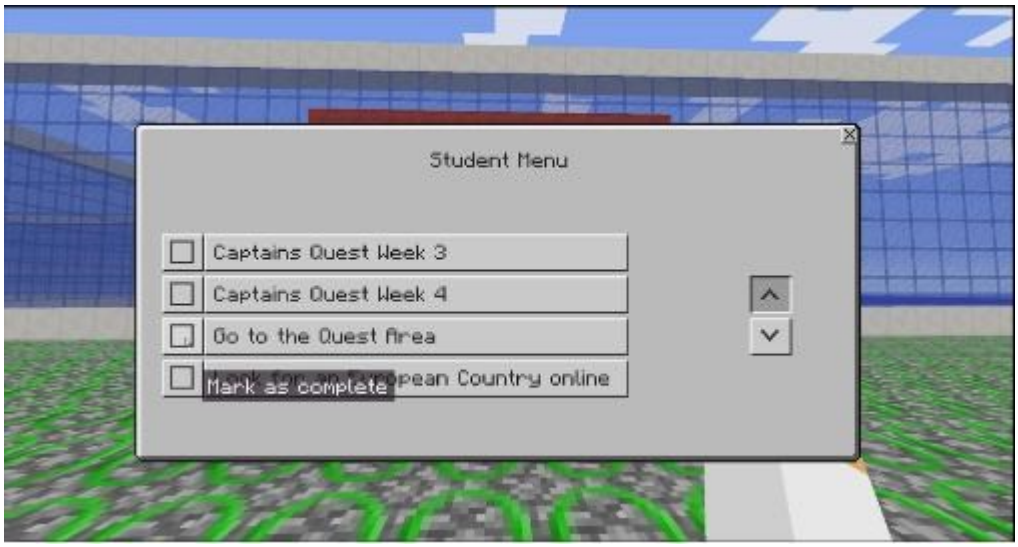

Figure 25. Assignments tool view for students.

To answer this problem teachers experimented with the tutorial blocks so student would not have to klick and read something rather they would stand in one spot and they could both read the theory and watch what was happening in front of them.

Why the change back from design iteration 2 to iteration 1?

Design iteration 2 had a major problem which can be seen from the (Figure 26.) The info text is covering up the assignment textbox and student cannot read what is in the tutorial blocks. When this was noticed change was quickly made back to the design iteration 1.

Figure 26. Tutorial block info blocking assignment textbox.

Differences between design iterations 1 and 3

Same as said before iteration 1. Had problem that students would not know what they were supposed to be doing. The changes was to explain how the learning area worked before students were unleashed upon it. Teachers would use the function: ”Freeze students” and then demo play through the learning area explaining what students needed to do in certain places.

Teachers noticed and it can be seen from the gameplay videos (Figure 27.) that after this change to task assigning students were more focused on their tasks. There were less random wondering around learning area by the students. Students knew where to go to get items they needed, what they needed to do and where to do it.

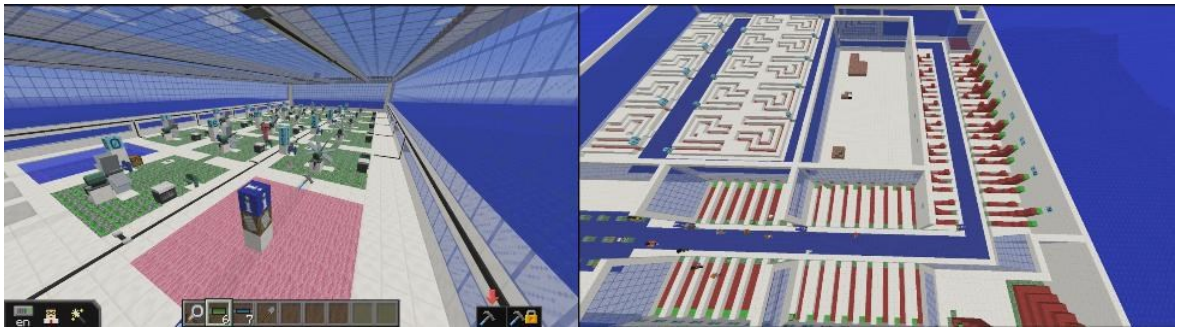

Figure 27. The change: left picture: students have wondered through the whole learning area within 3 minutes. Right picture: Students are in first two rooms even though 8 minutes have passed since session started.

Club meeting design iterations 1 and 2

Change to the club meeting design was made because there was a lot of confusion amongst the students. Students were not sure what they were supposed to be doing in the learning area. Students' assignments were displayed in the assignment display which students could access by pressing the M-key but this was not enough for some students. Because of this teachers decided that they should demonstrate to students what they were supposed to be doing in certain places of the learning areas.

4.3 How to iteratively design learning areas during the Minecraft-club?

Learning areas were designed by using methods described in chapter 2.7. Process of learning area design was a constantly proceeding cycle which goal was to create new theory or correct the existing theory. Theories created here are domain specific instructional theories

as stated by diSessa and Cobb (2009). These theories make it possible to develop and test created theories. According to Edelson (2007) there is no universal models how to make design-based research happen. The following description is how this process was done in this particular study.

Theory creation: at the start of a single learning area's development cycle teachers had the topic of next club meeting. Topic defined what teachers were going to teach. Teachers' now took this information & previous experience and created theory: "how this particular topic could be implemented in the MinecraftEdu world." Previous experience is the existing theory which was created during the previous development cycle.

Implementing the theory: second stage is to implement this theory into the MinecraftEdu world. Teachers went into the game world and built the learning area following their theory. Developing of the theory wouldn't stop during this building time. Teachers were constantly changing ideas amongst themselves and developed the existing theory while they were building the learning area.

Empirical test: third stage of the development was the empirical test, the club meeting. Here was the place where students would test how well teachers had built and developed this particular learning area. Here teachers took notes: "What went wrong? What worked? What should be changed? What should be deleted from the design? "And gameplay footage while students were playing.

Evaluating theory: forth stage of the development was after the club meeting. Teachers would have a reflective conversation about the club meeting and the learning area. What kind of problems did students run into? Were there problems that teachers noticed? What can be done to these problems?

Creation of new theory or assimilation of new information to existing theory: This is the fifth and final stage of development. Here we took the new information and results of the evaluation which we had acquired during and after the club meeting and either created brand new theory on learning area design or we assimilated new information to our existing theory. After this stage was completed a new development cycle would start and the next learning area design would be based on the theory which was created during the last development cycle.

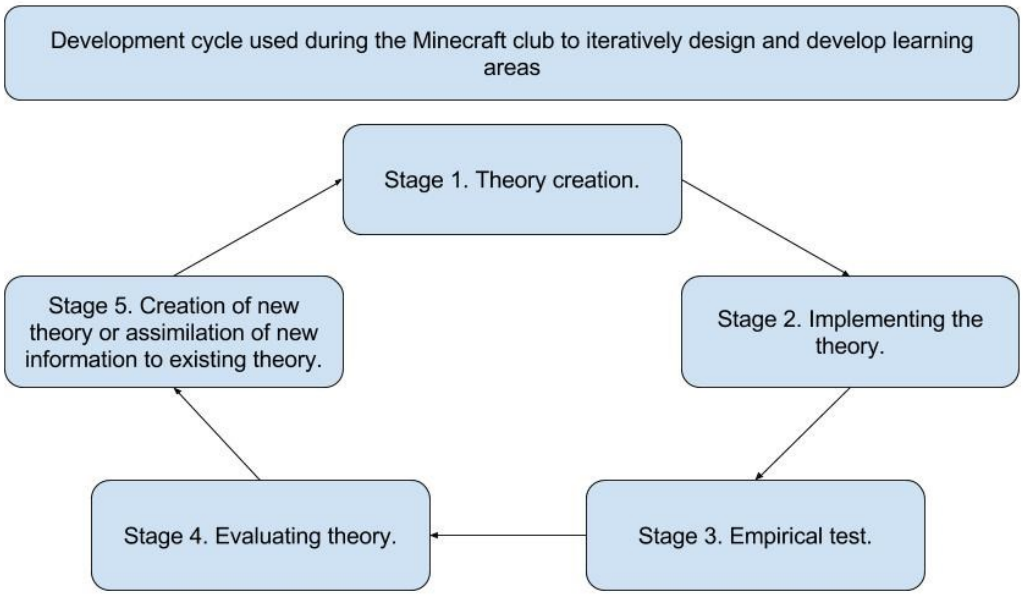

Figure 28. Development cycle

5 Discussion and conclusions

This research to me was very interesting endeavor. I am a video game enthusiast and I firmly believe that video games can be used to do good things in our schools. Something meant for entertainment can be used to teach and even make the students want to learn.

At the start of the research three research questions were laid out.

- How to iteratively design learning areas during the Minecraft club?
- How did the design of the learning areas change during the Minecraft club?
- Were there change in test performance at the end of the club compared to start of the club?

How to iteratively design learning areas during the Minecraft club? Was one of the questions which this study set out to find answers to. The development model which we created during this study is very reminiscent of the DBR methods. Our development cycle goes through theoretical part and empirical part in cycles. When one cycle ends then next one uses previous one's results as a base which to build on. See figure 48. (Edelson, 2007)

Looking back to the changes which were made to these learning areas a trend can be detected. Most of the improvements were aimed to counteract student behavior. It was very hard to design areas so perfectly that students wouldn't find a way to misbehave. It was rather interesting to notice that such a small change as moving border block by one would result in students not even trying to escape. (Chapter 5.2.1.) Learning area design or level design as it would be called in game design terms is very complex process. Slight changes may fix all problems you are having or they might spell out doom for your design. The most impressive result which this study yielded is the last learning area: "the turtle world" (See chapter 5.2.1). It is the result of 6 development cycles and tens of hours of work. This learning area is crystalized result of all the development which took place during the Minecraft club.

Although we noticed that students did better in the post conceptual test (table 6.) than in the pre conceptual test average improvement to test score was 76,5 %. Even when we have this piece of data not much can be said is this a good method of teaching. It worked for this group of students but it cannot be said that this would work with every group of students. But we can say that it is possible to teach topics which are in the curriculum it can be done. Results may wary.

If I were to start this research again I would change few aspects of the club design. I would consider to taking wider pool of students in the club. More players and greater age differences. Next time I would capture game footage from the youngest and the oldest club participant and compare their gameplay and their achievements.

We were able to create an working example of a club that uses MinecraftEDU as a teaching tool it took time and effort but now we have what we started out towards. This study provides an example how video games can be used in teaching context. This example is far from perfect sample but it provides results from 6 cycles of development. This study can be used as a small stepping stone for the upcoming studies. Even though this goal was achieved there is still need for research in this field. The use of video games as a teaching tool is starting to rise to the consciousness of teachers. More concrete examples are needed to show what the video games are capable of.

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7 Appendix

7.1 APPENDIX I: Minecraft blocks

When we talk about normal blocks we mean blocks that are also in the normal Minecraft-game. These blocks on their own don't have any unusual properties. These blocks were picked for the aesthetic.

Block of quarts

White stone block in the game. Were pleasant to look at. It has the same properties that any other block in the game. This block was selected only because it looked nice.

Block of wool

Block that comes in many colours and is fast to destroy and pick up. This block was usually selected for building material for the students for those reasons.

Block of glass

Same kind of properties than other blocks in the game but breaks easily. This block comes in many colours and we picked it just for the aesthetics.

Redstone

Redstone is Minecraft's take on electricity. With Redstone player can power up certain machines and lights. Redstone dust works as electrical wire it conducts Redstone power thought it. Very simplistic take on electricity.

7.2 APPENDIX II: MinecraftEDU blocks

These blocks are only available in the MinecraftEDU version of the game. These blocks have interesting properties and are extremely useful for the teacher.

Info-block

This block is used to write down information for others to read. On these blocks teacher can display information of tasks and theories of the topics. In our learning environments we used these blocks to inform the students what to do in certain areas.

Boarder-block

This block doesn't allow students to move under or over it. Students also can't break these blocks. But this block doesn't effect turtles. In our learning environments these blocks were used to keep students where we wanted them to be.

Build disallow-block

This certain block is what it sounds like. Students cannot build or break blocks on these build disallow-blocks. In our learning environments we used these blocks to make sure that students don’t destroy blocks that we don’t want them to destroy.

Build allow-block

These blocks are opposite of build disallow-block. On these blocks students can build and they also can destroy blocks that are on the build disallow-blocks. With these blocks we marked the building are for students. These were usually places where students completed their assignments.

Spawn-block

This is a block where everybody spawn when they enter the world. With this block you can determine where players start. In this club spawn-block was placed on the ship. This made it easier for the students to get immersed on the frame story about pirates.

Teleporter-block

With this block players can teleport from one teleporter-block to another. Its use is really strait forward. You place teleporter-block and name it. After that you place another teleporter-block and now you can have connection between these two. Teacher can also determine which teleporter-blocks students can teleport to.

Turtle build disallow-block

This block is a same thing as the build disallow-block it just effects little robots called turtle. On these blocks turtles cannot place blocks or destroy them. These blocks were used when we were

creating learning environment for programming. These were used just to make sure of that students don’t break walls or quest area.

Turtle boarder-block

This block is same as the boarder block although it only effects turtles. Turtles cannot go over or under these blocks. These blocks were used to keep student's turtles in the working area.

Tutorial-block

This block is electrical age-mod only. This meaning that you can only use it if your server is using this mod. With this block teacher can get information to the student. By standing on this block student will get text the upper left corner of the monitor. This allows information to be available while student is observing electrical devices.

7.3 APPENDIX III: Science center

First room: Basic circuit and cables

In this room students receive information how to move through this wing of the science centre. They also were assigned with the quests they were supposed to do during they stay in this learning area.

Here the words electricity, voltage, resistance and current are brought up first time. In this room students receive: Allmeter and magnifying glass. With Allmeter student can check all the properties of certain electrical device and with magnifying glass student can point at a block and gets it information.

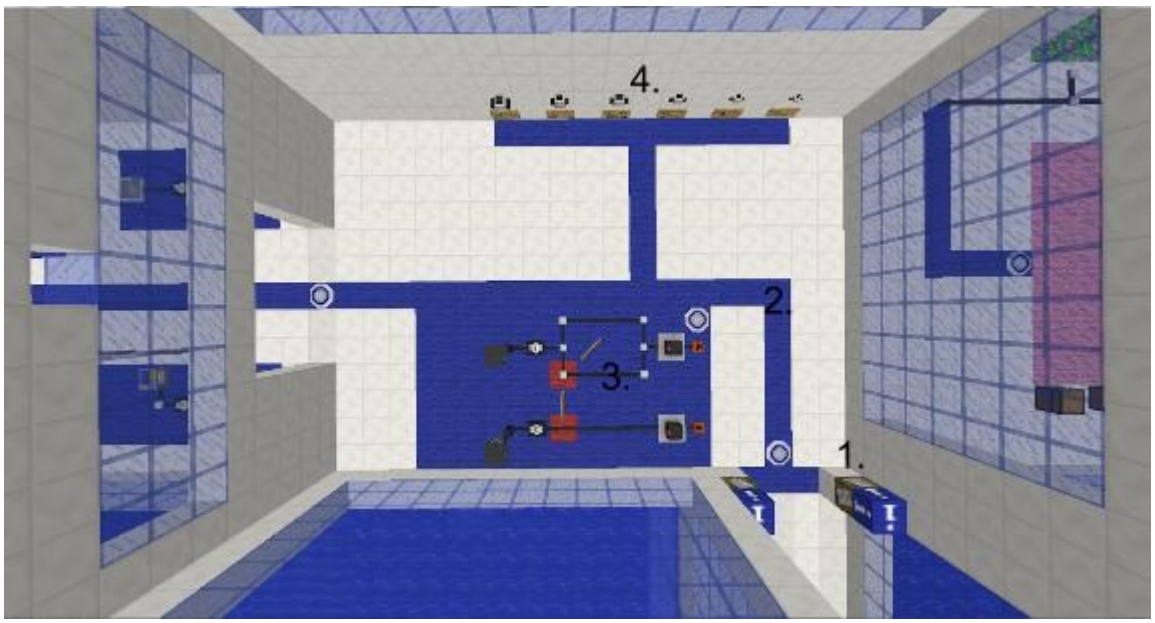

Figure 29. First room of the electrical wing.

Info-blocks: these info-blocks contained information how students should proceed through the science centre.
Route through the centre
Electricity example: here students could observe how basic circuit works and what difference it makes when you use one or two cables.
Wall of cables: here students could see all the cables that are available to them.

Second room: Couplings series and parallel

In this room student gets more examples about the basic circuit and can observe the different ways this circuit can be build. They can see the difference between batteries that are in series and that are parallel to each other.

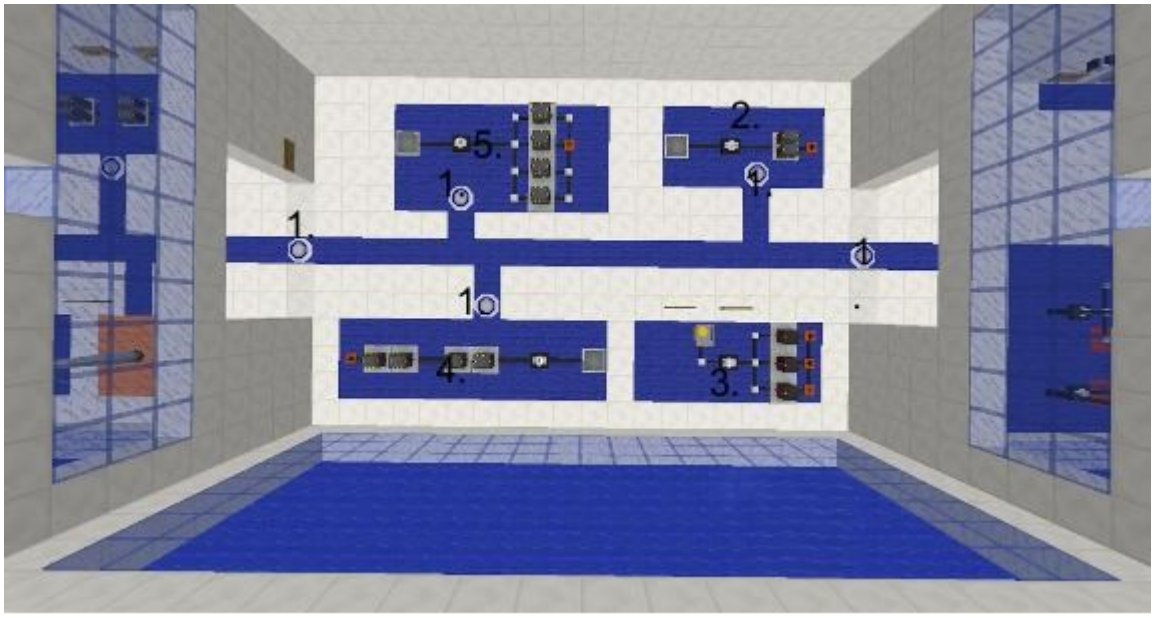

Figure 30. Second room of the electrical wing

1. **Tutorial-block:** While student is standing on this student will get information about this room.
2. **Basic circuit:** Here is a demonstration of how to build basic circuit with battery.
3. **Egg-boiler:** Here we have egg-boiler. Just a fun thing that is in the game
4. **Series-coupling:** here is coupling that has batteries in series.
5. **Parallel-coupling:** here is coupling that has batteries in parallel to each other.

Third room: Power sources

Figure 31. Third room of the electrical wing

1. **Tutorial block:** while standing on this student will get information about the room.
2. **Battery collection:** here are all the batteries that are available for students in the game.
3. **Power sources:** Here are all the different kinds of power sources that are in the game.

Fourth room: Signals

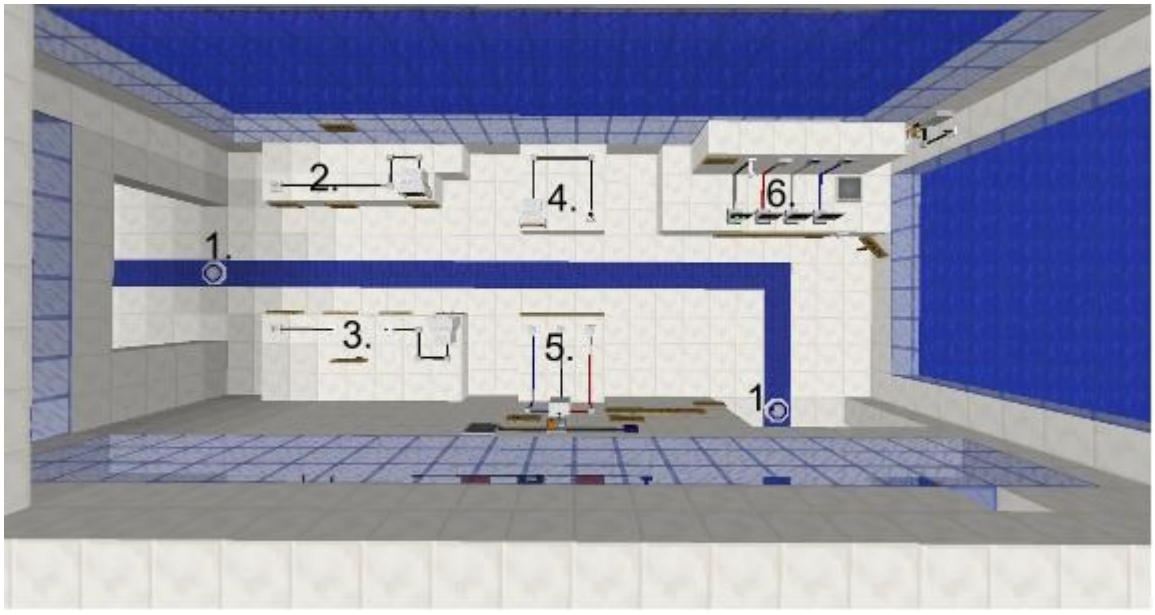

Figure 32. Forth room of the electrical wing

1. **Tutorial block:** while standing on this student will get information about the room.
2. **Wired signal:** Here is example about signals. This one uses signal cable to transmit the signal.
3. **Wireless signal:** Here we have signal being transmitted through the air wirelessly.

4. **Adjustable signal:** here is an example about signal transmitter that can adjust the power of the signal
5. **Multiple signals:** Here is an example about multiple signals. 3 buttons sends out one signal each. These signals connect with signal box and when this box receives all three signals the lamp will light.
6. **Sensor wall:** Here is an example wall which has all the sensors. These sensors can detect variable things. Wind speed, light level, rain, thunder.

Fifth room: Voltage convertors

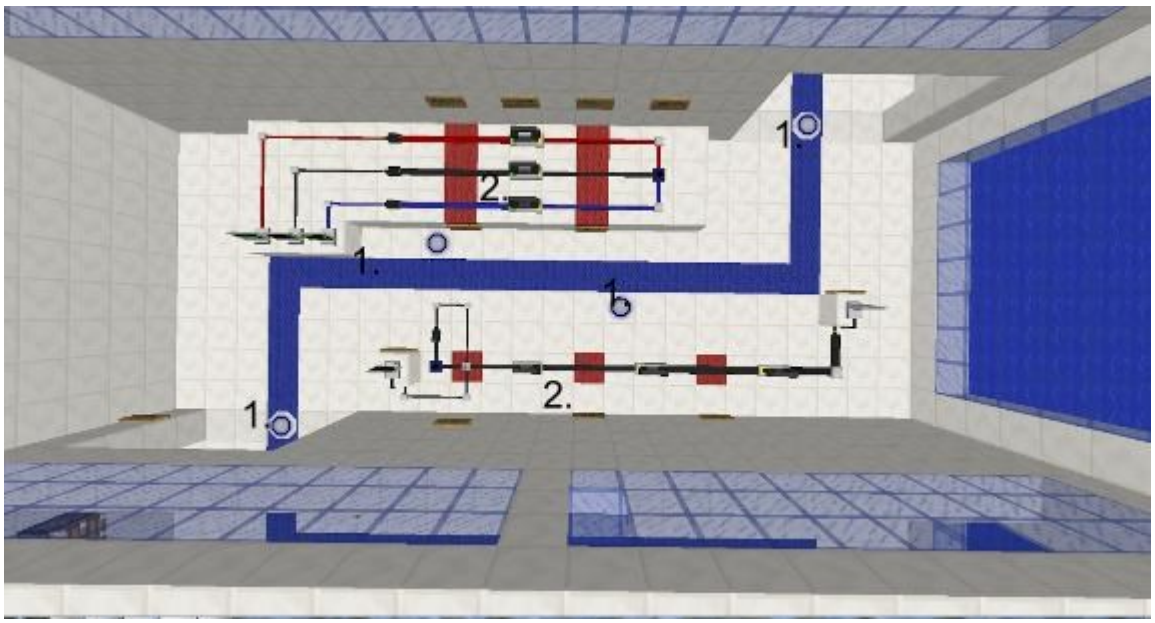

Figure 33. Fifth room of the electrical wing

1. **Three voltage convertors:** Here student can observe how voltage convertors effect voltage on the cable
2. **Voltage convertor example:** Here is an example how voltage can be manipulated with convertors

Sixth room: Fun Redstone applications

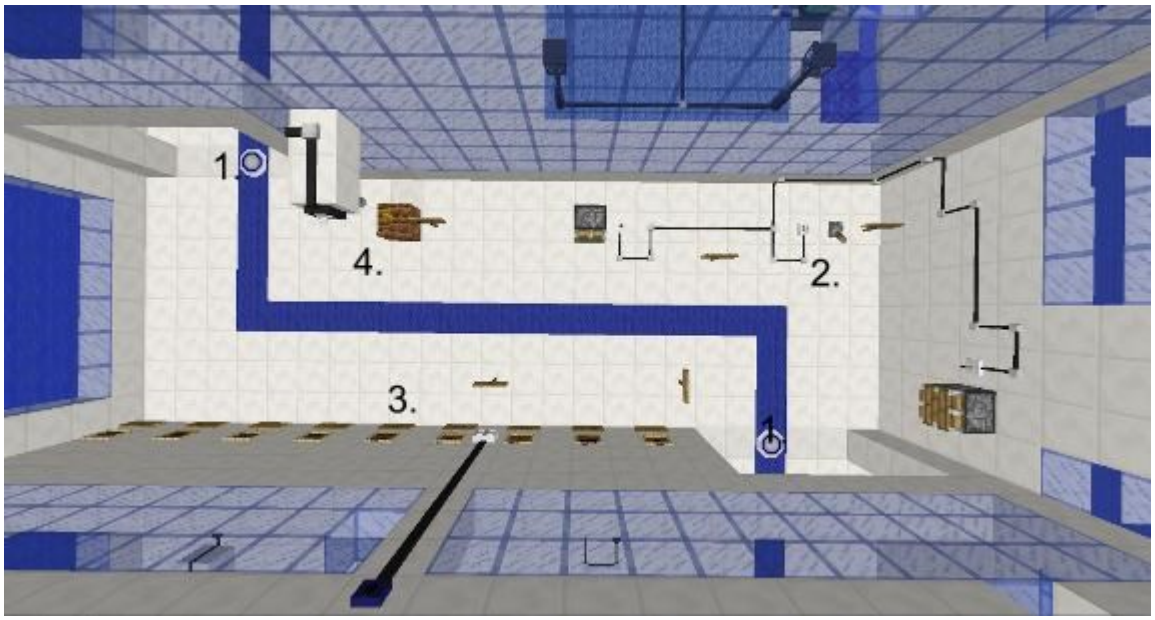

Figure 34. Sixth room of the electrical wing

1. **Tutorial block:** while standing on this student will get information about the room.
2. **Piston system:** When student uses the lever pistons activate. These can be used for traps
3. **Wall of items:** On this wall there are pictures of all the items students can craft with Electricalage mod.
4. **Crowing example:** Here students can observe that the light from the lamps is enough to crow crops.

Seventh room: Power sources review and battery charging

Figure 35. Seventh room of the electrical wing

1. **Water turbine:** Here is the water power is demonstrated for the student
2. **Heat turbine:** Here the use of heat as a power source is demonstrated

3. **Solar panels:** Here student can learn how to use solar panels
4. **Wind turbines:** Here student can learn how to set up his/her own wind turbine
5. **Experimental teleporting device:** this device is here to showcase what kind of things students can build.
6. **Automatic drilling machine:** This device is here to show students that it exist

Eight room: Solar power house

This house was built to show an example how you could power you entire house with solar panels and rechargeable batteries. Student can walk in and observe how the house was build and after the lecture apply this knowledge to his/her own house.

Figure 36. Living room of the solar power house.

In this room we can see the crafting applications for the solar power. This is just a one example how you can build your house.

Figure 37. Basement of the solar power house.

This room houses the batteries and signal hubs.

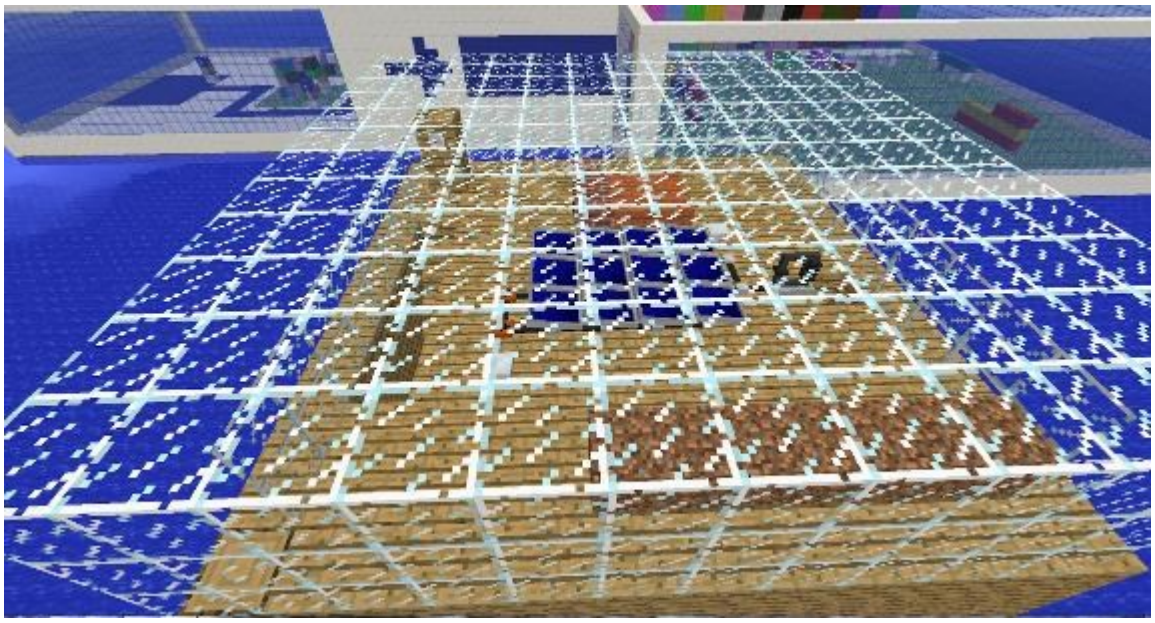

Figure 38. Roof of the solar power house.

On the roof house has solar panels and voltage transformer. This way the low voltage produced by solar panels can be amplified.

Ninth room (on the roof): Wind power

Figure 39. Ninth room of the electrical wing

1. **Wind turbines:** These wind turbines produce electricity which can be used to power the lamps
2. **Switch:** Student can turn on the lights
3. Lamp
4. **Wind sensor:** Measures the wind speed and sends the data to the display
5. **Display:** from here student can observe how fast the wind is blowing

7.4 APPENDIX IV. Math wing of the science center

Disclaimer during our club we used different kind of design of the learning area than we have now on our server. This was due to server crashing and corrupting our saved world. Figures that you see here now are taken from the similar design that we had but there are some minor changes. Places of the boarder-blocks are different and boarder-blocks are used more in this new design.

First room: Area theory and teacher created tasks

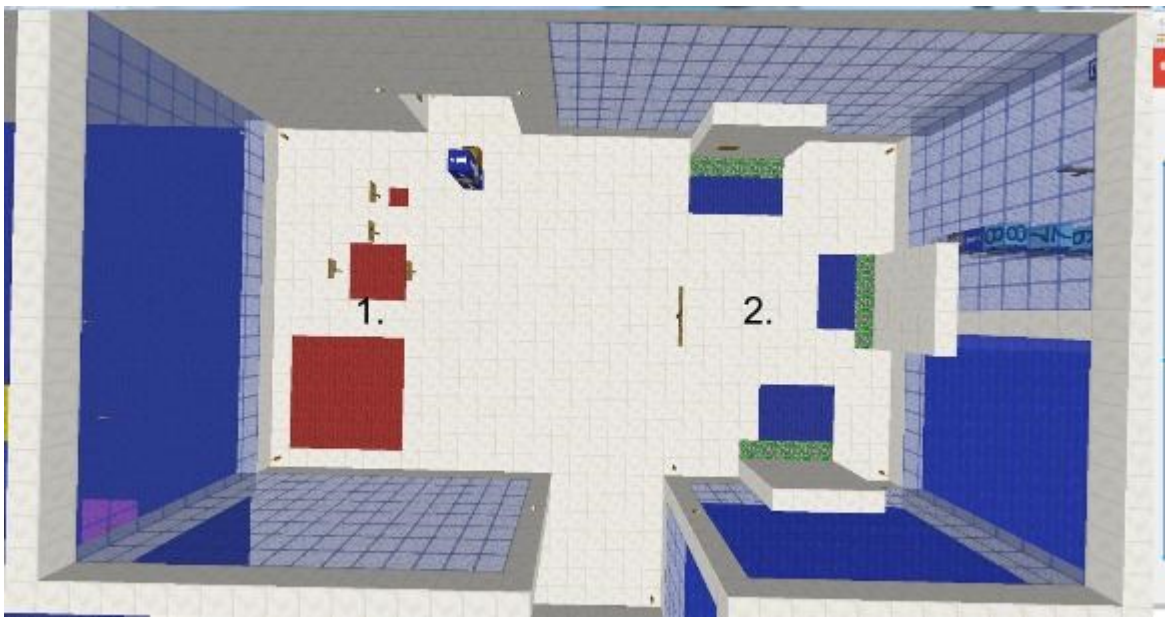

Figure 40. First room of the math wing.

Within this room is theory part of area calculation and teacher created tasks. Here students are reminded about area. What it is and how is calculated.

Area calculation examples: Here students can observe the examples provided by the teacher.

Teacher created tasks: Here students need to calculate area of the blue squares and place sign on the wall with their answer on it.

Second room: Student working area

Figure 41. Second room of the math wing

Here students practice area calculation by building shapes and then calculating area of the shape. This whole room is covered with build allow blocks so students can work where they want teacher has also provided example for the students.

Third room: Volume calculation theory and teacher created tasks

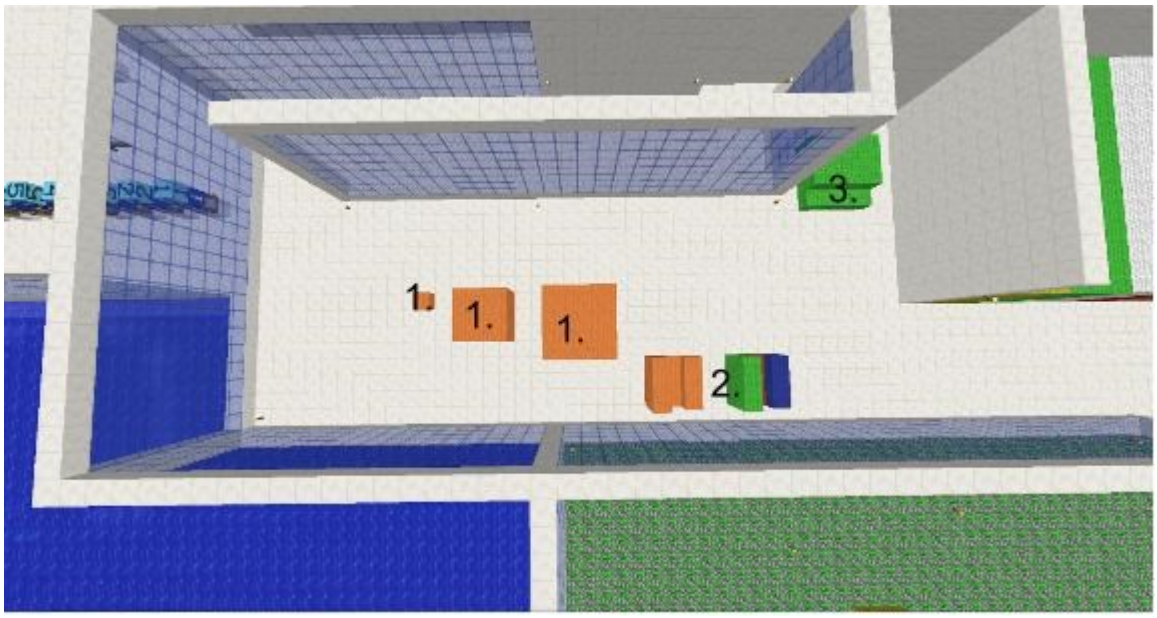

Figure 42. Third room of the math wing

This room is much like the first room in this learning area. When student enters the room first what he/she sees is the teachers examples (1.) how the volume is calculat-

ed. The theory of this calculation (2.) is also demonstrated in this room. There is also teacher created objects (3.) which volume students need to calculate.

Forth room: Student working area

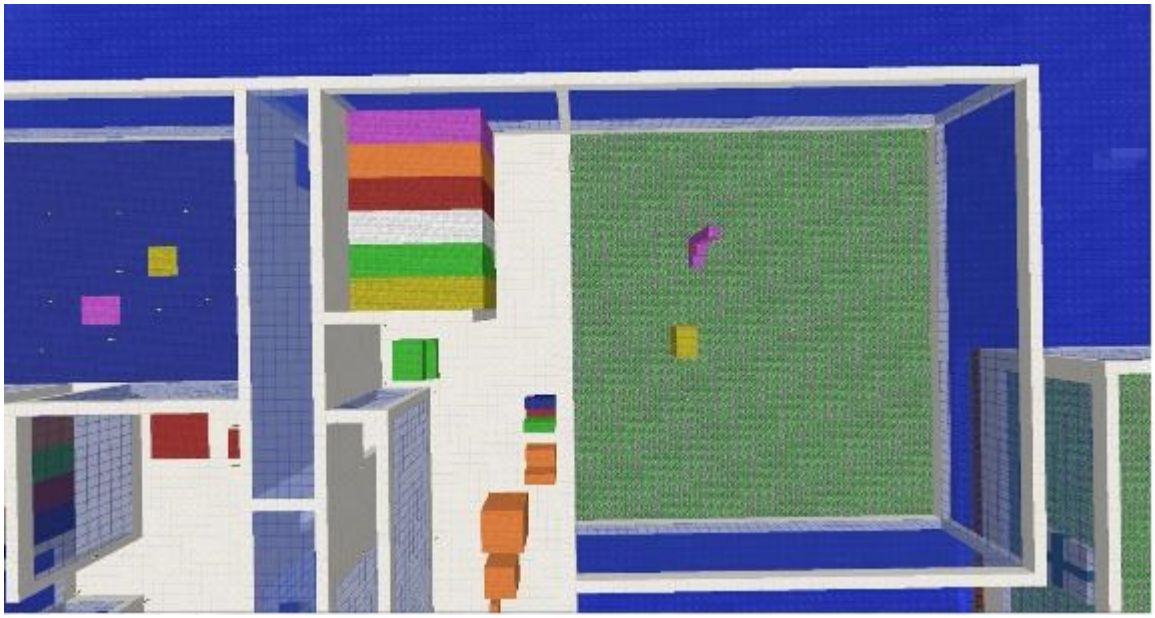

Figure 43. Forth room of the math wing

This room works in same principals as the second room. Here students can freely practice the volume calculation by building different kinds of shapes and then calculating its volume.

7.5 APPENDIX V. Design of the programming wing of the science center

Following pictures are going to explain in more detail how the learning area was build. Following is a recreation of the building

Step one: Defining the borders.

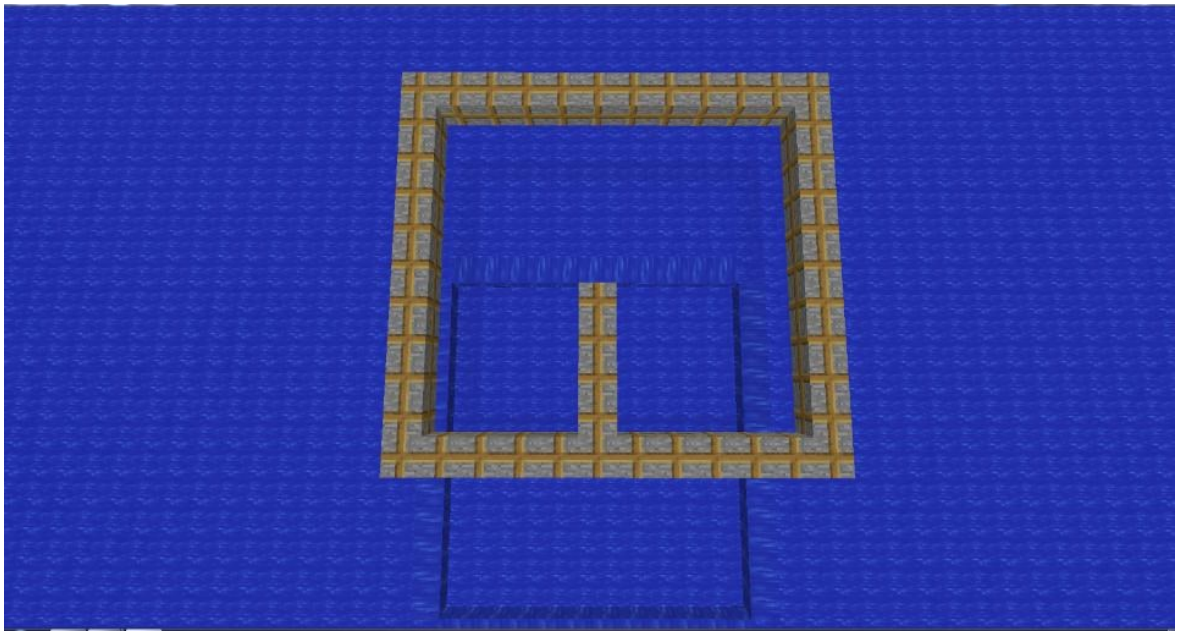

Figure 44. Border block placements for the third architectural iteration.

First step when building this learning area is defining its borders with border-blocks. (Appendix 2.) In this face teacher also decides how the area is divided in rooms.

Step two: Borders for turtles

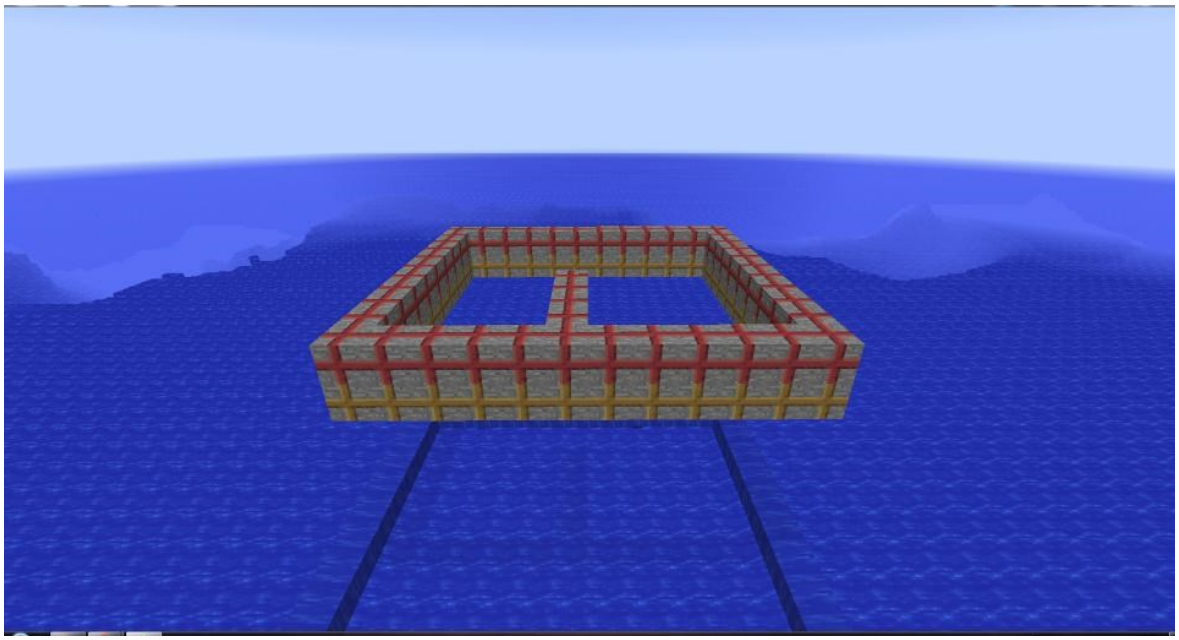

Figure 45. Turtle border block placements for the third architectural iteration.

Following the borders set with normal border blocks the turtle border blocks (Appendix 2.) are laid in place. This makes sure that students cannot lose their turtles behind border blocks because their turtles cannot move through turtle border blocks.

Step Three and four: Build disallow blocks both normal and for turtles

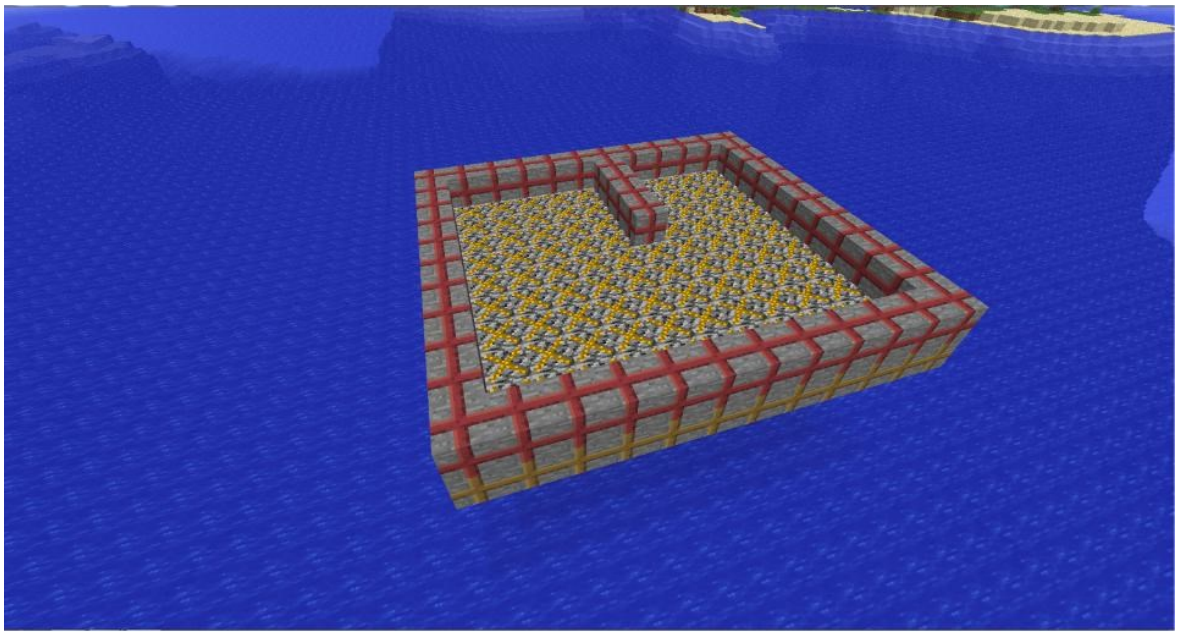

Figure 46. Turtle build disallow block placement

Layer of turtle build disallow blocks. (Appendix 2.) This makes sure that students cannot build or destroy blocks with their turtles where they aren't supposed to.

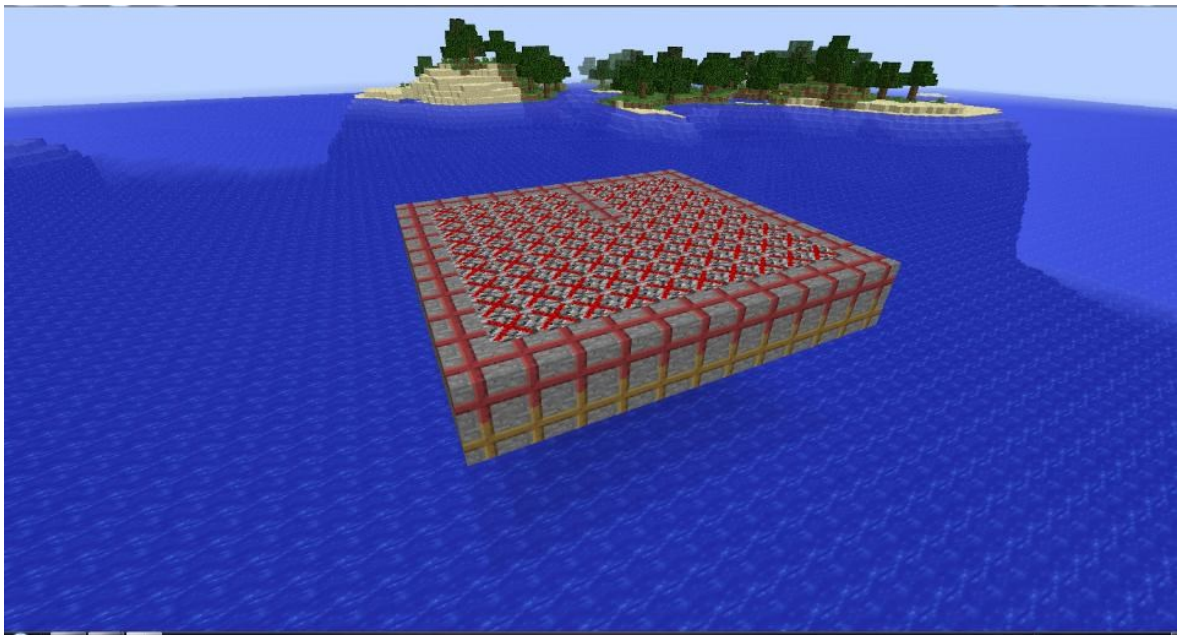

Figure 47. Build disallow block placements

Next layer is with the normal build disallow blocks. (Appendix 2.) This is normal for all the learning area to make sure that students don’t destroy blocks they aren't supposed.

Step fife: aesthetic layer

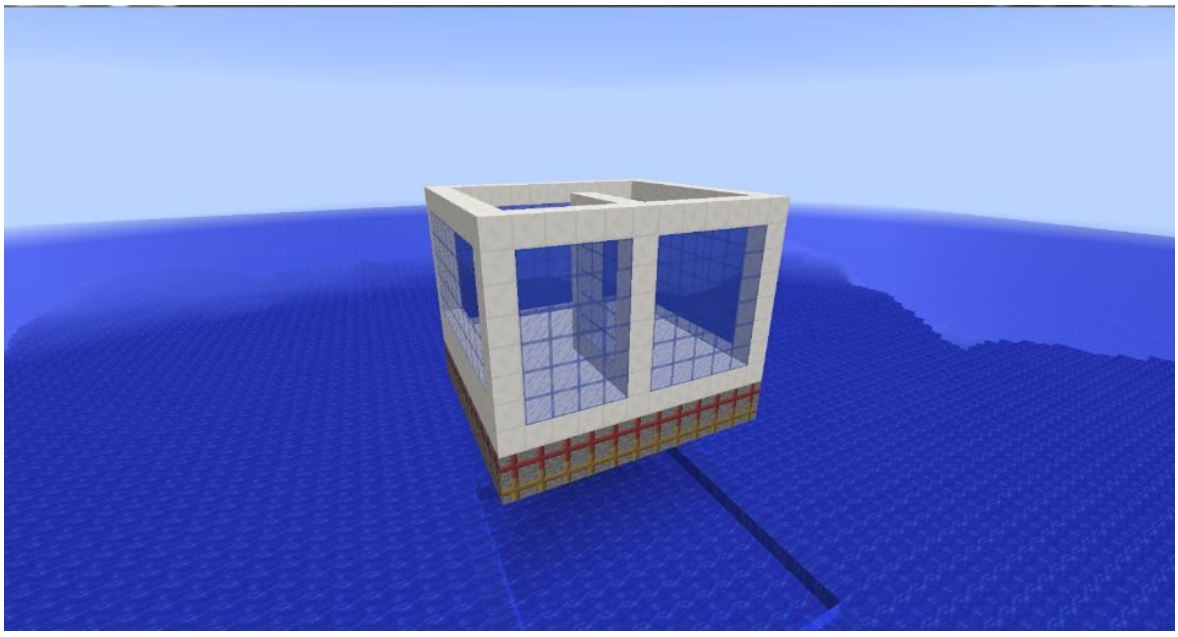

Figure 48. Aesthetic layer

The surface layer is build last. This layer is made out of quarts blocks and blue stained glass blocks. (Appendix 1.)

Figure 49. Cross-section of the third architectural iteration.

This is how the blocks are layered in this building. Last week's build is not considered as a new iteration because it's basically the same design as in the week four but it has blocks which were not used in any other build.