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Co-designing artisanal mining practices

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Abstract: In this paper we introduce a method for facing water pollution issues with the participation of stakeholders (communities, companies and the government). We consider that every water pollution issue is a consequence of human practices, therefore, the re-design of human practices should be the starting point for achieving a more sustainable world. We understand Design as a discipline that makes tacit knowledge tangible and we recognize the power that Design and designers have to modify practices through things. To do so, we propose a method that follows a participatory design approach to understand socio-technical systems, together with stakeholders/communities. We base our method on Beckman and Barry's innovation process of observation-frameworks-imperatives-solutions, that considers two levels of thinking: concrete and abstract; to go from analysis to synthesis. We propose participatory tools to bring the stakeholders/communities through all the stages of the process allowing them to be part of the above mentioned concrete and abstract levels of innovation.

Key words: *gold mining, design process, innovation, design tools.*

1. Introduction

In this paper we introduce a method for facing water pollution issues with the participation of stakeholders (communities, companies and the government). We consider that every water pollution issue is a consequence of human practices, therefore, the re-design of human practices should be the starting point for achieving a more sustainable world. Here, we understand Design as a discipline that makes tacit knowledge tangible and we recognize the power that Design and designers have to modify practices through Design Things (Bjögvinsson et al. 2012). To do so, we propose a method that follows a

participatory design approach to understand socio-technical systems, together with stakeholders/communities.

2. Where do we take our approach from?

Based on Owen's design process model, Beckman and Barry (2007) propose an innovation process model where participants move between a concrete and an abstract world. Participants use observation to create an abstraction of the observed practices, framing them through analysis to find a problem. Then, after selecting the problem that should be addressed, the participants proceed to synthesize defining imperatives and proposing coherent solutions, resulting in several concrete solutions. This process is then repeated after selecting a solution and observing it implemented on the initially observed context. This model in four stages [(1) Observations, (2) Frameworks, (3) Imperatives and (4) Solutions] is well known among Design Thinking followers and is used as a basic model in several design processes. Above that, what we highlight about this model is that it is not presented just as a way of describing the innovation process. Beckman and Barry argue that this innovation process is also a learning process, and that innovation is the accumulation of knowledge through its process. A knowledge that is then embedded in design artifacts.

Likewise, Donald Schön (1983) proposes an approach to innovation based on learning systems, systems capable of bringing their own continuous transformation through reflection. He argues that a practitioner learns about his own practice through reflection and generates a new understanding of what he does allowing him to change the situation (Schön 1983). To achieve this the practitioner has to be able to compare two different situations, one that he feels familiar with and one that is unfamiliar to him to relate both and understand the unfamiliar based on the familiar one (Schön 1983). As a result of this process practitioners frame the situation, determining which features they will attend, the order that would be imposed to the situation and the way that they will try to change it. In this process, practitioners and other stakeholders identify the ends and the means that could be employed to alter the starting situation (Schön 1983).

It is possible to recognize on Schön's approach a sequence of steps similar to the one proposed by Beckman and Barry. His process also goes from analysis to synthesis, and implies the need of an abstraction of the concrete to achieve learning, using metaphors to understand the concrete through abstractions.

3. Our Method

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The principle behind our method is allowing the design team to bring the stakeholders to the abstract side of the Beckman & Barry's innovation process loop (Beckman & Barry, 2007) to make the community part of the analysis reducing the subjectivity and involving the community member in the recognition and management of their own conflicts, achieving a modification of practices through learning. We follow the four stages of Beckman and Barry and make special emphasis on supporting Schön's learning systems.

3.1 Observations

3.1.1. Interviews and contextual inquiries

Every project that involves communities implies the exploration of the relevant groups or the relevant actors that would be willing to participate and that would have an interest on being part of the project. The synergy between the participants is essential and working with people who does not want to be there might be pointless. Finding contexts where links of trust have already been established is a good drive for the project. During this initial phase interviews are essential for exploring these links of trust and finding the right people and the right context to start. After identifying the relevant actors, the use of contextual inquiries allows the design team to understand the practices and reinforces the trust between the design team and the community.

The contextual inquiry tool consists of observing and talking with practitioners in their workplaces as they do real work during 1 or 2 hours. The goal is to have a conversation with the relevant actor(s) and share information focused on a specific topic so everyone, the inquirer and any other participant(s), can learn something from it. (Raven & Flanders, 1996).

3.1.2. Social cartographies

Social cartographies are a space for discussion that facilitates the understanding of the community by the stakeholders on three levels: (1) the understanding of the different stakeholders as part of the community; (2) the understanding of the community as a whole; and (3) the understanding of the community from the design team as an outsider. With this tool the design team can achieve an increase of the participation of the community in the observation phase by making everyone feel equal and by providing a space for expression with very few limitations. This tool also helps the stakeholders to achieve a high level of self-awareness over their practice by creating a visual memory of the structure of the community. (Navarro-Sanint, 2013)

After finding groups that are willing to participate and building trust between them and the design team, the use of social cartographies helps to get a deeper understanding of the context, the interactions between actors, the different interests of the stakeholders, the available knowledge and resources, etc. In sum, the cartography is the starting point for creating a common language and a common understanding among the participants.

The recommended setting is to create groups from 3 to 6 people. A table is set with a blank paper, post-its, markers, wood cubes and laces and each group gathers around it. Someone from the design team facilitates the session asking questions and conducting the participants towards pre-determined topics. Everything that is said should be represented on the paper using the available materials. Sometimes, it is not easy for the participants to start representing things by themselves, thus, the facilitator should give example and represent some of the things that are said during the discussion by drawing something, adding a block, adding a post-it, etc.

Depending on the interests of the different stakeholders, several cartographies can be created, either by topic, e.g. social relationships or agricultural resources; or by time, e.g. past, present, future.

3.2. Frameworks

Just like cartographies, games help the participants to build a common language for discussions. Games are powerful analogies of real life that allow the stakeholders to participate in discussions and explore possible scenarios. It is through games that participants can achieve the level of reflection suggested by Schön (1983) when framing a situation, by comparing a familiar situation recreated by the game with different unfamiliar situations that can be reenacted through the game. A game works as a tangibilization of practices and knowledge that can be altered at will through a conversation between the participants and the game. This conversation of the practitioner with his own practice creates awareness about his own practice and gives the practitioner the possibility to modify his own situation by simulating the possible outcomes in a short time. In addition, games have that power of contracting and expanding time, allowing the participants to explore several 'what if' situations and explore the possible repercussions of previously made decisions. These games have to reflect underlying realities, have certain rules, and a quantifiable outcomes that are coherent with the different interests of the stakeholders. (NAVARRO-SANINT, 2015)

3.3. Imperatives

When thinking about design imperatives, games work in two ways: (1) participants can suggest different ways of altering their practice, suggesting changes for example in the social infrastructure, the information flow or the access to resources or technologies, among other; (2) the design team can test hypotheses of possible artifacts or interventions that could take place, those interventions can be suggested in the game as possible transformations to the game as a scenario.

The role of the design team in this case is to register as much information as possible either by video, photos and notes, to understand the underlying opportunities that could be suggested to the stakeholders based on the imperatives that emerge during the discussion.

3.4. Solutions

After the participation of the stakeholders on the abstract side of the process, the introduction of the stakeholders as part of the solutions is essential to close the innovation loop that we propose. At this point, the participants should feel some ownership over the proposed solutions. The connections between the previous steps, the contribution of the stakeholders and the solutions should be evident.

At this point the solutions should be tested with the participation of the stakeholders who were part of the previous three steps in an iterative process of defining the solution through prototypes. Initially, the prototypes can be as low fidelity as needed to make this process agile. Low fidelity prototypes also encourage the participation of stakeholders, as if they perceive the solutions as unfinished they will tend to intervene more and will also be more critical towards the proposed solution. The design team has to balance the fidelity of the prototype so it works as an artifact for proving the intervention but also invites the participants to propose changes, gradually increasing the fidelity of the prototype while specifying the solution.

We call these prototypes Participatory Prototypes, knowing that essentially every prototype should be participatory by default, but emphasizing that in this case the prototypes should encourage participation during the tests and not only the testing part of introducing them into the current practices to see how those are modified.

To sum up, our method consists on the participation of the stakeholders during the totality of the design process, starting with interviews, contextual inquiries and social cartographies, followed by games as scenarios for reflection in a process of gaining awareness, resulting in imperatives that are materialized in participatory prototypes that

redefine the current practices. With this we intend to bring the stakeholders through the entire learning process suggested by Beckman & Barry and Schön, transforming practices through knowledge, expecting a sustained loop of innovation.

4. The case

During the development of Río Mío (spanish for My River), a project that intends to modify artisanal mining practices in rural Colombia, we focused first on understanding the context in which rural miners work, their explicit and tacit knowledge about mining and the construction of practices around it. This understanding of the context helped us as external stakeholders to understand the codes inside the community we worked with and to initiate a participatory design process with a common language between the parts in order to find the path that could allow us and the other stakeholders to re-think and re-design practices around gold extraction, water use and sustainability in their territory.

The extraction of mining products in Colombia is widespread over the entire country. Coal, gold, emeralds, nickel, rock, sand and gravel among other, can be found in different places of the country. Most of these products, especially coal, gold and gravel, are localized near water sources, resulting in the pollution of drinkable water as a result of the deposition of residual materials and the destruction of important ecosystems. It is estimated that there are more than 14 thousand mines in total, from which 66% do not own a mining title, do not fully comply with the law and do not follow proper regulations; resulting in bad practices with immense ecological and social repercussions. As a consequence, these mines, that employ approximately 75 thousand people, generate 5 times more ecological impact than all legalized mines, which employ around 67 thousand people. Likewise, every year between 80 and 90 people die due to a mining accident. (Gueiza, 2013)

In the case of gold mining the extraction is carried out by: Multinational enterprises with license, big foreign mining companies that extract large amount of minerals each year using heavy machinery with the government's permission to work; legal national miners with license, groups of national miners that sometimes use heavy machinery and are attached to the regulations of their labor; illegal national miners without license, miners that extract minerals without permission, do not obey the regulations and sometimes are related to illegal armed groups; informal national miners, people who practice the extraction of minerals without heavy machinery and permission; and artisanal national miners, groups of miners that extract minerals with artisanal methods learned from generation to generation and without legal paperwork that guarantee their right to

extract. In many cases, many of these actors are situated in the same territory and interested on the extraction of the same source, resulting in social conflicts among them. The project Río Mío (Spanish for My River) is a way to explore, understand and intervene the resulting interactions and dynamics from the above mentioned problematics.

Due to accessibility reasons, we decided to do our observation phase in the Department of Risaralda, where the gold extraction practice is very common and 91% of the mining extraction is illegal or informal.

4.1. Observation

Our first field trip focused on mapping the different types of gold extraction in the region, the relationships between the mining communities, the hydric resources and the law; the stakeholders on the territories; and to find a community for developing the other 3 phases (frameworks, imperatives and solutions).

4.1.1. Interviews and contextual inquiries

We performed several interviews and contextual inquiries in three different parts of Risaralda. Mistrato was the first location we explored. After talking to several people about the possible mines and not receiving any answer about their existence and their location, we talked to a store owner, our contact and the reason why we went there. Contrary to what other people told us, he gave us the directions to arrive to the mine. Following the indications we arrived to one of Mistrato's gold mines, located five minutes from the road and over the riverside. In this mine we found two types of miners: illegal miners who use heavy machinery to extract material from the bottom of the river and then process it by gravimetric methods in order to separate the gold from the dirt and stones; and artisanal miners who use pans to separate the gold from other materials without causing damage to the riverside or the vegetation. Both were members of the Mining Association of Mistrato (Asomim).

Even if the connection with the community was good and they were open to sharing knowledge with us, we noticed a clear lack of trust toward us from some of the stakeholders. We were not allowed to take pictures and interviewing people was seen as suspicious. This general lack of trust was clearly stated by one of the miners in one of the interviews when he told us "I prefer to work alone because in this business you cannot trust anyone." (Interview with Ruben Darío, miner, translated by the author)

Our contextual inquiry helped us understand two problematics that could be faced: (1) on the environmental side, even though this mining community does not use mercury in their extraction process, the constant dredging of the river side had cause deforestation and the lost of a large quantity of native species. This is reflected on the loss of tropical rain forest replaced by grass; (2) on the social side, gold fever has attracted to the territory many outsiders, some of them related to armed groups outside the law that use the mining as a way to finance their operation.

The second location we visited was Quinchía, Risaralda. In this municipality gold mining is seen as a traditional activity because it has taken place since the indigenous communities lived in it, although it is now occupied by colonizers. Some of the several mining associations are working to guarantee the maintenance of their labor and becoming entirely legal (Figure 1). Likewise, a multinational mining enterprise has its offices here and is getting ready to start extracting gold using a mining title that covers also some of the mines of the traditional miners. The president of one of the associations that is menaced by the multinational company expressed his unconformity with the situation arguing that "they have been working that mine for more than 30 years and before them, their parents also worked there." (Interview with Fernando, president of Miraflores miners association, translated by the author) The multinational suggests to relocate the families that live and work there. They have the support of the government arguing that they will "begin gold cyanidation as soon as they start extraction" (Interview with Govanni, manager of the multinational company, translated by the author), but have against them that there are "263 miners, and gathering all the families they are around 1000 people" (Interview to



Fernando, president of Miraflores miners association, translated by the author).

Figure.1 Miners adjusting the mill during a contextual inquiry

The interviews and contextual inquiries showed us three problematics: (1) Even though this miners have being working in this mine generation after generation for more than 60 years their extraction techniques are artisanal and are considered illegal practices by the government. This means that is easier for the multinational enterprise to impose their extraction over the current miners association, generating a passive conflict between this two stakeholders for the mining license and the use of the land. (2) The inadequate use of mercury in the mine such as the dumping of this metal into the river and into the air constitute a problematic issue not only for the inhabitants of Quinchía but to the rest of the population that depends on this water. This problematic seems to be a consequence of the lack training of the artisanal miners in managing mercury or using other extraction methods that help them stop using this toxic metal. (3) The lack of organization of the artisanal miners and the constant work of the multinational to get their permission to extract gold is building a social crisis in the town. Inhabitants feel abandoned by the government and in imminent danger of losing their job and their home. This has also led to a passive conflict between this stakeholders in order to get the final permission over the use of the land.

The third and final community we visited was the indigenous reservation of San Lorenzo in Riosucio, Caldas. The principal economic activity that sustains the village is gold extraction. In the reservation gold is extracted from the mountains and from the river. Being an indigenous reservation they have an autonomous governance structure where a community council rules. All the activities that involve the community must be passed and approved by indigenous leaders, in order to protect their traditions and assess the entry of outsiders that may affect their current interactions and dynamics. The community was really closed to foreigners, and apart from the interview with the vice-governor that did not gave us much information to work with, and the interest shown by the local radio station, the only inquiry we conducted was with a colonizer who belonged to a group of miners that worked next to the river. Through this inquiry we identified the problematic of mercury use but we could not go deeper because of the lack of collaboration of the most powerful stakeholder, the indigenous council.

As a result of these interviews and inquiries, we considered the trust that all the stakeholders showed towards us in Quinchía, where the multinational company and the small cooperatives were open to work and share their knowledge. This location also had interesting social dynamics that motivated all the stakeholders to act towards a substantial change.



Figure.2 Social cartography

4.1.2. Social cartographies

In a second field trip to Quinchía we agreed with the community to develop a social cartography workshop as one of the steps needed to identify how to work as a team to follow the requests made by the government. We develop two workshops, the first one involved people from different mining groups and different mines from the municipality. The second one was in one of the mines in the township of Miraflores.

The first workshop took place in a restaurant near the town's church, this event was conducted with the support of Universidad de los Andes, the National University of Colombia and the Mines and Energy Ministry. With our intervention inhabitants of Quinchía, workers of mines in the territory and a member of the national police participated as a team to re-think the way their community responds to the ecological and social requirements made by the government.

The workshop started by a presentation from the Mines and Energy Ministry that exposed the informal situation of the gold mining communities from the municipality. During the workshop the participants were asked to answer the next questions: Which are the principal characteristics of your territory? What type of mining activity do you develop in your territory? Is it possible that the mining activities could help to develop of your territory? What are the socio-economical needs of your community? Which strategies should be integrated to the entrepreneurship model of your community? What is your

position about associating? Which activities would you prioritize in order to construct a mining entrepreneurship?

To the second workshop (developed near the mine) attended 70 persons (miners and their families). This time the activity focused on reconstructing the past, describing the present and designing the future (ten years from now) while drawing a map of their territory.

During this activities, drawing the interactions, dilemmas and conflicts in the territory helped the participants to tangibilize their tacit knowledge over a map, making evident the capitals exchange between the different actors and possible future interactions that could take place in Miraflores (figure 2). After making the maps each group publicly exposed them to us and to the rest of the community, clarifying their dreams, fears and ideas for future projects.

As a result of these cartographies, and as an example of our outcomes, one of the miners made the observation that they "have the gold, and therefore they have the money to transform their practice without the need of the government." (Social cartography, reflection of Juan Romero, translated by the author) All this tacit information helped us and the other participants to understand in deep all the needs, problems and opportunities in the territory. It was a priority for us to translate all the acquired data into tangible information that could be used as a reflection tool for the miners, a tool that can help them visualize from the outside all the interactions in their territory in order to identify and design by themselves solutions to their dilemmas and a route to achieving a formal practice.

4.2. The framework

Based on the discoveries made during the observation phase, we constructed a collaborative game. Although the game follows the pattern of a cooperative game, it is not made explicit during the setting of the game, and other patterns of game are also open for the players to decide how do they want to face the challenge, allowing them to reflect on their organization as a team, although the easiest way of facing the challenge is to use the collaborative game pattern. The contextual inquiries showed us 3 phases during the gold extraction practice: (1) extracting ore, (2) milling the ore to get the gold and (3) selling the gold. Some of the miners have these 3 phases clearly defined during a week time, others do it daily, depending on the amount of material they gather. Thus, the game has 3 parts, each one of them for a different phase of the production cycle. To encourage the participants to reflect about their practice we included elements that would make the

participants make decisions and experience how they could achieve a holistic change. Some of the factors that can be modified are the possibility to improve their extraction activities, their safety, to switch technologies, fomenting the understanding of how to be more environmentally and socially responsible and to value cooperative work. (NAVARRO-SANINT, 2015)

4.3. Imperatives

During gameplay, one of the participants expresses that by playing "you can see how you work the mine. If you work it well or not." (Miner observation during gameplay, translated by the author), another miner highlights that they have to join and "start a company" (Miner observation during gameplay, translated by the author) in order to win. This suggests a change on the way they associate and the way they manage their resources. What the game shows is the need of a collaborative use of resources.

The game also worked for us as a way of testing the perception towards the existence of a device that could inform them about the presence of mercury in water. As water is extracted while being blindfolded, polluted water can be extracted, losing health points in the game and altering the miners capacity to extract gold. The idea of being able to perceive the quality of the water before using it is well received by the stakeholders not only because it could have a positive impact in their health, but also because it is seen as a tool that could allow them to identify how much they are polluting and, in case that they do manage to change their practice towards a more environmentally friendly one, it could help them show that they are no longer polluting, giving them a political advantage over the multinational company.

Likewise, one of the miners suggests the construction of different machines that could extract gold through gravimetry, profiting from the local capacity of producing their own mills and machinery for extracting and processing ore.



Figure.3 Monitoring device in context

4.4 The solutions

From the different solutions proposed by the miners we continued with the initial intervention that we explored during the game. An artifact that could allow the stakeholders to measure the presence of mercury in water. The initial approach was using PH colorimetric tests. These were used with miners directly in the mines. With them we wanted to explore the possibility of using colorimetric tests to understand water quality. Even if the PH test did not give any information related to the potability of water, the miners participated actively in the prototype, measuring in different points of the canal that goes out of the gold extraction facilities. The interest from the miners on the artifact was real. Therefore, for our following visit we built an artifact that used a colorimetric sample to identify mercury in water and save it on a database with the location and time (Figure 3). This device was tested with one of the miners who decided to perform different tests in different ravines in the area, suspecting that some of them might not be polluted because of the lack of residual mining water flowing into them. Water appeared to be polluted in all the ravines in the area, although some of the water was less polluted than other. The device allowed him to explore the quality of the water and to perceive the magnitude of the problem. This miner was encouraged to construct machines that could

provide the rest of his community with solutions that do not imply the use of mercury. With the participation of his family, he started to create prototypes of those machines using the accumulated knowledge he has.

5. Conclusions

Even if communities have a continuous transformation, we consider that with the proposed method design can facilitate that process. As we have seen, when an extractive community gets familiarized with its techniques they stay in their comfort zone and their practices stagnate. The involvement of stakeholders in these projects results in the reactivation of innovation in their practices.

Our experience showed us some things that should be considered when doing this kind of interventions: (1) to achieve a real transformation of social practices people should be aware of their current practices, should recognize how they could be better and should be willing to change; (2) the perception of ownership over the created artifact eases the introduction of the artifact into peoples practices; (3) to integrate artifacts into people's practices it is desirable that the end users takes part on the design process and participate actively on key decisions about the artifact in context. This can be done by using prototypes; (4) as sustainability is often related to long term impact of practices, the use of scenarios can contract time and expose the possible consequences of a certain practice, this was evident during the game as in a short time miners could relate to the social and environmental impact of their practices.

To conclude, the use of the proposed method showed to be pertinent in this kind of complex situations. Design things did worked as a way to create reflection in the participating practitioners raising awareness towards current practices. The participation of the stakeholders in the totality of the design process did prove to have a positive impact on the construction of learning systems, constructing knowledge and encouraging a constant innovation process. Nevertheless, this is an initial exploration of these tools in this projects. Some more projects should explore it more in order to build on our findings and expand the spectrum of tools that could be used on each of the phases.

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