EarthCaches: An Opportunity for Learning Geoscience; a Pilot Study for Glaciomorphologically Themed EarthCaches

Stefanie Zecha and Ludwig Hilger

Katholische Universität Eichstätt Ingolstadt, Germany · stefanie.zecha@gmx.de

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Abstract

This paper examines how EarthCaches, published on the website http://www.earthcache.org, influence non-formal learning in the field of geoscience. First, we investigate where the learning opportunities in the non-formal learning process of earthcaching are. Second, the authors analyze the information conveyed by EarthCaches. As it is not possible to analyze all EarthCaches, we have restricted our study to the ones dealing with glacial features located in Bavaria and focused on the tasks and illustrations using the method of content analysis (FRÜH 2010). Therefore the authors developed different category systems in relation to illustrations, tasks, and glacial features focused on by the EarthCaches. The authors found that the illustrations and tasks used in the cache descriptions have some didactical quality, but reason they could be improved methodologically and scientifically. As a result, the authors give advice on creating more effective EarthCaches.

1 Introduction

Earthcaching is a special form of geocaching, which features unique geologic formations or geomorphologic landforms. It is a possibility for non-professionals to independently learn earth science in non-formal learning settings. Different international studies have shown that the non-formal learning process contributes 60-80% to total learning (OECD 2012). The significance of the current study resides in its focus on the learning aspects, especially the methodological content of EarthCaches, like explanatory texts, illustrations and tasks to be fulfilled by the earthcacher. Currently, there are thousands of EarthCaches worldwide. As it is not possible to analyze all of them, we have restricted ourselves to "geomorphological" EarthCaches dealing with glaciomorphology within a specific region, that is, Bavaria. The findings of this study will be useful to earthcachers and educators interested in self-directed, collaborative, and experiential learning activities, and in optimizing the learning effect of earthcaching.

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2 Theoretical Background

2.1 Literature Overview about Earthcaching and Learning Processes

The publications about geocaching can be divided into themes like environmental education (ZECHA 2012, LUDE et al. 2013) or training media competences (MAYBEN 2010, IHAMAÄKI 2012). Another differentiation can be made between formal learning settings (ZECHA 2012, LUDE et al. 2013) or informal learning settings (CLOUGH 2010, MAYBEN 2010, IHAMAÄKI 2012). Until now, there is no article which concentrates on earthcaching with a special focus on the scientific and methdodological content of the caches, the tasks, and the illustrations. This article attempts to close this gap.

2.2 What is an EarthCache?

EarthCaches are a subtype of geocaches. EarthCaches are different from other geocaches because there is no physical container present in the field, and they are always connected with a learning process. These caches are supervised by the Geological Society of America's (GSA) Education and Outreach. All EarthCaches have to pass a reviewing process, controlled by a reviewer of the Geological Society of America before they can be uploaded. They have to, among others, conform to the following criteria (THE GEOLOGICAL SOCIETY 2013):

> "1. EarthCaches must provide an earth science lesson. 2. "EarthCaches must be educational. They should provide accurate, educational, but non-technical explanations of what visitors can experience at the site. The cache page, including the description and logging tasks, must assume a basic knowledge of geology. 3. EarthCaches must highlight a unique feature. EarthCaches that duplicate existing EarthCache information about the site, or related sites, may be rejected. EarthCaches must be developed to provide a unique experience the location's visitors, and to teach a unique lesson about the feature at the site."

Before somebody can log the cache, he has to send the results of the tasks to the creator of the cache, so that he/she can be sure that the exercise was completed.

2.3 Non-formal Learning

Before EarthCaches can be examined in the context of non-formal learning, it needs to be defined what we understand by non-formal learning. "Non-formal learning consists of learning embedded in planned activities that are not explicitly designated as learning, but which contain an important learning element. Non-formal learning is intentional from the learner's point of view" (COLARDYN & JBJORNAVOLD 2004, 71). In relation to earthcaching, this means that each EarthCache is related to a special learning lesson in the field of earth science, and these are geospatial skills, earth literacy, and learning related skills (THE GEOLOGICAL SOCIETY 2013). This is not the case with normal geocaches.

2.4 Glacial and Glaciofluvial Landforms

There are different reasons to choose EarthCaches with a thematic focus on glacial landforms in our study. The formation of the surface by exogenous forces, like flowing water and ice, is a central theme of geomorphology. Moreover, glacial and glaciofluvial landforms and the processes causing them feature comparatively prominently in Bavarian high school education, probably because a great part of the state had been under direct glacial influence during the Pleistocene. In addition, the second most caches in the state deal with that topic.

2.5 Research Questions

The following research questions result from the theoretical part: 1) Which and of what kind of learning opportunities are there in earthcaching? 2) Which glaciomorphological scientific themes are treated in the EarthCaches? 3) Which kinds of illustrations are used in the EarthCache description published online? 4) Which didactical quality do they have? 5) Which didactical quality do the tasks have? 6) Which geographical methods do the authors of the EarthCaches use?

3 Research Design and Methodology

An appropriate method is required to solve the research questions above. The content analysis after FRÜH (2011) is a method for summarizing any form of content by counting various aspects of the content. This enables a more objective evaluation. For analyzing the different materials (features, illustrations, tasks) we developed system categories for each aspect (see above). The aim of the first phase was to analyze current state of scientific knowledge to each category system. In the second phase, those elaborated criteria were transformed in different category systems. This comprised several subsequent steps, which have been built on current state of scientific knowledge. This ensured the validity of the research instrument. The system of categories was subsequently tested in terms of reliability. The revisions were accompanied by systematic critical reflection of description of each category in relation to the theoretical basis. The following third phase concentrated on a frequency analysis. In this phase the content of each EarthCache was assigned to a relevant category. Later, a qualitative analysis was undertaken with selected examples of each category system (FRÜH 2011).

In total, a dataset of n = 48 EarthCaches was analyzed for this study.

Category System: landforms created by the direct or indirect influence of glaciation
To get an overview of what the caches focus on thematically, we created a frequency table for different categories, encompassing the most prominent glacial and glaciofluvial landforms. The criteria for category creation were informed by our general geomorphological knowledge, but are based upon the structure used in STAHL (2013). The categories are listed in table 1. We defined main categories according to the forming process and subcategories that further differentiate by form size in large (longest axis > 500 m), medium (longest axis 10 – 500 m) and small (longest axis < 10 m) scale landforms. We acknowledge that e.g. moraines can have lengths from several meters to several kilometers, but we have assigned

landforms to a scale class according to the most common traceable sizes in our study area (if present). We are also aware of the fact that it is sometimes difficult to label certain landforms to a certain genesis, as different processes have contributed to the feature's formation until it arrived at the state at which we observe it today (e.g. peat bogs in tongue basin). We also excluded landforms directly formed on glacier ice (e.g. glacier tables).

Table 1: Categories used to classify the scientific content of EarthCaches

Genesis-based Category	Scale-based Subcategories	Examples
Glacial erosional	large	cirque, circus stairway, arete, horn peak, nunatak, U-shaped valley, hanging valley, valley shoulder, tongue basin
	medium	tarn, circus threshold, roche moutnonnée, ice-scour terrace, ice-scour limit, trough end, diffluence pass, confluence step
	small	striations
Glacial depositional	large	terminal moraine, lateral moraine, ground moraine
	medium	drumlin, kettle hole/pond
	small	erratic
Fluvioglacial erosional	large	–
	medium	subglacial gorge, subglacial channel
	small	pothole
Fluvioglacial depositional	large	outwash plain, glaciofluvial terraces
	medium	kame, esker
	small	–
Unfocused		Cache deals with glacial morphology but gives an unfocused overview of the geology and formation of the whole area

Category System: quality of illustrations

The authors chose illustrations for further analysis because they play an important role in the learning process (see chapter 4.2.1). There is no exact definition of the term "illustration" in German geography didactics. For this study, the following types of illustrations are used: photos, area images, charts, and maps. Others, like caricatures, diagrams or tables are excluded from the analysis. The well-documented category system for illustrations of STRAHL (2013) with the following main categories was applied: title, legend, didactical quality and correctness regarding the subject. These categories also have subcategories, which we do not discuss further here but are referred to in figure 2.

Category System: performance level of the tasks

The authors categorize the tasks according to the different competence levels of the Geographical Standards used as a guideline in German high school teaching (DGfG 2014). They are well recognized, defined and give a good base for the category system: six competences (subject-specific, knowledge, spatial orientation, gathering information/methods, communication, evaluation, action) and three performance (reproduction, reorganization and transfer, reflection and problem solving) levels (DGfG 2014).

4 Selected Results and their Interpretation

4.1 Non-formal Learning in Different Stages of Earthcaching

Learning opportunities are identified along a trajectory from reader (level 1), via visitor (level 2) to creator (level 3) of EarthCaches (CLOUGH 2010). The 3 stages of EarthCache usage are compared to Jonassen's attributes of constructivist learning with technology. The four attributes are used: active, intentional, authentic and cooperative (JONASSEN 1995).

Level 1: Reader. At this stage, people create an account to be able to access meta-information about EarthCaches, but do not yet intend to visit them. The learning possibilities are intentional, as people intentionally decide to visit the website, to look at special EarthCaches, because they might want to learn something about geomorphological features. There are no active, authentic or cooperative learning processes.

Level 2: Visitor. The earthcacher starts to download information about a certain EarthCache with the intention of finding, solving, and logging tasks. This is an intentional learning process. It is also an active process as the earthcacher seeks for the place and wants to solve the tasks at the location. As the challenges are in nature it is also an authentic learning process. Later, visitors can interact with one another on the EarthCache's website when they log the cache and can give opinions about their experience with a certain EarthCache and can even ask continuative questions. This is also a cooperative learning process.

Stage 3: Creator. This class refers to people who create EarthCaches for others to visit. It is an intentional learning process, because the author of the cache needs to look whether the selected location fulfills the criteria of the guidelines and needs to prepare basic geographical and geomorphological knowledge. Searching for scientific information (e.g. the genesis of the respective landform) and creating specific tasks, finding the right geographical methods is an interactive learning process. In addition, of course, the creator needs all skills a visitor must have as to test his/her finished creation.

In total, it is evident that earthcaching provides different kinds of learning processes during different stages. The learning profits for a cache creator are higher, as he needs to accomplish all tasks readers or visitors have to as well.

4.2 Evaluation of the Category Systems

4.2.1 Scientific Focus of Different Glacial and Fluvioglacial Landforms

The frequency table resulting from counting out the different thematic foci can be found as table 2.

It is evident that the distribution of EarthCaches over different glacial and glaciofluvial landform classes is all but homogenous. There are several landform classes that are not represented in any of the examined geocaches, while others – like moraines – are represented very often.

Table 2: Frequency table for different glacial and fluvio-glacial landforms as themes of EarthCaches

Genesis-based category	Scale-based subcategories	Count
Glacial erosional	large	4
	medium	0
	small	1
Glacial depositional	large	4
	medium	9
	small	4
Fluvioglacial erosional	large	---
	medium	0
	small	3
Fluvioglacial depositional	large	4
	medium	0
	small	---
Unfocused		19
		∑ 48

This can be mainly attributed to two reasons: moraines (especially from the pleistocene) are very easy to access, and are generally highly present in high school education. Medium scale glacial erosional landforms are not represented by any EarthCache in Bavaria, which is rather surprising because the class includes some very prominent landforms like tarns, roche moutnonnées and diffluence passes. This clearly shows that the Earthcaches tend to cluster thematically around well known concepts and landforms that are treated in high school, but do not offer information about glacial and fluvioglacial processes. This is certainly due to the fact that the cache creators are non-professionals, who are not acquainted with the whole landform ensemble related to glacial sculpting of the earth's surface. It is evident, that there are still many opportunities of creating unique and educationally valuable EarthCaches concerning glacial geomorphology. It is also conspicuous from the frequency table that almost 40% of EarthCaches are very topically unfocused. In these cases, an EarthCache often deals with the geomorphological and geological evolution of the location on timescales of several million years, and does not consider the specific landform at the specific location. They often drastically violate #3 of the guidelines for EarthCache submittal ("EarthCaches must highlight a unique feature" (THE GEOLOGICAL SOCIETY 2013)), and fail to convey the genesis and importance of the specific location, often also because of crude scientific errors and misunderstandings of the EarthCache's creators.

4.2.2 Evaluation of Illustrations in Regard to Learning Processes

Different psychological studies have shown that illustrations can influence the learning process in a positive way (PEECK 1994).

4.2.2.1 A Quantitative Perspective to the Illustrations

Table 3 shows the number of illustrations used in total in the selected EarthCaches. Some EarthCaches have two or more photos for example.

Table 3: Illustrations in total used in the 48 EarthCaches

	photos	**charts**	**areal image**	**maps**
numbers	42	20	8	9

There are photos in 21 of 48 caches that illustrate the geomorphologic features in nature. Secondly, there are charts, which you can find in 14 EarthCaches descriptions (one example figure 4), followed by areal images in 4 EarthCaches descriptions (one example: figure 3), and maps in 6 EarthCaches descriptions (one example figure 5). A photo can give a first impression of the glacial feature, so that the earthcacher can see what to look for in nature. Charts are very helpful because they can convey complex information (see figure 4) and thus improve the learning process (RINDSCHEDE 2009). There are maps in 6 earthcache descriptions only, although they help orientation in nature and reduce the complexity of reality (figure 4) (BIRKENHAUER 1997).

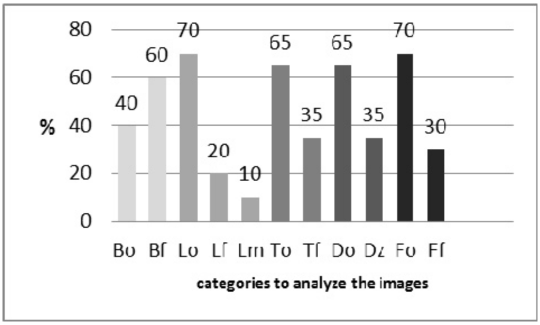

Fig. 1:
Category analysis of the illustrations

As seen in figure 2, 40% of the illustrations have a title (Bo), and 60% of the illustrations have no titles (Bf). 70% of the legends are okay (Lo), in 20% the legend is missing (Lf), and in 10% of the EarthCaches the legend is insufficient (Lm). 65% of the illustrations have a relation to the cache description (To); in 35% there is no information of the illustration in the text (Tf). Titles and legends are important to help the earthcacher to orientate themselves on the illustration, and the learning effect is also higher (PEECK 1994), so the percentage in these categories should be higher. A lot of illustrations have no relation to the text, so they cannot support the learning process. One reason is that a lot of photos only show the area, but not the geomorphologic feature. One cause for this result is certainly, that the guidelines mentioned above do not include any special rules on how to use illustrations. Ideally, each EarthCache should be guided by a photo, which shows the geomorphological feature in question and an explanatory chart.

4.2.2.2 A Qualitative Perspective to the Illustrations

The authors selected several caches to exemplify the use of different illustrations on EarthCache description sites. The first one is the Earthcache "Grubmühler Feld" which focuses on pleistocene river terraces of the Würm period as a central theme.

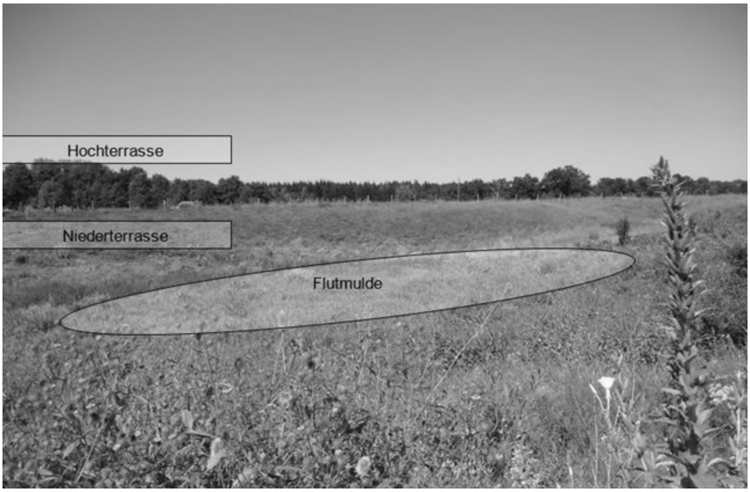

Fig. 2:
Photo of the area
(ELWAGNER 2004)

The picture to be found on the Earthcache description site (figure 2) shows two terraces on the "Grubmühler Feld". A tidal pool can be spotted in the foreground, is labelled in the photograph and referred to in the text. In addition to the photograph, a profile chart is provided that gives an overview over the general geomorphological situation at the EarthCache site. This cache can serve as a positive example and it is not surprising that it was created by scientific experts (Geologisches Landesamt / Bavarian State Office of Geology).

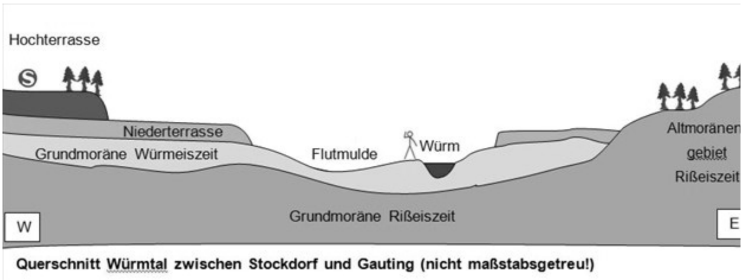

Fig. 3:
Profile drawing
("Grubmühler
Feld")
(ELWAGNER 2004)

A further EarthCache was selected to show the use of maps: "Rund ums Leutstettener Moos". The Leutstettener Moos is a fen on the north end of the Lake of Starnberg south of Munich, which in earlier times formed part of a lake. During the Würm period, the terminus of the Isar-Loisach glacier scoured the area. The map (figure 4) provided by the EarthCache creator illustrates this situation.

4.2.3 Evaluation of the Tasks to be Accomplished to Log an EarthCache

Learning is an active and constructive process. Therefore, the earthcachers should be as active as possible while being in the field at the geomorphological feature. This can be achieved by assigning tasks to be completed for a successful cache log (KRAPP 1998).

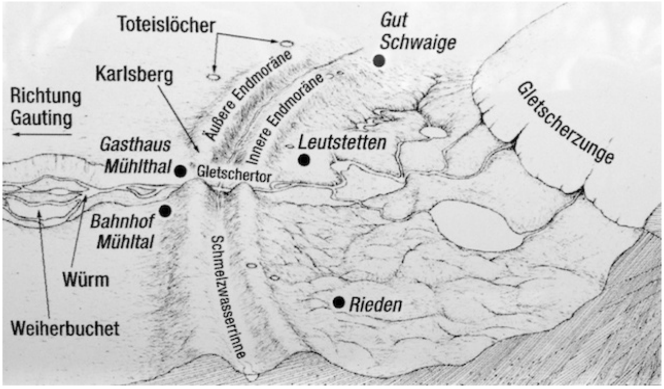

Fig. 4:
Map of the situation around Leutstetten during the Würm Period (ELWAGNER 2004)

4.2.3.1 A Quantitative View of the Tasks

Table 4: Tasks in the EarthCaches in relation to the geographical standards (DGFG 2014)

	Knowledge on the pleistocene	**Spatial orientation**	**Gathering information/methods**
performance level I	85%	60%	
performance level II	13%	40%	100%
performance level III	2%		

In a lot of caches you find more than one task. Table 4 shows that 85% of the tasks belong to the competence of knowledge on the Ice Age, performance level I, 13% to performance level II, and 2% to performance level III. In regard to spatial orientation 4% of the tasks belong to level I, and 2 % to level II. Regarding the methods, 100% of the tasks belong to performance level II. As not all competence fields are activated by any of the examined caches, communication (C), evaluation (E), action (A) are missing in the table. This also shows a certain development potential for EarthCaches. Most of the tasks belong to the aspect of knowledge, and to the first performance level at the same time, which operatively means describing characteristics and facts (DGFG 2014). With regard to methods, the second level means method application. In 17 caches, visitors have to apply a specific geo-scientific method to obtain the result. Taking a close look, the geographical methods used in the tasks are the following: logging coordinates to find a certain place in the task (2), measuring something (8), and rating (3). Somewhat more complex methods are rare: drafting (1), drawing a profile (1), creating a model (1), or measuring the color of the river (1). Altogether, it can be said that the tasks do not reach a very high methodological level. Also, only a bit more than half of the caches request the visitor to apply certain geoscientific methods in order to log the cache.

4.2.3.2 A Qualitative Perspective to the Tasks

For the qualitative analysis, the authors chose the EarthCache "Toteisloch Wolfsgrube". It deals with the development of a kettle hole. In the last of different tasks, the visitor has to build a 3D model (in snow, sand, or similar) for the development of a kettle hole, and take a picture of three genesis stages: a) The glacier before it separated from the kettle hole, b) The dead ice at the location of the future kettle hole covered with sediments, and c) the kettle hole after the ice has molten, i.e. in its final state. The three-dimensional model helps to visualize the essential aspects of the kettle hole, and helps to understand the development of this glaciomorphologic feature.

5 Conclusion

The study in this paper described how earthcaching can produce learning opportunities in general, and presented a didactical analysis of the caches, especially the tasks and the illustrations. Different types of learning possibilities can be found in the different stages of earthcaching. The most effective stage in regard to learning is the creation of earthcaches.

The content of the EarthCache description site itself, i.e. illustrations and the tasks to be fulfilled in the field, can all have special functions. Unfortunately, only 65% of illustrations are of didactical value. Especially some photos are more or less redundant and only in a few caches charts are used for a better understanding.

The tasks play an important role to activate the learning process. The German standards of geography education were used to build a category system. The performance level in the field of cognitive competence is very low in most EarthCaches. The creators only use geoscientific methods in a few EarthCaches, but the variety is not very high.

To improve the quality of the EarthCaches, the authors suggest two things. One suggestion is that a chapter on how to use illustrations should be included in the EarthCache creation guidelines. Also, different geoscientific methods could be presented. There should also be a chapter, which explains why illustrations are important for the learning process, and how they can be integrated to support the learning process during earthcaching. There should be a kind of checklist in the guidelines, so the cachecreator can see if they have fulfilled the quality criteria. Examples of qualitative good EarthCaches should be named in the guidelines to get an impression for qualitatively good ones. As each cache has to fulfill a reviewing process, reviewers should be chosen among as professional geoscientists as possible.

Nevertheless, earthcaching has terrific potential for learning in non-formal situations. In this way, culture of geographical literacy can be fostered. The big advantage is that learners can go into nature to study geomorphology by themselves. Till now, a similar opportunity for non-professionals interested in geoscience did not exist. Especially geography teachers, as semi-professionals, should get in touch with earthcaching. Students could have the possibility of using earthcaching during their training in geoscience to understand content presented in theory in the classroom better.

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