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Abstract

Environmental issues are complex and malicious problems involving many characteristics, variables, increasing their level of uncertainty. While accompanying groups in solving their environmental problems, it is important to develop collaborative and creative approaches to properly define the problem at hand. In Morocco, flooding combined with climate change is damaging the drinking water supply system. The victims of this problem are searching for adaptation strategies. Design thinking and Facebook were selected as the methods to guide ten Moroccan women in solving a problem with flooding. Design thinking encourages a needs analysis, abductive reasoning, and rapid prototyping. Digital tools, such as Facebook, can also help with problem definition, discussion, and solution development. Through the use of videos and pictures, the women shared their flood experience on Facebook and together solved the issue of poor drinking water as they were guided through the steps of design thinking. The experience allowed the women to broaden their definition of the problem and prototype various water purification solutions that demonstrated potential. The women developed a sense of collaboration and carried out flood adaptation strategies.

Diane Pruneau

Faculté des sciences de l'éducation

Université de Moncton, Moncton, NB, Canada, E1A 3E9

e-mail: diane.pruneau@umoncton.ca

Boutaina El Jai

Faculté des sciences de l'éducation

Université de Moncton, Moncton, NB, Canada, E1A 3E9

e-mail: boutaina.el.jai@umoncton.ca

Abdellatif Khattabi

École Nationale Forestière d'Ingénieurs, BP 511, Tabriquet, Salé, Maroc

e-mail: ab_khattabi@yahoo.com

Sara Benbrahim

École Nationale Forestière d'Ingénieurs, BP 511, Tabriquet, Salé, Maroc

e-mail: benbrahimsara92@gmail.com

Joanne Langis

Faculté des sciences de l'éducation

Université de Moncton, Moncton, NB, Canada, E1A 3E9

e-mail: langisj@umoncton.ca

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1 Introduction

Millions of people are currently feeling the impacts of environmental degradation. When confronted by floods or droughts, for example, they must find ways to mitigate risks to their health, their families, and their property. Through the work of subsidized projects, diverse organizations guide those people in solving the problems with which they are faced. For instance, scientists working with social groups reflect on flood adaptation strategies. All of the contributors aim to help these groups recapture their quality of life and a healthy and viable environment. What is the best approach to facilitate the development of original, effective, and realistic solutions among victims of environmental problems? Indeed, external stakeholders have a poor understanding of the victims' experiences, context or the cultural and material constraints. A **collaborative** problem-solving approach imposes itself such that the issues must be defined and solved together by the affected persons and their guides. In addition, these complex and malicious problems encompass a wide range of characteristics (causes, area, actors, impacts..., Pruneau and Langis, 2015), interdependent variables (Jonassen, 2000), that change rapidly and increase their level of uncertainty and difficulty (Pourdehnad et al., 2011). For these problems, there are neither rules nor a list of possible actions that might facilitate finding solutions. Environmental problem-solving requires defining and redefining its structure and aspects in both detailed and systematic manners (Irwin, 2000; Thakker, 2012). According to English (1997), **defining** a problem consists of properly formulating it in order to solve it. The advantages of a well-defined environmental problem are varied: having a clear idea of what is sought; identifying relevant information; reducing the sense of disorientation; and, applying effective solutions (Pruneau et al., 2015). Indeed, Stoyanova (2000) posits that while defining the problem, the resolver interprets the problematic situation in his own words, rearranging information linked to the issue, and frames the problem statement a number of times in order to make it clear and identify the challenges and objectives of solving it. In some ways, the resolver is taking personal ownership of the problem and using specific

wording to help solve it. This is a difficult task to accomplish. To **define** a problem, the resolver relies on his knowledge, combines ideas, reasons, makes abstractions, questions, synthesizes, evaluates, and visualizes the information that was discovered (Pruneau et al., 2015). Various aspects of environmental problems must be considered: causes, time, actors involved, impacts, duration, the nature of the problems, and their social and scientific aspects, both quantitative and qualitative (Pruneau et al., 2015). Thus, when we accompany victims of an environmental disaster, it is desirable to follow an **approach that fosters a broadened definition of the problem.**

Moreover, a creative approach and an effort to understand the short and long term impacts are recommended (Dos Santos, 2010). Indeed, **creative** problem-solving is vital in tackling global issues such as climate change, pollution, or environmental diseases. As mentioned by United Nations (2015) in their new Sustainable Development Goals (for 2015-2030), different and new practices are needed in today's world: renewable energy, efficient transportation, healthy cities, resilient agricultural systems, etc. When accompanying groups in solving their environmental problems, it is important to develop **collaborative and creative approaches promoting the best possible definition of the situations that may arise.**

To build these support processes, the literature offers two types of problem-solving approaches: the scientific approach by which we discover the laws that govern the natural world and, more recently, design thinking with which we invent a different future (Liedtka, 2000). The scientific approach calls upon inductive and deductive reasoning to solve closed problems such as researching the position of a star in a given annual period. In the scientific approach, problem-solvers are distanced from the object of study (Dos Santos, 2010). However, when solving complex problems such as identifying climate change adaptation strategies, it is necessary to add another competence: abductive thinking, which consists of imagining things that could work. Design thinking, during which the problem-solvers immerse themselves in the object of study's environment, calls upon inductive, deductive, and abductive reasoning. It would be productive in situations where there is uncertainty. In 2006, IDEO launched a creative problem-solving approach called *design thinking*. Since then, this approach of innovation, adopted by numerous corporations, fostered the development of efficient and original products: ICT applications (Apple computer mouse); engineering and scientific articles; educational innovation. IDEO also inspired the development of a number of creative problem-solving approaches: the Innovation Lab, Strategic Design, Transformational Design, Human-Centered Design... Design thinking is a creative and collaborative method of working in which intuition plays an important role, solutions are numerous, experimentation happens rapidly, failures are perceived as learning opportunities and, mostly, the needs of consumers are considered (Liedtka and Ogilvie, 2011; Lockwood, 2010). Design thinking applies the sensibilities and methods of the designer to complex problem-solving. Indeed, designers routinely deal with complex problems by generating various options that are progressively refined through testing. As part of a rigorous process, and with the use of well-defined tools, design thinking calls upon both creative and analytical thinking (Liedtka, 2015). It follows a number of defined steps: 1. Observation-inspiration: we conduct an ethnographic study to understand the individuals concerned with the issue and

the situation. This is achieved by following them in their daily lives to better grasp their aspirations and unmet needs (pain points). 2. Synthesis: the problem is defined and redefined several times and in different ways. The goal is to uncover information and various perspectives on the problem. The information is synthesised to express the problem in concise statements and with the use of visual aids. 3. Ideation: we generate a number of ideas and select a certain number. 4. Prototyping: we quickly build prototypes to illustrate the proposed ideas and share them with others to evaluate their potential in both form and function. 5. Testing: the prototypes are assessed by gathering the opinions of experts, novices, and users. The winning prototypes are refined (Scheer et al., 2012). 6. Communication: we make the product known (Brown, 2009). Seidel and Fixson (2013) summarise the design thinking process in the following way: extensive research on consumer needs; brainstorming to generate a number of ideas; and, prototyping to test and select the best ideas. The steps in design thinking are not entirely linear since the focus of designers meanders between the problem and the solution while empathy for consumer needs deepens and the best solution is refined. The process – which is first divergent and then convergent – is centered on human needs. Prototypes that are developed quickly and without seeking perfection become “playing fields” that foster discussion and learning about certain solutions (Liedtka, 2015). As such, the problem and the solutions co-evolve (Dorst and Cross, 2011).

Design thinking – initially used to develop commercial products – is now used to foster human flourishing and environmental health. Among movements such as *Design for Life* (Buchanan, 2001) and *Human-Centered Design*, and NGOs such as *IDEO.org* and *MindLab*, the focus is on developing processes favourable to quality of life and the eradication of poverty. Accompanied by these organizations, individuals grappling with these issues collaborate during some of the design thinking steps (steps 1 and 5, and sometimes more). The positive environmental transformation and humanitarian effort are thus recently at the heart of design. Because of the deductive, inductive, and abductive (imagining what *could* be) reasoning that places demands and potentiates the development of creative solutions, design thinking and its variations (Innovation Labs, Transformational Design...) may be useful as support processes for groups engaged in solving environmental problems (Pruneau and Langis, 2015). Indeed, Pruneau et al. (2014) have typically observed the presence of design thinking among numerous leaders in sustainable development.

Moreover, with design thinking, specialists now have access to technological tools that support citizens in problem-solving at times when they are remote. Indeed, there are current ICTs that might be used during different stages of problem-solving: to share opinions and information about a situation (*Stormboard, Narrative Clip*); to summarise information (*Popplet*); to consult experts (*Skype*); to propose and comment on ideas (*Padlet*); to vote (choose among ideas, *Loomio*); to sketch prototypes (*iDroo*); to plan (*Wrike*); and, to communicate (*Facebook, Glogster*) (Pruneau and Langis, 2015). Some research has demonstrated the potential of online brainstorming: quick, independent, and simultaneous sharing of ideas; motivation; time to reflect and allow ideas to ripen; creativity... (DeRosa et al., 2007). Digital tools used in design thinking have yet to be

properly evaluated with respect to their ability to facilitate problem-solving in general or for environmental problems.

The strengths of design thinking could indeed be found in its deeper definition of the issue under consideration; in taking real customer needs into account; in its prototyping (which allows for the optimal development of ideas); and, in a better consumer adoption of the solutions found. Given its novelty, design thinking and its enablers have not yet been properly studied, particularly in collaborative environmental problem-solving. It is thus within the scope of this reflection on accompanying citizens facing environmental problems that an exploratory case study was led in Morocco with low education rural women grappling with devastating floods. Leveraging design thinking and Facebook as a networking tool, ten women from the Ourika region were accompanied in their research on adapting to the frequent flooding of the river. The two research questions that were asked in this exploratory and descriptive case study were the following:

- *How could design thinking help groups define and solve environmental problems with which they are faced?*
- *How could Facebook facilitate collaborative environmental problem-solving?*

2 Methodology

To answer the research questions within the context of the major GIREPSE (*Gestion intégrée des ressources en eau & paiement des services environnementaux*) project, an exploratory and descriptive case study in Morocco was carried out with women from the remote and impoverished Ourika region. The GIREPSE project is most closely related to three of the Sustainable Development Goals adopted by the United Nations (2015): 5. Gender equality; 6. Clean water and, 13. Climate action. This project involved accompanying the women using design thinking and Facebook, and observing how these two approaches would allow them to collaborate in defining and solving a flooding problem. Ten women were selected based on their reading and writing abilities (minimal) and hailed from six remote villages (Aghbalou, Timalizen, Amlougi, Oualmes, Tazitount and Setti Fatma) located in the Ourika region, approximately 35 kms from Marrakech. The regional economy in Ourika is based primarily on agriculture and livestock breeding. Industry and mining, tourism, and the arts also make up an important part of the labour force. Over the past few years, floods of the Ourika wadi have increased in frequency and intensity in conjunction with climate change. These floods have devastating effects on the landscape, agriculture, human capital (injuries, deaths), infrastructure (roads, bridges), and food security (water, food). The women, who are the family guardians while their husbands work in Marrakech, are often tasked with confronting the floods and protecting their families and property.

The interventions with the women took place over a period of seven months, during which two minor floods of the Ourika occurred. The design thinking approach dictated the activities organised with the women, and Facebook was used for networking while we were away from the women. During the first two phases of design thinking (*observation-*

inspiration and *synthesis*), individual interviews were conducted with the women to capture their descriptions of the major flooding problem and their needs in the face of disaster. A *Journey Map* visually representing their daily life before, during, and after a flood was prepared by our team of researchers. In preparing for floods, the women said they stored wood and food staples (wheat, oil, vegetables...) to avoid a shortage in the case of road closures. They lay plastic on the roof of their houses and filled the holes with dirt to prevent water leakage. Some dug small canals in front of the house to divert the current and prevent water from invading the house. During flooding, they moved family belongings to a room that was less prone to immersion, and some took their children and sought refuge with neighbours or acquaintances. Following the floods, they cleared the roads covered in rocks and dealt with problems in the water supply. Indeed, the sediment-laden water was placed in plastic jugs so the debris could settle at the bottom. After settling, the water was then consumed or used for other domestic purposes.

During the two initial two-day workshops with the 10 women in August 2015, the *observation-inspiration* and *synthesis* phases of design thinking were put to the test and facilitated in Arabic by a researcher from our team. The women were encouraged to complete the previously prepared *Journey Map* together and share their experiences of the flood. They were also trained on how to use tablets and Facebook. Next they chose to work on a smaller problem that was easier to solve: the quality of their drinking water following a flood. The exchanges on Facebook stretched from September to November with communication flowing through the social network between the women and our team about the underlying problem of post-flood drinking water. At the outset, the women were asked to post pictures, videos, and comments on Facebook about flooding (in general). Next, the women were asked specific questions in order to define the underlying problem of water quality after flooding: *Where? When? Why? Impacts? Solutions?* etc. The women were to observe the problem in their village and answer the questions using the tools available on Facebook: comments, videos, pictures... The women met again for the third workshop, held on one day in November 2015, to complete the *synthesis, ideation, prototyping, and testing* phases of design thinking on the issue of water quality. During this workshop, a summary of the facets of the drinking water problem and solutions proposed on Facebook was completed. Water collected from the wadi in the villages was then tested with the women for its quality: pH, coliform, bacteria, etc. The women were also invited to invent filter prototypes by using materials available in or around their homes: fabric, coal, plastic bottles, sand, rocks... They were also required to verify the filter's ability to purify the water. Following the third workshop, the Facebook exchanges resumed from November to January and planned according to the *prototyping, testing, and communication* stages of design thinking. The women tried to construct their own filters at home and shared their trials on Facebook so they could receive feedback from their peers. On Facebook, an overall assessment of the solutions identified concluded the exercise.

In order to address the two research questions during the design thinking process, individual and group interviews were conducted with the women, and their use of Facebook was analysed. During the interviews, the women were asked open-ended questions. Here are some examples: *Tell me about your experience with Facebook since*

the beginning of the GIREPSE project. What do you like about the Facebook group? What value do you feel is added by using tablets for the GIREPSE project? How do you feel the Facebook group helps in solving the problem of drinking water following floods? etc.

The conceptual framework that prompted the analysis focused on the benefits from the chosen support measures (design thinking and Facebook). Did design thinking – equipped with Facebook – encourage collaboration, a broadened definition of the potable water issue, and creativity in developing solutions?

In order to observe how the women collaborated in solving the main flooding problem and the related drinking water issue, a table was developed using social media participation indicators proposed by Garau (2013): total number of posts over a given period of time; activity type (images, videos, text); mean number of comments per post; and, mean number of “likes” per post.

As a means of analyzing the women’s definition (whether broadened or not) of the potable water issue, interview data and Facebook posts underwent a thematic analysis (Paillé and Mucchielli, 2008) by two researchers both on an individual and combined basis. The themes identified by the thematic analysis were how the women represented the drinking water issue as well as the types of learning they stated having achieved together.

The creativity behind what the women proposed as solutions to the drinking water issue was evaluated by two researchers (triangulation of analysts) based on fluidity, originality, and feasibility, as proposed by Torrance (2008). According to Amégan (1993), fluidity is the resolver’s ability “to have a fast flow of ideas; to think of more things, ideas, and questions; to consider the greatest number of possible solutions in a given amount of time when faced with a particular problem,” (p. 25). Torrance and Goff (1999) define originality as the ability to produce new, innovative, and unusual ideas, while Torrance (2008) suggests it is ideas that are statistically rare. Fluidity and originality allow the assessment of divergent production (creativity), while feasibility is used to evaluate the extent to which proposed solutions can be put into practice and solve the problem. To assess the participants’ solutions, the researchers – individually and then combined – scored each creativity criteria from 0 to 2. The fluidity score was awarded based on the number of pertinent solutions linked to the requested task. The originality score was awarded based on the novelty of the proposed solutions (as perceived by the researchers). The feasibility score was awarded according to two indicators: achievability (1) and effectiveness (1). Achievability was considered in relation to the local availability of materials as well as human and material resources to develop the solution, while effectiveness was determined by evaluating the potential improvement to water quality as a result of the proposed solution. The mean creativity score was then calculated for all participants’ solutions by taking the total fluidity, feasibility, and originality scores of the eight solutions (44), and dividing it by the maximum possible score (48).

One limitation of this research has been what we generally associate with exploratory and descriptive studies, namely the poor generalizability of the results to other cases or regions. In sustainability research, on the other hand, exploratory or descriptive case studies are recommended by Evans (2011) and Yin (2009) as reliable and useful methods to observe ground-breaking initiatives that highlight the practical benefits to the participants. Another limitation was the result of a budget allowing only a limited number of in-person meetings with the women to build and assess prototypes in a team setting.

3.1 Results: the women’s participation in the Facebook group

First of all, it should be noted that the effects of the selected method (design thinking) along with Facebook might be difficult to differentiate as they are complementary tools. Table 1 shows qualitative and quantitative data on the women’s participation in the Facebook network.

Table 1 Women’s participation in the Facebook network

Month/ week	Total number of posts	Type of activity on the Facebook group (pictures, videos, text...)	Average number of comments per post	Average number of “likes” per post
August				
Week 1	3	Pictures and videos	2	4
Week 2	19	Pictures and videos	2	5
Week 3 up to the 31st	17	Pictures, videos, and text	1	12
September				
Week 1	3	Pictures, videos, and text	6	15
Week 2	4	Pictures, videos, and text	8	3
Week 3	4	Pictures, videos, and text	5	3
Week 4	13	Pictures, videos, and text	4	7
October				
Week 1	3	Pictures and text	9	3
Week 2	2	Text	10	3
Week 3	1	Text	25	4
Week 4	1	Text	10	3
November				
Week 1	1	Text	6	5
Week 2	2	Text	9	2
Week 3	Workshop	Workshop in Morocco	Workshop in	Workshop in

	in Morocco		Morocco	Morocco
Week 4	8	Text and pictures	1	5
December				
Week 1	1	Text	2	4
Week 2	3	Text, videos	6	3
Week 3	5	Pictures and videos	3	4
Week 4 up to the 31st	4	Text and pictures	4	3
January				
Week 1	10	Text, pictures, and videos	5	3
Week 2	9	Pictures and videos	5	6
Week 3	6	Pictures and videos	3	3
Week 4	5	Text and pictures	5	5

As demonstrated in Table 1, these women with low levels of formal education were for the most part able to take advantage of various tools available on Facebook – pictures, videos, text, comments, “likes” – and did so regularly. The posts with pictures and videos showing the reality of the two major floods were very popular. The women seemed mostly happy to share, with the help of photos and short videos, the scope and the impacts of the floods in their respective regions. They also chose photos and videos to illustrate the prototypes of the filters that each of them built. Writing texts describing the various aspects of the problem (regions, causes, impacts...) was a challenge for these poorly educated women but they nonetheless actively participated to the gradual definition of the problem by answering to the best of their abilities to weekly questions. Comments on other women’s posts, as well as « Likes » were more abundant at the beginning of the Facebook Group’s existence. At the end of the seven-month period devoted to the problems with their drinking water, motivation to participate to the Facebook Group seemed to have decreased, except following another flood in the Ourika. This flood triggered postings of new videos and photos from some participants.

3.2 Results: collaborative learning as reported by the women

Table 2 shows the main collaborative learning that participants said were made during the project

Table 2 Collaborative learning reported by the women

Types of learning	Acquirements
Techniques	- Use tablets and Facebook to communicate
Environmental	- Expand their knowledge on the water quality - Became aware of the poor quality of their drinking water - Accomplished flood adaptation measures : better choose their

	water source, improve water filtration, alert others when a flood arises.
Geographic	<ul style="list-style-type: none"> - Know the other villages and what is happening with their water - Learn what is going on in the world and in their country
Social	<ul style="list-style-type: none"> - Make new friends - Be part of a network that wants to improve the future of villagers - Communicate one's ideas and feel like you are being heard
Practical	<ul style="list-style-type: none"> - Better choose their water source - Know how to clean and conserve their water

During individual and group interviews, the women shared with us that the input from the other women and the facilitators helped them learn a number of things: learning how to use tablets and Facebook; gaining a detailed understanding of the problem with water quality; knowing what was happening with water in other villages; becoming aware of the poor quality of water they consume; having solutions; being able to choose better water sources; learning how to purify and conserve their water; and, gaining an awareness of what is happening in their country and in the world. With respect to communication, they mentioned feeling less isolated and part of a friendly network sharing news about themselves while collaborating on adapting to flood conditions. Indeed, when a flood is about to occur, women living upstream warn those living downstream of the incoming flood. The women also privately share their views on a range of local issues. On an emotional level and linked with empowerment, they mention how much they enjoy sharing their ideas with the group and being heard. They also state feeling motivated and capable of getting involved in solving other problems, such as the polluting behaviors of fellow citizens who toss their household refuse into the Ourika and ruptured drinking water pipes during floods. They would also like to pursue the approach initiated by the group to improve flood adaptation. Lastly, they enjoy sharing what they have learned with their families, friends, and fellow citizens from the village.

3.3 Results: representations of the water quality problem

We noticed a growth in the way in which the women discussed and understood the major flooding problem and underlying water quality issue after a flood occurs. They now identify various aspects about the nature of the problem (the Why): “The floods arrive suddenly and take away everything in their path.” “The heavy rains and floods destroy the drinking water pipes in the villages.” “Water becomes unavailable. We must drink dirty water from the wadi or find other sources.” “After the floods, the water is highly polluted. Its colour and odour change.” “The traditional methods (purifying water by adding chlorinated water and allowing it to settle) are ineffective.” They are aware of several impacts due to flooding: “Despite its poor quality, residents use well-water for drinking and cooking. After consuming it, some residents – especially children and the

elderly – suffer from fever, diarrhea, kidney and stomach infections, allergies...” They know about new causes of poor quality drinking water: “The floods carry rocks and sediment which dirty the water.” “People toss garbage on the riverbank. It is worse during tourist season and near restaurants. The garbage mixes in with the flood water.” Finally, they have a lot more to say about the aftermath of a flood: “After a flood, the water remains polluted for a week or more depending on the weather conditions.” “The pipes are left broken for about fifteen days.” “The water is dirty even after the pipes are repaired.”

This growth in their understanding of the problem-space seemed to directly influence the solutions they proposed on Facebook. Here are a few examples: “Find better water sources.” “Build a water storage structure to ensure delivery to residences.” “Treat well-water with appropriate quantities of chlorinated water.” “Raise awareness so people stop dumping garbage in the river.” “Build solid pipelines.” “Build wells far from the river and flood zones.” “Filter the water before it reaches the tap.” We notice that some of their solutions are aiming to eliminate causes of the problem (proactive adaptation) while others are in reaction to the impacts of the problem (reactive adaptation), which demonstrates a deepened understanding of the problem that needs to be addressed.

In meeting the challenge of purifying contaminated water using handicraft filters made from household materials, the women built prototypes that turned out to be moderately effective (according to us). The prototypes built by the women made the water a lot clearer but did not necessarily eliminate coliform and bacteria. Here is an illustration of a typical filter built by the women using a plastic bottle, a sieve, coal, sand, stones, and fabric (see Figure 1).

Fig. 1 Example of a filter prototype built by the participants



In this case, it turned out to be a significant challenge, given the poor variety of filtering materials available in the Ourika houses and given the limited scientific knowledge of the

participants. However, the women claimed to be satisfied with the new filtration methods since, prior to this, they would simply let the water settle and consume it immediately, which was making the children sick. When the water becomes polluted during future floods, they claim that they will use these types of filters and these raw materials to purify the water. The filters as constructed do not entirely satisfy the research team but seem to please the study's participants.

3.4 Results: analysis of the creativity of solutions proposed by the women

Table 3 displays the research team's assessment of the creativity of solutions proposed by the participants. Recall that three indicators were used to evaluate creativity: fluidity, feasibility, and originality. Given the chosen assessment scheme, the mean creativity score for all solutions was 91.7%.

Table 3 : Creativity scores for the participants' solutions as given by the research team

Water quality solutions proposed by the participants	Fluidity score (/2)	Feasibility score (achievability + effectiveness) (/2)	Originality score (/2)	Mean creativity score (for all solutions) (/100)
Find better water sources	2 / 2	2 / 2	2 / 2	91.7%
Build water storage structures to ensure home distribution	2 / 2	2 / 2	2 / 2	
Treat well water with appropriate quantities of chlorine	2 / 2	2 / 2	1 / 2	
Educate the public so they avoid throwing their trash in the river	2 / 2	2 / 2	2 / 2	
Build solid pipes	2 / 2	2 / 2	1 / 2	
Build wells far away from the river and flood zones	2 / 2	2 / 2	2 / 2	

Filter water before it reaches the tap	2 / 2	2 / 2	2 / 2	
Use filters superimposed with sand, rocks, coal, and tissue in plastic containers	2 / 2	1 / 2 (2 for achievability and 1 for effectiveness)	1 / 2	

Given the variety of valid solutions proposed by the participants, the research team gave all solutions a fluidity score of 2/2. Across the eight solutions, feasibility also often received a high score (generally 2/2 with one solution receiving 1/2). All proposed solutions appeared to be more or less achievable with the equipment and human and material resources available in the region, and could effectively contribute to improving water quality. Given the unique nature of the solutions proposed for the region, most solutions received elevated scores (2/2) for originality, except for solidification of pipes and filter prototypes, which both received scores of 1/2. In fact, the filters did not entirely satisfy the research team even though the participants appeared quite pleased with them. We considered that the women did not really develop an innovative filter, but rather variations of the prototype developed during Workshop number 4. The women essentially rearranged the coal, rocks, sand, tissue, and plastic containers in different configurations.

4 Conclusion

The guided approach with Moroccan participants aimed to broaden the scope of issues under examination through collaboration and creativity. Following the results demonstrated above, we can posit that the approach used (design thinking + Facebook) allowed the women to collaborate on a broadened definition of the main flooding problem and related drinking water quality problem according to their experiences and their needs.

While not necessarily original, the solutions proposed by the women were varied (fluidity), realistic, and with a good level of efficacy (according to them and to us). The tablets and Facebook fostered the creation of a social network that was strong, engaging, and effective in defining and solving a local problem in a collaborative way. The women came out of isolation, learned to communicate their ideas, felt like others were listening, and collaborated well. Thanks to the social network and workshops, they learned a number of things such as the flow and precise locations of the floods, the causes, the impacts (both short and long term), the ways in which other women managed water, the quality of the water they consumed, as well as techniques to purify and conserve drinking

water. Prototyping water filters seems to have motivated them to learn and act locally. The approach in general modified their water consumption behaviours. They established proactive and reactive adaptations to flooding: better choice of water sources; better water filtering; building a support network; and, warning others when floods are arriving. Finally, the project fostered a sense of self-efficacy among the participants: they believe that together, they can make a difference in their way of life.

To deal with floods and their impacts, the women will need to gradually address other underlying problems related to flooding: ruptures in drinking water pipes; the behaviour of citizens who toss their garbage into the river; the possibility of deviating the water flow so that flooding bypasses villages... all of which demonstrate the significant complexity of environmental problems and the tremendous challenges when trying to adapt to extreme weather events caused by climate change. This project reinforces our opinion that solving problems linked to climate change requires a mentoring approach that is detailed, creative, and engaging that stretches over a long period of time since new underlying problems appear while trying to solve the primary one. Given the difficulty in solving environmental problems, design thinking facilitated by a Facebook group as demonstrated appears to provide good results and fosters numerous solutions, which are not perfectly effective, but improve the women's ability to adapt to flooding. According to us, in a country where women are largely unrecognised for their ability to solve problems, the combination of design thinking and Facebook allows the women to express themselves and be heard. However, we believe that the empowerment of our female participants still requires more time to be fully realised and perceived by their peers.

Other case studies should be conducted in order to strengthen the results of our study and, over time, identify the steps, instructional interventions, and communication tools that foster the development of effective environmental solutions using design thinking.

However, this research reinforces the idea promoted by the International Telecommunication Union (2015): ICTs could facilitate the achievement of the Sustainable Development Goals (SDGs). They could empower people, particularly women, by reinforcing their capacities to solve their problems and to resist to climate change. Mazman and Usluel (2010), Ajjan and Hartshorne (2008), Barron (2006) and Mason (2006) argue that Facebook is potentially beneficial for interaction, collaboration, information, resource sharing and problem solving. In this case study, Facebook was mainly used as a communication tool, and mostly in the problem space, to share opinions, information, and solutions related to one issue. Future research should focus on discovering ways to leverage Facebook for other uses linked to problem-solving with design thinking: summarising information, consulting experts, voting (choosing among different ideas), and planning tangible on-site adaptation strategies. This would bolster all steps of design thinking and allow deeper work in the solution space, which may result in original and more effective solutions. To increase creativity, other online brainstorming tools (*Padlet, Popplet, Mind 42, Loomio...*) might be used favorably in solving environmental problems, which was not possible in the current research given the novice ICT abilities of our participants.

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References

- Ajjan H, Hartshorne R (2008) Investigating faculty decisions to adopt Web 2.0 technologies: Theory and empirical tests. *The Internet and Higher Education* 11(2):71–80
- Amégan S (1993) *Pour une pédagogie active et créative*. Presses de l'Université du Québec, Sainte-Foy, QC
- Barron B (2006) Interest and self-sustained learning as catalysts of development: a learning ecology perspective. *Human Development* 49(4):193-224
- Brown T (2009) *Change by design: How design thinking transforms organizations and inspires innovation*. Harper Collins, New York
- Buchanan R (2001) Human dignity and human rights: Thoughts on the principles of human-centered design. *Design Issues* 17(3):35-39
- DeRosa DM, Smith CM, Hantula DA (2007) The medium matters: Mining the long-promised merit of group interaction in creative idea generation tasks in a meta-analysis of the electronic group brainstorming literature. *Computers in Human Behavior* 23(3):1549-1581
- Dorst K, Cross N (2001) Creativity in the design process. *Design Studies* 22(5):425-443
- Dos Santos M (2010) Sustainable development requires an integrated design discipline to address unique problems. *Triple C: Cognition, Communication, Cooperation* 8(1):28-35
- English LD (1997) The development of fifth-grade children's problem-posing abilities. *Educational Studies in Mathematics* 34(3):183-217.
- Evans R (2011) Case study method in sustainability research. In: Franklin A, Blyton P (Eds) *Researching sustainability*. Earthscan, London. pp 54-70
- Garau C (2013) *Optimizing public participation through ICT and social networks: Questions and challenges*. Reviewed paper, University of Cagliari, Faculty of Architecture, DICAAR – Department of Civil and Environmental Engineering and Architecture, Cagliari, Italy.
- International Telecommunication Union (2015) *ICTs for Sustainable World*. Online: <http://www.un.org/sustainabledevelopment/blog/2015/10/icts-for-a-sustainable-world> (Last Accessed 25 May 2016)
- Irwin T (2000) Design for a sustainable future. In: McNall SG, Hershauer JC, Basile G (Eds) *The business of sustainability: Trends, policies, practices and stories of success*. ABC-Clio, Santa Barbara, CA. pp 226-278
- Jonassen DH (2000) Toward a design theory of problem solving. *Educational Technology Research and Development* 48(4):63-85
- Liedtka J (2000) In defense of strategy as design. *California Management Review* 42(3):8-30
- Liedtka J (2015) Perspective: Linking design thinking with innovation outcome through cognitive bias reduction. *Journal of Product Innovation management* 32(6):925-938
- Liedtka J, Ogilvie T (2011) *Designing for growth*. Columbia Business Press, New York
- Lockwood T (2010) *Design thinking*. Alworth Communications, New York
- Mason R (2006) Learning technologies for adult continuing education. *Studies in Continuing Education* 28(2):121–133
- Mazman S G, Usluel Y K (2010) Modeling educational usage of Facebook. *Computers and Education* 55(2):444–453
- Paillé P, Mucchielli A (2008) *L'analyse qualitative en sciences humaines et sociales*. Armand Colin, Paris

Pourdehnad J, Wexler ER, Wilson DV (2011) Systems & design thinking: A conceptual framework for their integration. Paper presented at the International Society for the Systems Sciences (ISSS) 55th Annual Conference, Hull, UK, July 2011

Pruneau D, Lang M, Kerry J, Langis J, Fortin G, Liboiron L (2014) Leaders of sustainable development projects: Resources used and lessons learned in a context of environmental education. *Journal of Education for Sustainable Development* 8(2): 155-169

Pruneau D, Langis J (2015) Design thinking and ICT to create sustainable development actions, In: *Proceedings of the 7th International Conference on Computer Supported Education*, Volume 1, Lisboa, Portugal. pp 442-446

Pruneau D, Barbier P-Y, Daniels F, Freiman V, Paun E, Nicu A, Therrien J, Langis J, Langis M, Lirette-Pitre N, Iancu P (2015) Pedagogical tools that help pupils pose and solve environmental problems. In: Sullenger KS, Turner S (Eds) *New Ground. Pushing the boundaries of studying informal learning in science, mathematics, and technology. Bold Visions in Educational Research* (46). Sense Publishers, Rotterdam. pp 191-224

Scheer A, Noweski C, Meinel C (2012) Transforming constructivist learning into action: Design thinking in education. *Design and Technology Education: An International Journal* 17(3)

Seidel V, Fixson S (2013) Adopting «design thinking» in novice multidisciplinary teams: The application and limits of design methods and reflexive practices. *Journal of Product Innovation management* 30(S1):19-33

Stoyanova E (2000) Empowering students' problem solving via problem posing. *Australian Mathematics Teacher* 25(10): 33-37

Torrance EP (2008) *Torrance tests of creative thinking: Manual for scoring and interpreting results. Verbal forms A and B.* Scholastic Testing Service, Bensenville, IL

Torrance EP, Goff K (1999) A quiet revolution. In: Puccio G, Murdock M (Eds) *Creativity assessment: Readings and resources* The Creative Education Foundation Press, Buffalo, NY. pp 25-33

Thakker K (2012) *Start with sustainability: making sustainability the meta-objective for design.* Theses Paper 29. Carnegie Mellon University, Pittsburgh, PA

United Nations (2015) *We can end poverty. Millenium Development Goals and beyond 2015*
 Online: <http://www.un.org/fr/millenniumgoals/beyond2015.shtml> (Last Accessed 25 May 2016)

Yin RK (2009) *Case study research, design and methods.* Sage, Thousand Oaks, CA

Authors Biography

Professor Diane Pruneau has a Ph.D. in Environmental Education. She is currently professor at the Université de Moncton, Canada and Director of the Littoral et Vie Research Group. Her current research interests are located in environmental and science education. Her recent national and international research projects focused on the development of sustainability competences (problem solving, design thinking) and on the use of ICTs in problem solving.

Mrs Boutaina El Jai has a Masters' Degree in Environmental Studies. She is a researcher with the Littoral et Vie Research Group, Université de Moncton, Canada. Her research interests include the restoration of biodiversity in urban areas and other subjects related to sustainable cities and environmental actions.

Professor Abdellatif Khattabi has a Ph.D. in forestry. He is currently professor at ENFI (École Nationale Forestière d'Ingénieurs), in Rabat, Morocco. He does research in

environmental and natural resources economy, in forest economy, in rural development, in integrated natural resources management and on the use of ICT to teach. Member of the IPCC (Intergovernmental Panel on Climate Change), he has directed and is still directing large international teams such as in the ACCMA (Adaptation aux changements climatiques au Maroc) and GIREPSE (Gestion Intégrée des Ressources en Eau et Paiement des Services Environnementaux) projects.

Mrs Sara Bembrahim is an engineering student at ENFI (École Nationale Forestière d'Ingénieurs), in Rabat, Morocco. Her research interests include gender analysis and the socio-economic vulnerability to climate change.

Mrs Joanne Langis has a Masters' Degree in Environmental Studies. She is a researcher and the Coordinator of the Littoral et Vie Research Group, Université de Moncton, Canada. Her research interests include climate change adaptation, the restoration of biodiversity and environmental actions.