

Affordances of design thinking and collaborative digital tools during the search for sustainability solutions

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Abstract

Design thinking, which emphasizes user needs, abduction and rapid prototyping, is a promising avenue in sustainability. Used during design thinking, collaborative digital tools can also facilitate co-construction and resolution of a problem. Helped by facilitators, adults from four case studies worked on problems such as adapting a University campus to international students' needs, improving a drinking water problem, adapting to floods and decontaminating groundwater. The researchers studied the affordances of design thinking and of Facebook, RealTime Board and Knowledge Forum during the resolution of these problems. Some affordances of design thinking were: a broader understanding of problems, identification of real users' needs, mutual learning, caring towards users and proposals of appropriate solutions. Information and communication technologies (ICTs) have been promising tools for solvers' support at a distance: Facebook, to share images of disasters and solutions; RealTime Board, to visualize a whole problem and to remember its details; and Knowledge Forum, to analyze a problem.

1. Introduction

Environmental problems affect citizens, who then need solutions to improve their living conditions. Sometimes facilitators accompany citizens in their quest. What are the key interventions that promote effective support for such citizens towards applicable solutions? Environmental problems are complex, with multiple causes, actors and risks. Some international organizations currently use a creative problem-solving approach, called *design thinking*, to pedagogically assist social groups as they analyze local problems, propose and test solutions. Some facilitators also use collaborative digital tools, to help problem-solvers think collectively and represent situations and solutions.

Design thinking comes mainly from the IDEO design and innovation firm. It is a creative and collaborative way of working in which intuition matters, solutions are numerous, experimentation happens quickly, and users' needs are considered (Brown, 2009). Generally, in design thinking, facilitators use traditional tools such as post-its, whiteboards, role plays, etc. Today, facilitators also use digital collaborative tools (ICTs) to co-create solutions during design thinking. Using ICTs, the problem-solvers might better share and synthesize information, propose and comment on ideas, build prototypes and communicate. However, there is little research on the potential benefits of technological tools in design thinking.

According to IDEO.org, Hasso Plattner Institute and Design for Change, design thinking can lead to the creation of products or experiences that improve the lives of communities. What exactly are the pedagogical impacts of design thinking? And, how could technologies facilitate design thinking? This research project looks to answer the following questions: What would be the affordances of design thinking and of digital tools in environmental problem solving? The concept of "affordances" corresponds to the values and potentialities of actions perceived by a living organism towards a given object (Gibson, 1979). Four case studies helped to answer the research question on affordances of design thinking and ICTs. First, Moroccan women used design thinking and Facebook as they sought adaptation solutions to the poor quality of their drinking water, due to recurring floods. Secondly, University of Ottawa Education students used design thinking and RealTime Board, as they looked to improve their campus environment in such a way as to better meet the needs of international students. At Laval University, students in the Education faculty used design thinking and Knowledge Forum to solve a drinking water problem in Québec City. Finally, engineering students from the Moncton University used a design thinking approach as they attempted to solve a contaminated groundwater issue. No specific collaborative digital tools were used at the Moncton site, where students preferred to use more familiar communication tools.

This paper presents the perceived affordances of design thinking and of Facebook, Realtime Board and Knowledge Forum, as collected from problem-solvers and facilitators, in the various experiments.

2. Materials and Methods

2.1 Design Thinking

Design thinking uses both creative and analytical modes of reasoning. It takes place according to specific, yet non-linear steps, in which back-and-forth actions intersect. The steps shown in Figure 1 are inspired from Brown (2009) as well as from Scheer, Noweski and Meinel (2012) and are described below:

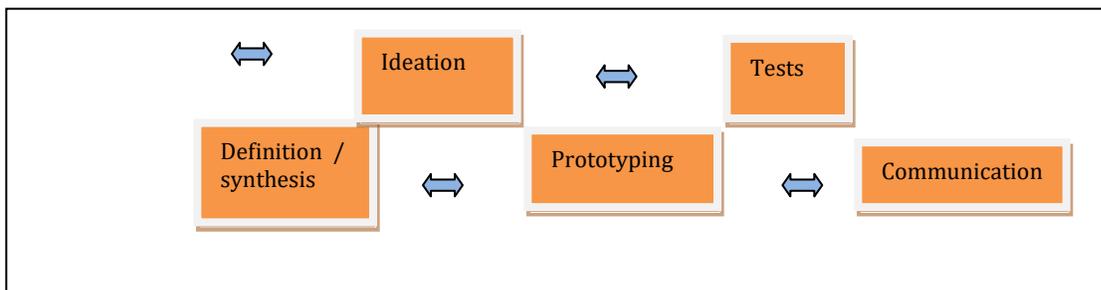


Figure 1: **The stages of design thinking**
From Brown (2009) and Scheer, Noweski and Meinel (2012)

1. Observation-inspiration: a survey helps to understand the people concerned by the problem (the users) and the situation.
2. Definition-synthesis: the problem is defined several times and synthesized to pose the conceptual challenge.
3. Ideation: ideas are proposed and some are chosen.
4. Prototyping: prototypes are quickly constructed to illustrate ideas.
5. Tests: prototypes are assessed by collecting the opinions of users and experts. The winning prototypes are refined.

6. Communication: the final solution is made public.

2. 2 ICT Tools

Studies point at the benefits of digital technologies in problem-solving. More specifically, ICTs are mainly used to promote sharing and disseminating information, and to facilitate the emergence of shared and effective solutions (Barborska-Narozny, Stirling and Stevenson, 2016). In general, digital tools can play an important role in areas such as project coordination, popularization and citizen engagement.

2.3 Methods

Perceived potentialities of design thinking and ICTs were sought from participants and facilitators in four case studies, where adults attempted to solve local environmental problems. The problem-solvers and facilitators were asked to explain what the design thinking approach and the use of digital tools brought as potentialities of actions or learning. The data sources were the written and graphic artefacts left by participants on their preferred ICT adjunct (i.e. screenshots), individual and / or group interviews with problem-solvers and facilitators (at various moments during experimentation), and the researchers' journals. In each case site, qualitative analysis of data was carried out by two researchers and consisted of applying Paillé and Mucchielli's (2008) thematic content analysis approach, which mainly involved the extraction of common themes.

In the first case study, ten Moroccan women were supported as they tried to find solutions to the problem of unsanitary drinking water, caused by floods (Pruneau et al., 2017). Facebook was used as a networking tool when women were at a distance. The women shared photos and videos of their flood experience on Facebook and then attempted to solve the sub-problem of unsafe drinking water. Along the way, users' needs were identified and one common concern emerged, that of diseases caught because the water was contaminated by waste transported by floods. The conceptual challenge was: How could we reduce the amount of waste in the water? Women implemented the following solutions for flood adaptation: making filters, making compost, creating recycled jewelry (with plastic waste); and starting a waste reuse cooperative. All solutions were shared and assessed during workshops and on Facebook.

The second case involved seven pre-service teachers at the University of Ottawa (the problem-solvers) working on how to make the campus more sustainable for the well-being of international students (the users). The problem-solvers used RealTime Board as they attempted to identify various needs of international students specifically related to the campus, such as a lack of vegetation, of meeting places, of entertainment venues, and of places representative of their culture. During the meetings and through weekly entries on RealTime Board, the participants proposed the following additions to the campus environment: pergolas, trees, swings, ping-pong tables, working spaces, shady socializing places, trails, art and a garden of international flags.

The third case involved pre-service teachers (the problem-solvers) at Laval University who were dealing with water quality problems in Québec City. Eighty four students worked collaboratively, in groups of four, using the digital platform Knowledge Forum (KF) during an entire semester. Users identified two main needs, namely a lack of information of the part of citizens as to the existence and seriousness of the problem at hand and a need for better protection of watersheds. Several proposals were made around the need for better awareness on the part of the user regarding the problem. For

example, an educational program for Québec City parks could help raise awareness about water use and overconsumption and an educational kit used by a "beach squad" could serve to educate navigators on the fragility of local streams. Some teams stressed that regulation was part of the problem and should be adapted to protect sources of drinking water.

In the fourth case, design thinking was used with civil engineering students from the University of Moncton to solve a problem of high arsenic levels in the groundwater of a village. The conceptual challenge was to find solutions to treat the water in wells containing high levels of arsenic. The students verified whether the residents' wells had an arsenic concentration above the acceptable limit. They subsequently realized that this concentration varied strongly from one well to another. It was recommended to each well owner to have a sample of the water assessed to determine whether it was necessary to proceed with a technical solution. The students then proposed solutions such as a reverse osmosis treatment system, a distillation system and the distribution of water bottles. Interestingly, solutions emanating from the design thinking process led to a wider range of solutions, which included some less technical proposals.

3. Results

3.1 Affordances of Design Thinking

Design thinking is seen as a tool that can provide a deeper understanding of the problem. Before the experiment, the Moroccan women mentioned that they did not know the causes of the floods, nor the health risks of domestic waste in the river. Ottawa students did not anticipate most of the needs expressed by international students regarding university campus development. Québec City students were not aware of the drinking water issues and, initially, showed little concern for the issue, admittedly because they had an impression of "overabundance" of the resource.

Moroccan women, Ottawa students and future engineers in Moncton also considered design thinking as an efficient way of identifying the real needs of people. They felt that the process facilitated the formulation of appropriate solutions. Empathy is another affordance attributed to design thinking. A feeling of kindness towards the users' needs emerged. Speaking about the users, the problem-solvers wanted to find solutions "for them and with them".

The four groups of participants also believed that with design thinking, solutions are better and more original since they address users' needs. The approach would allow enrichment of personal ideas ("Together we did better!"). Design thinking would support an opening to new and more innovative ideas ("Let the imagination go!"). According to Ottawa students, prototyping brought ideas to life, contributing to the quality of the ideas proposed ("This visual support gives us a better idea of what the space would look like"). Moncton students said that spending more time listening to user concerns can lead to less conventional non-technical solutions to a water contamination problem, from a civil engineering perspective.

Design thinking finally improved communication. The group of solvers became cohesive, as knowledge of the people and a desire for action developed.

3.2 Affordances of Technological Tools

Facebook was used in the study case involving Moroccan women (on the topic of floods), while RealTime Board was used with the Ottawa students (on sustainable campus development) and Knowledge Forum with the Québec City students (on drinking water contamination).

Facebook

A Facebook page usually shows a list of the members' publications: images, emoticons, videos, Internet links and text. In the Moroccan project, the types of Facebook publications were chosen by the facilitators and by the problem-solvers. Over the course of the project Facebook's affordances were discovered and then gradually exploited by both parties. Thus, various aspects of the case problems and their solutions were documented and commented on, one at a time, by the members of the Facebook group (including the facilitators). According to the participants, Facebook presented the following affordances:

- communication tool,
- tool for progressively defining the problem,
- learning tool (how to compost, how to craft),
- empowerment tool,
- tool for sharing and criticizing solutions and prototypes,
- planning tool (exhibitions, compost and jewelry sales, management of the cooperative).



Figure 2: Example from Facebook

RealTime Board

RealTime Board (RTB) is an online whiteboard allowing users to collaborate by writing and drawing on a shared screen. Tables, concept networks, a chat option, stickers, emoticons and comment bubbles are available via this online resource. On RTB, problem-solvers were invited to represent each user's needs in a network of concepts (see Figure 3), to collaborate online, to co-build the empathy card, to synthesize all users' needs, to propose conceptual challenges, to vote for a challenge, to generate solutions, to evaluate and transform ideas, to vote for the best solution, to share pictures of the prototypes, to assess the final solution and to compile users' comments about the final prototype. The main affordances that participants identified for RealTime Board are:

- follow the progress of the project,
- find information about the problem,
- propose, sort and remove solutions,
- advance the project in class and at a distance,
- react to colleagues' work.

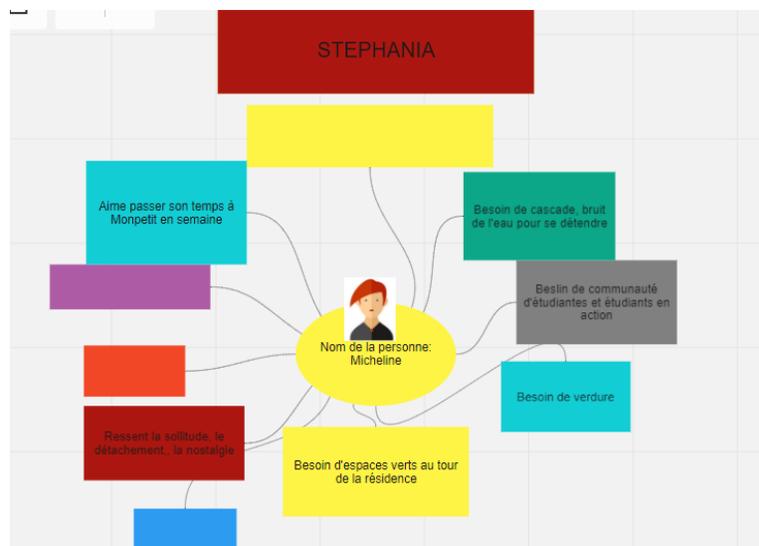


Figure 3: **Example from RealTime Board**

Knowledge Forum

Knowledge Forum 6.0 (KF), a "discussion forum" tool, was used with students to share and develop their perspectives, ideas and research. The choice of KF was motivated by the presence of numerous writing aids (scaffolding, key words, feedback) as well as the quality of the image in terms of co-development of ideas ("conceptual map" type structure).

The KF affordances include the construction of the discussion team and the elaboration of a common representation of the problem, of users' needs and of possible solutions (see Figure 4). Using KF, participants developed a logical assessment of the problem and possible solutions. At first, the nature of the problem was not accessible; it could not be solved. The KF helped the participants' structure their contributions. It seemed that the participants all contributed to "advance" the discussion, to organize it in such a way

that the discussion produced concrete results, instead of falling into sterile argumentation.

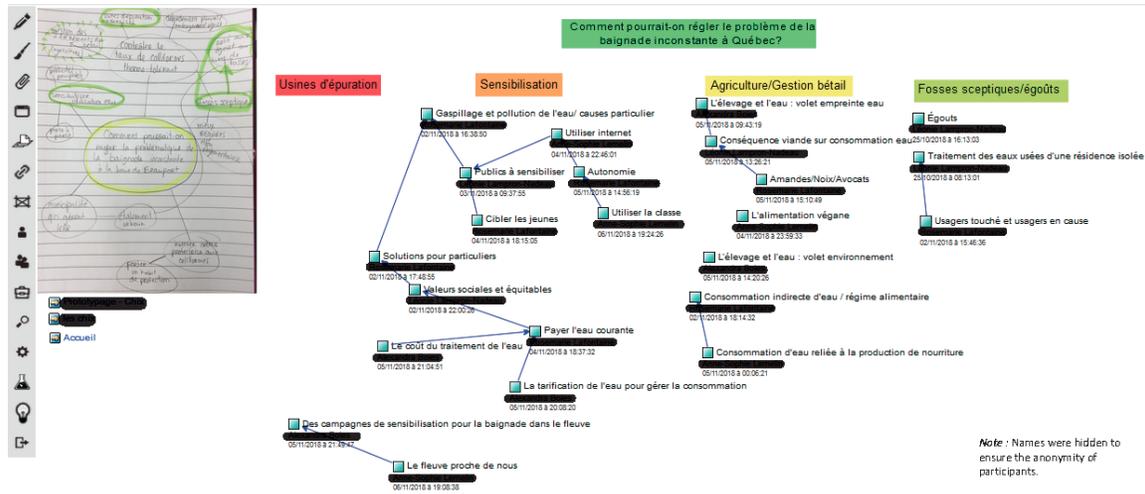


Figure 4: Example from Knowledge Forum

4. Discussion

Design thinking seems to "humanize environmental problems." The problem space widens to include social aspects. The solutions emerging from design thinking are varied and often original in some way. The problem-solvers' final solutions more frequently meet users' needs, and typically differ from the first solutions, the latter emerging more spontaneously. The emergence of new solutions, along the way, can be related to creativity.

Should collaborative digital tools be used during the stages of design thinking? Using RealTime Board, Knowledge Forum and Facebook, during an applied design thinking approach to problem-solving, our trials have demonstrated the following beneficial affordances:

- visual representation of complex problems;
- analysis, processing and dynamic sharing of available information;
- management of the resolution process (consensual identification of the harmful impacts and of the conceptual challenge);
- source of reflection, support and motivation to continue working from a distance;
- support for creativity, since the problem elements and solutions appear side by side on the screen and can therefore be combined to reveal new ideas (connection facilitates innovation);
- communication: gradual building of interpersonal relationships.

The Facebook page, which was gradually expanded over time, one publication at a time, did not provide an overview of the broader problem of flooding or the sub-problem of water contamination. Facebook led to the gradual development of information on different aspect of a complex problem. The solutions and prototypes were built and improved upon in person and later on Facebook, which made it possible to put aside the problem, to think about it, then to come back with new solutions. RealTime Board allowed the participants to visually represent their thought process and to consider the

various aspects of a problem, its solutions and the various prototypes, on a few pages. Like Facebook, RealTime Board facilitated progressive problem definition, the sharing and criticism of possible solutions and prototypes, as well as the building of a problem-solving team. RealTime Board let participants gather information about a problem, which was helpful because the complexity of an environmental issue make it difficult to remember all relevant elements. RealTime Board uses fewer images than tables and conceptual networks to capture and analyze problems. Knowledge Forum enabled the development of a common representation of the problem, while serving as a discussion forum and a tool to keep tracks of the work-in-progress. KF seemed to provide problem-solvers with a variety of options to organize their ideas.

5. Conclusion

Our experiments demonstrate that design thinking offered multiple affordances for pedagogical accompaniment of people in problem solving. During design thinking, defining the problem leads to more analytical thought, which in turn contributes to a better description of complex problems. A large and well-organized problem-space is conducive to proposing solutions better adapted to the situation. Using ICTs in problem solving seemed promising and could depend on their nature (user-friendliness, available functions ...).

Acknowledgments

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