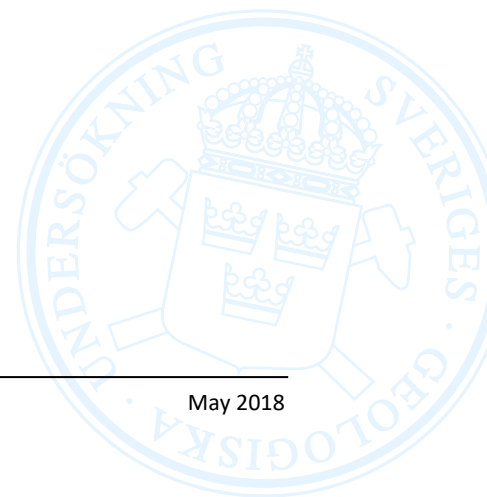


Experience report for BetterGeoEdu

Teaching about raw materials using computer games

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FOREWORD

The Geological Survey of Sweden is an expert agency for issues related to bedrock, soil and groundwater. One of its important tasks is to bring geology and geological knowledge to the fore in social debate and in schools. The BetterGeoEdu project aimed to raise the knowledge about geology and raw materials for children, and help schools integrate innovative exercises in their education with the tool BetterGeo, developed by SGU based on the popular game Minecraft. BetterGeoEdu was funded by the EIT Raw Materials KIC, a body of the European Union, and involved four European partners: The Geological Survey of Sweden (coordinator), The University of Limerick, The Geological Survey of Slovenia and The Finnish Safety and Chemicals Agency (Tukes). SGU wants to thank all the partners and EIT for making the project possible.

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SAMMANFATTNING

EUs befolkning ökar och många medlemsländer har en växande ekonomi där en stigande andel av befolkningen tillhör medelklassen. När levnadsstandarden ökar blir även konsumtionen av varor och tjänster större, och därmed även behovet av naturresurser som ballast, mineral och metaller. Dagens och framtidens samhällen ställs inför utmaningar kring utvinning, återvinning och hållbar användning av mineral och metaller.

Inom EU kommer arbetskraft att behövas inom industri, offentlig sektor, akademi och forskning för att tillgodose det ökade behovet av ballast, mineral och metaller. För att trygga denna arbetskraft är det viktigt att elever blir mer medvetna om frågeställningar relaterade till mineralutvinning, hållbarhet och återvinning. Ett tidigt intresse för geologi kan också påverka eleverna att välja karriärvägar inom dessa sektorer.

BetterGeoEdu-projektet finansierades av EIT Raw Materials, ett organ inom EU. Projektet syftade till att utveckla och testa pedagogiskt material för BetterGeo – Sveriges geologiska undersöknings modifikation till spelet Minecraft – samt att utveckla och utföra en lärarworkshop. Målet var att tillhandahålla ett interaktivt verktyg för lärare att använda i sin undervisning om naturresurser. Lektions- och lärarinstruktioner, tillhörande material, installationsguide och mer information finns tillgängligt på fyra språk (svenska, engelska, finska och slovenska) via www.bettergeoedu.com.

Reaktioner från både elever som testat lektionen samt lärare som varit med i lärarworkshop har varit positiva. Pilotprojektet har varit lyckat, men ytterligare insatser behövs för att sprida materialet samt för att skapa mer material. Det finns också behov av att tillhandahålla ytterligare lärarworkshoppar för att skapa bättre trygghet hos lärare att använda materialet, och för att hjälpa lärare att ta fram eget material.

ABSTRACT

The population of the EU is increasing and many member countries have a growing economy in which an increasing proportion of the population belongs to the middle class. As the standard of living increases, so does consumption of goods and services, and thus also the demand for raw materials such as aggregates, minerals and metals. The societies of today and tomorrow face challenges regarding raw material extraction, sustainability and recycling.

Within the EU, labor will be needed in industry, public sector, academy and research, to meet the increased demand for aggregates, minerals and metals. To safeguard this workforce, it is important that students become more aware of issues related to raw material extraction, sustainability and recycling. An early interest in geology may also influence students to choose career paths within the sectors.

The BetterGeoEdu project was funded by EIT Raw Materials, a body within EU. The project aimed to develop and test educational materials for BetterGeo – the Geological Survey of Sweden's Minecraft modification – as well as develop and perform a teacher workshop. The goal was to provide an interactive tool for teachers to use in their education about raw materials.

BACKGROUND

With a growing population and an emerging middle class the need for raw materials is increasing in the member states of the EU. Infrastructure projects that require a large amount of aggregates and metals are expected to increase due to increasing populations in urban areas. In Sweden alone, the National Board of Housing, Building and Planning estimate that approximately 70 000 new accommodations per year until 2025, needs to be built to meet the demand for housing. To do this, production of aggregates in Sweden need to increase by about 50 per cent. Metals are also needed for infrastructure, as well as in modern technology such as computers, smartphones, trains and green technology such as wind mills, solar panels and their batteries. Aggregates, minerals and metals are raw materials that derive from and are constrained by geology

The Geological Survey of Sweden, SGU, is the governmental agency responsible for issues related to bedrock, soil and groundwater in Sweden. 2014–2016 SGU led a project within the national Mineral Strategy: “Increasing the public knowledge about geology and its importance in society”. One subproject concerned gamification and reaching out to younger people, and indirectly their families. A modification (or “mod” in short) was developed for the popular game Minecraft, a game which has sold over 100 million copies worldwide. The game revolves around surviving in an open 3D world, collecting raw materials such as wood, rocks and metals to build houses, tools and weapons, to defend against monsters. Mining for raw materials such as metals and diamonds is a big part of the game; however, the game has a severely simplified geology. Gold, diamonds and iron can all be found in the same grey rock called “stone”, whereas in reality hundreds of different rocks, minerals and ores host different raw materials. The mod developed by SGU, BetterGeo, changes this, adding multiple new rock types, ores, minerals, metals, gemstones and fossils to Minecraft along with realistic placements for them in the world. BetterGeo also adds more realistic ways to extract the metals from the minerals and rocks, along with even more new



Figure 1. One of the most fundamental differences with BetterGeo is that the mod adds realistic rocks, ore deposits and stratigraphy in Minecraft. Screenshot from Minecraft with BetterGeo.

features such as environmental impacts, weathering of certain rocks, new soil types and alloys. New items can also be crafted from the new materials, such as prospecting tools, jet packs and defibrillators.

By playing BetterGeo, one learns about geology and raw materials, how they interact and their importance in everyday life. The mod also gives the game more features, making it more fun to play. With BetterGeo, Minecraft players are introduced to a more versified geological vocabulary. The mod presents raw materials in a more accurate geological setting, which makes extraction more challenging and prompts the player to address issues related to raw material extraction, sustainability and recycling. During the latter part of 2016, the mod was expanded with new features revolving around education and teaching geology. By finding new rocks, minerals, metals or soils, the player receives in-game books which give more information about the item, its geology and where it can be found. The update also introduced a new *achievement system*, which allows the player to see their progress in the game. For example, when finding a new rock the player would get an *achievement* for it, and one more when extracting metals from a mineral in the rock. Achievements could also be given for making use of the metals when constructing, for example, an electronic conductivity meter (a new item in the game), and then using it to find more raw materials in the ground. This gives the player a sense of progression, which could also be used in teaching. The student can for example be given the task to complete a certain set of achievements and then explain the chain from rock to finished product.

BetterGeo was released as a free download late 2015 and received an update during 2016 called version 2.0. BetterGeo was originally made as a game to be played at home, but during the development of the mod SGU was contacted by teachers who had questions about how they could implement the mod in their lessons. With the aim to help teachers use BetterGeo to teach about geology and raw materials in classrooms SGU received funding from EIT RawMaterials for the project called BetterGeoEdu in 2017.

WIDER SOCIETY LEARNING

As the need for raw materials is increasing, so does the need for expertise and knowledge about raw materials, geology and the chain from extraction to end-product. Within the EU, the mining and aggregate sectors are however sometimes having difficulties finding staff, and are challenged by large retirement numbers. Young adults also often show a low interest for working with raw material and related career paths, and the public awareness for raw materials and metal producing industry is generally low in the EU, as shown by the EU in EUs Raw Materials Initiative. Public knowledge about raw materials is also low in Sweden, one of the leading mining countries in the EU. Sweden has for example not implemented geology in primary schools. The mining and aggregate sectors need to secure workforce to meet the demands for raw material in the future. To do this, the publics knowledge about raw materials need to be raised.

Gamification is the application of games, game-mechanics and game-design elements in non-game contexts. Gamification is often used in social media, in advertisement, by corporations as well as in education. Many young people's spare time is spent on gaming. The idea of using the enthusiasm and desire to play games as a complement to education has been around for many years, working with the theory that education which is fun and interactive stimulates learning.

BetterGeo puts the game in the first place, learning is a bonus. If the mod is fun, it fuels the drive to play and learn more. The aim is to raise the interest and awareness for geology and raw materials, at the same time as making the knowledge more accessible and interesting for a younger crowd. The mod provides shortcuts to learning about the complex subjects of geology and issues concerning raw materials, which often require field visits which are not always accessible to all.

By working with an existing platform which is already known by millions of people, Minecraft, the learning curve can be lowered and build on an existing interest in the game. Minecraft has a large target group with people in all ages however, the largest player base is children in primary school.

PROJECT AIM, DESCRIPTION AND OUTCOME

BetterGeoEdu was a pilot project that aimed to help teachers use BetterGeo in the classroom to teach about geology and raw materials. The project had five primary goals:

1. Create educational material for primary schools based on BetterGeo
2. Hold four test lectures in two different countries
3. Develop and hold a one-day workshop for primary school teachers in Sweden
4. Translate the mod and the material to four languages
5. Spread the material through the channels of the EIT RawMaterials consortium and build a website

Educational material

The educational material focuses on teaching about raw materials and their importance in everyday life, from extraction to end-product. The game functions as a complement to practical studies. The material is aimed to be user-friendly, easily accessible and relevant for the all the different partner countries.

One complete exercise was developed within the pilot project. The exercise focuses on rocks and mineral and teaches students how to identify them. The first half is based in the game, where the students get to find, name and sketch different rocks along with testing properties such as hardness. The second half is done without computers, with students looking at real rocks and trying to identify them based on the knowledge they gained in the game. The rocks are then looked at in plenum with a group discussion about how they are used in modern technology and all-day items. The exercise is targeted towards children in ages 8–11. The exercise is explained step-by-step on the website, and comes with a complete guide on what material is needed, target group, difficulty and time consumption.

Test lessons

The exercise was tested in both Sweden and Ireland a total of three times. There were two tests in Ireland and one in Sweden. The test in Sweden was supposed to be with two separate groups, but was later combined to one big group due to difficulties in finding time for two groups. The number of people in the test were however the same.

The test lecture in Sweden was held in cooperation with Biotopia, a local museum and activity centre in Uppsala. Biotopia provided the locale, equipment and invited a class while SGU and Biotopia together held the test lecture. The class from second grade was from a local school, around eight years old. The class was bigger than ideal, but was successful with minor adjustments to the exercise. The children were also a bit younger than originally thought, but proved to be no problem as they handled the exercise with ease. The exercise was successful and both students and teachers gave the test high scores during a group discussion after the test. Generally the students thought the exercise was fun, challenging and something they would like to do again. They had never had a similar exercise before.

The test lectures in Ireland was held in cooperation with the University of Limerick. A class of 10–12 year olds was invited to a science day where their morning class was split into two activities: a germ lab and a rocks and minerals lecture with Minecraft using BetterGeoEdu. The class itself was also split up in two. For the Minecraft exercise students worked in pairs, first examining and drawing rocks and minerals within BetterGeo and then comparing the rocks and minerals with real specimen. Afterwards there was a general discussion about everyday raw materials. The students had questions concerning where they could find different rock types, how different rocks are used and whether there were more features in the mod than what was presented in the exercise. They were also eager to share their own experience on local geological sites. A take home message was that the students appreciated working with real rocks and minerals in the exercise. It was insightful to compare the blocks in the BetterGeo with rocks types in nature.



Figure 2. Pupils in Uppsala, Sweden, doing a BetterGeoEdu exercise. Photo: Pontus Westrin, SGU.

Teacher workshop

Teachers are the end-users of the educational material and their knowledge of how to use the material is vital to the project. SGU has therefore developed and performed a teacher workshop for a school in Insjön, Sweden. 16 teachers from different classes in primary school attended the workshop. The aim of the workshop was to teach how to install and use BetterGeo, how to do different exercises and teach with games. Throughout the workshop the teachers got to discuss about raw materials and how they could use this in their own classes.

The teacher workshop was successful and well received by the teachers. All the teachers had heard about Minecraft but most of them had little or no experience with playing the game and had not thought of implementing it in their classrooms. One of the teachers that attended the workshop held a lecture with the BetterGeoEdu tool the day after the workshop.


Translation

The BetterGeo mod was originally available in Swedish and English but was further translated in to two more languages in the project, Finnish and Slovene. The website and educational material is available in the same four languages.

The work with the translations was carried out by the partners Tukes (Finnish Safety and Chemicals Agency) and GeoZS (Geological Survey of Slovenia). The translations were done effectively with some minor adjustments due to differences in languages.

Website

The website www.bettergeoedu.com was created to publish the educational material. An installation guide is also published on the website. All the material is available in the four different languages, complete with instructions and complementary material such as pdf's and game files.



Lecture: Rocks and minerals

In this exercise the student get to work on skills in Natural science, Computer science and English while looking at and describing different rocks and minerals in BetterGeo and in real life. The exercise is made up of two parts, in different steps, which can be found below.

WHAT DO YOU NEED?

- One computer for every two students. The computer needs to have BetterGeo and the ResetMap-mod (see installation guide). A special map is made for this exercise, which can be found through a link [link].
- A set of rocks and minerals (gneiss, gabbro, limestone, granite, sphalerite, halopex) for each group.
- A nail or something metal to scratch rocks with.
- A porcelain streak plate or a porcelain tube to look at the mineral's streak color.
- Colouring pencils.
- Instruction sheets for the students can be downloaded [link].

AGE AND CLASS SIZE?

The exercise is appropriate for ages 8-11. Class size depends on the experience of the class using Minecraft on computers. A smaller class, up to 8 groups, are recommended for inexperienced classes.

TIME NEEDED?

The exercise takes about 1,5 hours with an inexperienced class, but can be finished quicker if the class is more experienced in using Minecraft on computers as less time will be needed to start up for everyone.

DIFFICULTY LEVEL?

Low to medium. Difficulty depends on the experience in the class using Minecraft on computer. Some students struggle with the controls in the beginning. Using instruction tools given at the BetterGeoEdu site is recommended [LINK].

Part 1: Playing

Step 1: Preparation

The class is divided into pairs. It is an advantage if one in each group has played Minecraft before. Each group gets a computer, instruction papers and colouring pencils. One person starts to play while the other takes notes.

They choose when half the time has gone, so both gets to play. The half-way point is clearly started with in game signs.

Step 2: Rocks in BetterGeo

Start up the computers. The students choose Singleplayer -> Create from template -> Choose exercise Minerals and rocks and write names. They all play alone in a so called "singleplayer rock", not together (called multiplayer).

The students start to play in a special "real" mode for the exercise. The map is filled with signs which give instructions. The exercise is made up of different rooms in the game. Each room has a task for the students to do, revolving around minerals and rocks.

The first room is a room filled with gneiss. The students are tasked to look at the rock (which is a block in Minecraft) and write down the name and pair it (color, texture). The students also need to find out how hard the rock is. This is done by using a pickaxe acquired in the starting area and holding down left click. The students write down the amount of time (seconds) the rock takes to break. The time show an approximation of how hard the rock is. The results can be compared later.

When the students are done with the first room they continue to the next room through a door. The first three rooms are filled with rocks where the students get to do the same thing. When the students are done with the first three rooms they arrive to a staircase in the game. This marks the half-way-point and the end of step 2.

Figure 3. The educational material and teacher instructions can be found on the BetterGeoEdu website.



Figure 3. The mod BetterGeo introduces new landscapes to Minecraft, with realistic geology, including a variety of new minerals, rocks and soils. Screenshot from Minecraft with BetterGeo.

BETTER GEOEDU – A UNIQUE PROJECT

BetterGeoEdu offers something unique for teachers. The website contains educational material with step-by-step instructions for teachers new to teaching with games, and comes with detailed extra downloadable material such as printable templates for exercises and game maps with guiding instructions for students to use in-game. BetterGeoEdu gives tools to teach complex subjects such as geology and raw materials to a young audience. One of the most important parts is that it is possible to continue using the mod BetterGeo and learning more at home. Education with BetterGeo is not restricted to the classroom.

BetterGeoEdu also provides tips on how to be successful in teaching with games, not only BetterGeo, and may therefore be appealing for others who want to develop similar projects.

DISSEMINATION AND IMPLEMENTATION

The BetterGeoEdu material is available for free on www.bettergeoedu.com. As BetterGeoEdu was a pilot project it will not be actively advertised. The partners are ambassadors of the material, and will disseminate the material through their networks. It is also possible that the teachers that attended the workshop will spread the material. The pilot project did however focus on development of the material and not active dissemination.

Biotopia, which SGU collaborated with on the test lecture in Sweden, have implemented BetterGeoEdu activities in their ongoing activities as of 2018.

NEED FOR FURTHER ACTION

BetterGeoEdu was a pilot project aimed to develop and test exercises related to raw materials using the Minecraft-mod BetterGeo. Both teachers and students gave the exercise very positive scores and the exercise has already been implemented as an ongoing activity at Biotopia, an activity center and museum in Uppsala. The exercise can still be improved on, for example using other rocks and mineral and building on the current material. There is also a need for more exercises. This was requested at the teacher workshop, especially exercises for different ages of students. Some teachers educated younger or older students than recommended for the exercise. It is possible to develop new exercises for both younger and older students, building on different features in BetterGeo.

The teacher workshop was also a success, with several teachers asking for more workshops and more exercises. After the workshop, some teachers felt they still had more to learn. There is often a discrepancy between the knowledge of the game between teachers and students, or rather the average adult and the average child. Many students have a large knowledge of the game and have been playing at home for a long time, while teachers might feel at a disadvantage not having the same experience playing. This can be problematic when the game offers little limitations, meaning that it is possible to cheat or likewise using different codes if the students are aware of them. It is important that the teacher know and train to handle these situations to keep focus on the exercise. It is therefore proposed that a follow-up workshop would be necessary to teach more in-depth features of the game to help in their education. This knowledge can at the same time be used by teachers to develop their own exercises in the game, to tailor for the class or their own way of teaching.

There are also issues relating to how schools need access to computers and Minecraft licenses to use the material. These issues could be resolved by collaborating with museums and activity centers such as Biotopia, who can lend their facilities and computer rooms, or invite classes or groups to do exercises together with them.