Drawing Geothermal Energy: How Students Understand the Underground

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ABSTRACT

Andean territories have a great number of geothermal features, such as volcanoes, geysers and hot springs, however, there is little research about how much people understand one of the most abundant energy resources, geothermal energy. In this context, this paper explores how the Andean Geothermal Center of Excellence, CEGA, has used drawings as a social science methodology to describe conceptual knowledge to a young population about geothermal energy and volcanic activity in Chile. This method allows to understand their scientific knowledge regarding high and low geothermal applications in order to build better communication and dissemination strategies. The findings confirm that drawings are a valuable method for exploring perceptions and level of knowledge of geothermal energy.

INTRODUCTION

Geothermal energy in Chile

Geothermal energy refers to the heat contained within the Earth that can, or could, be recovered and exploited by humankind (Dickson and Fanelli, 2003). Electricity generation is the most important form of utilization of high-temperature geothermal resources (>150 °C). Geothermal power development is witnessing a rapid growth worldwide. An increase of about 1.7 GW in a five-year term from 2010-2015 has been achieved (about 16%). The short-term forecast suggests an installed capacity of 21,443 MWe by the year 2020. (Bertani, 2016).

Geothermal energy has several uses being power generation the most common, attributed to binary cycle plants that can generate electricity with temperatures above 73-90 °C (Zarrouk and Moon, 2014). Additionally, medium-to-low temperature resources (<150 °C) are suited to many other applications including: bathing, space and district heating, agricultural applications, aquaculture and some industrial uses are the best-known forms of direct utilization (Lindal, 1973). Direct-use is the oldest form of utilizing geothermal energy with more than 2000 years of documented history (Cataldi et al., 1999). Since 2005, there has been a growing awareness and popularity of geothermal heat pumps, having a significant impact on the direct-use of geothermal energy, mainly due to the ability of geothermal heat pumps to utilize groundwater or ground-coupled temperature anywhere in the world, making it a highly versatile technology (Lund and Boyle, 2016).

In Chile, geothermal resources have been traditionally used for recreational and touristic purposes with thermal waters been collected from natural hot springs and piped to buildings and pools. In a few spas, less than 10%, shallow wells have been drilled to extract geothermal waters. Lahsen et al., 2015 estimated that direct use in spas and swimming pools accounts for an installed capacity of 11.31 MWt, which equals an annual energy use of 152.12 TJ/yr.

In Chile, the use of heat pumps began in 1996 when 51 units were installed in the southern part of the country. Approximately 70% of them are closed-loop (ground-coupled) and the rest are open-loop (water-source) systems (Lahsen et al., 2015). The documented installed heat pump capacity is 8.6 MWt with an energy use of 34 TJ/yr (Lahsen et al., 2015). Approximately 83% of the units are installed in commercial, industrial and institutional buildings; only 17% in houses and apartments (Lahsen et al., 2015). The majority of geothermal heat system in Chile belong to private institutions. However, the Andean Geothermal Center of Excellence, CEGA, a geothermal research center from University of Chile and financed with public funds, has been focused on generating and improving geothermal knowledge in Chile, paying particular attention since 2014 to promote direct uses. During 2014, a researcher group from CEGA, along with the local office of the Ministry of Mining in Aysén, won a public bidding to develop a two years geothermal exploration campaign encompassing the Aysén region, South of Chile, where there is located one of the most polluted cities Coyhaique. This urban area is highly polluted due to the use of wood for heating and cooking. The positive results of this project leaded to further biddings won by CEGA, allowing the development of three pioneer projects focused on utilizing geothermal heat pumps: i) a geothermal greenhouse with a closed loop, ii) heating of a public school with an open loop system and iii) drying wood and heating up a greenhouse with an open loop system.

Geothermal energy is not a well-known energy among Chilean population. According to the National Energy Survey (2017) 30% of the population declared to know about how the resource is used and only 38% of Chilean people considered geothermal as clean energy. At the same time, geothermal energy does not have a high level of social acceptance in comparison with the other renewable energies (Popovski, 2003, Dowd et. al, 2011)

Taking this context as a backdrop CEGA has been focused on generating and improving geothermal knowledge in Chile since 2010. As one of its goals, CEGA has been carried out several outreach projects such as educational materials, videos, and scientific mural painting among others. At the same time, since 2016 CEGA has included a social research area focus on social and cultural aspects of geothermal energy. This paper is part of the efforts of understanding social perception of the energy in the Chilean culture.

Goals, research questions, hypothesis, and scope

Building on and contributing to the literature that examines the perception of geothermal energy, the overarching goal of this paper is to explore the process of understanding the underground to build better communication and dissemination strategies, especially among young population. To pursue this goal, this paper is articulated around three interrelated objectives. The first one was to explore how young population among different geographical contexts perceive and describe the underground, the second one was to identify which scientific information they do not include, and the third one was to explore how drawing, as social science method, could be used as a base line information to design outreach activities. This is an ongoing research; this paper includes preliminary conclusions.

METHODOLOGY

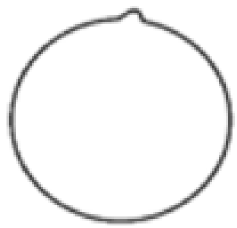
Drawing as a tool for data collection

This paper includes drawing as a social research methodology. There is nothing new in suggesting that visual language has been used as a social and cultural representation of how we perceive the reality and the environment, in this sense, visual representation is an opportunity to understand how a specific group of people perceive the world. This methodology has been used commonly for psychological perspective to explore environmental conditions around children (Blades et.al 1998). Taking into account that one of the advantages of this method is that, when compared with others, is more attractive, and allows to conduct more enjoyable activities, this is a great strategy for participants that may have difficulty expressing their thoughts verbally (Ongena, & Dijkstra, 2007). This methodology has been used in several studies to explore social perception. Young and Barrett (2000) used this method to explore how young children interact with the socio-spatial environment aspects, their work highlights that visual methods are attractive for young population of different ages and backgrounds. At the same time, Gibson et. al (2015) explore an analysis of a 3-D participatory models to describe risk perception and the relation between non expert knowledge and expert knowledge. Their results suggest that by this kind of experiences, geoscientists can develop messages and more directly engage local concerns and create open engagement pathways based on dialogue and also allow to include perceptions and ideas that experts might never have considered. Vosniado and Brewer (1993), using a mental model approach, look for how the conceptualization of the Earth changes since young population is exposed to cultural representations. Their work highlight that children have at least four representation of the earth (rectangular, disc, flattened, sphere).

Data collection

The data collection of this paper was carried out in Chile in three regions with different social, environmental and geological characteristic, from north to the south: Metropolitan, Araucanía and Aysén regions were considered. This paper includes the analysis of three kind of experiences. The first two activities payed attention on geological conceptual knowledge and the last one was focused on conceptual information about geothermal direct use.

This paper includes 160 drawing made by Chilean children and youth ranging in age from 11 to 16 years old. The first two experiences were developed in Araucanía and Metropolitan regions. In Araucanía region 77 students from two public schools participated, (54 boys and 41 girls), while in Metropolitan region, 57 students in total (28 girls and 29 boys) were involved in the activity. The drawings were developed in school settings just before a geothermal energy workshop took place (organized by CEGA in 2018). This was a controlled and directed activity, where participants completed a scheme designed to describe how young population understand and perceive the underground (figure 1 and figure 2). Students received randomly a figure 1 or figure 2, and then, they complete the figure. The instruction for the first one was: “freely complete the scheme taking into account that this figure represents the surface of the Earth”. The image does not include scale. Each participant took around 25 minutes to complete a drawing.



A second figure was used to understand how much technical knowledge young population had about power generation by geothermal energy. For this, participants completed the figure 2. The instruction this time was “Taking into account the profile of a volcano, how do you think that geothermal energy could be used for power generation”. Each participant took around 25 minutes to complete a drawing.

The last experience did not include a frame in order to provide more opportunity to examine how drawing method could be used as a better option to understand perceptions. This activity focused on direct use of the energy. In this opportunity the instruction was to draw on an empty sheet how they imagine and believe that a geothermal heat system works, and how the system could heat their school. They took around 20 minutes in the activity.

This third experience was developed in 2018 in Aysén region, Chilean Patagonia, in a public school where CEGA is currently installing a geothermal heating system, replacing a traditional system based on wood for a groundwater heat pump. In this case, 26 students participated (12 men and 14 women from 14 to 16 years old).

The data analysis was focusing on thematic analysis. The information was codified by themes identified in the drawings in order to illustrate the scientific information they have, and also the information gaps. At the same time, participatory observation was carried out in those three activities.

Ethics

Ensuring free, informed, and ongoing consent of the research participants was one of the pillars on this research. An informed consent was distributed among the parent of participants. In regard to this, all parent´s participants signed a consent form before the activity. Their participation was anonymous and completely voluntary. The drawing sheets only included information about age and gender.

PRELIMINARY RESULTS

In a general sense, the drawing methodology was well received by participants. The activity was an opportunity to open the discussion about geothermal energy among young population. Because this activity took place before a geothermal workshop it was also great chance to start a conversation with participants about the themes would be cover on the workshop.

For the first two activities, a preliminary assumption was that young population among different geographical setting would have different perception about volcanoes and geothermal resources, however, the reality was different. Among students from Santiago and Araucanía the drawings were very similar.

In terms of technical knowledge, students showed that they are able to describe the Earth in layers and place a heat source under de volcano. Their drawings included magma, volcanic conduits, and lava. However, the size of the layer as well as the volcanic conduits shape and size are usually oversized. A great number of students included a volcanic eruption in their drawings. A very important absence was identified, superficial and underground water was not included in most of the drawings. Another absent concept was the subduction zone, no participant included this geological feature in their drawings.

The majority of participants did not complete this drawing since the instruction was to draw how to use geothermal resource for power generation.

For the heat pump system drawing, the most common characteristic included was that students integrate big heat pump system underground. Most students included tunnels where people are able to walk or even have a room, a kind of basement, under the school. Participants illustrated the system close to the earth core.

CONCLUSIONS

In a broad level, this exploratory research highlighted that drawing methods could be an opportunity to adequately describe perception about geological concepts. At the same time, future experiences could combine other qualitative data collection methods such as deep interviews or groups discussion to expand the results and participants perceptions.

Taking into account the participatory observation, we could conclude that free activities, such as the last exercise focused on direct use, are better received by participants because they are able to express more freely their ideas. This argument is in the line of Ennew's approach, (1996), who points out that visual methods like this inevitably support adult interpretations, thus it is important to provide spaces to young participants to express their thoughts without borders.

The results of this paper confirm that there is a general lack of awareness about the resource, the research participants did not know about the direct use of geothermal energy for building heating purposes, for instance, or power generation. At the same time, the analysis of those experiences confirm that young population do not manage key information about the underground such as the existence of underground water or they do not make the connection between volcanic activity and geothermal energy uses.

Taking into account the preliminary results, future outreach communication strategies could aim to the lack of technical knowledge, focusing on increasing the awareness regarding underground water and geothermal energy systems.

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