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A framework for post-project evaluation of multicriteria decision aiding processes from the stakeholders' perspective: Design and application

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Abstract:

Numerous multicriteria decision aiding (MCDA) methods have been developed over the last decades and are now applied in various domains, sometimes using facilitated group workshops to create models. These models are all designed to improve decision processes. However, the lack of follow-up and post-project evaluations limit the understanding of how the participants experienced the group workshops and how the results were subsequently used within the organization. This is in contrast with the public participation research field, where a rich literature was developed for a posteriori evaluation of projects. Based on this literature, our research proposes a framework to evaluate, ex-post, MCDA projects. In order to illustrate this framework, we apply it to an MCDA project in Quebec City where a spatial decision support system to prioritize the redesign of streets as Complete Streets was built. Individual interviews were conducted with the Quebec City professionals that currently use, were leaders of the project, or have participated in the development of the decision support system. This research has identified that the need for change of practices within the workplace, communication problems, and the requirement for multidisciplinary work were at the root of the various challenges encountered during the workshops. Based on our experience, we propose some lessons learned and potential solutions that can enhance the body of literature in MCDA.

1 Introduction

The emergence of multicriteria decision aiding (MCDA) in the last decades has led to the development of several methods and numerous applications in various fields (Malczewski 2006; Behzadian et al. 2010; Govindan and Jepsen 2016). These applications often involve stakeholders through facilitated modeling based on different approaches such as decision conferencing (Phillips 2007), social multi-criteria evaluation (Munda 2008), decision analysis interviews (Marttunen et al. 2017) or group workshops (Salo and Hämäläinen 2010). Despite the large number of MCDA case studies in the literature, few actually conduct post-project evaluations to report what happened during group workshops or how the resulting artifacts[1] were subsequently used and perceived within the aided organization. This is a disappointing situation considering the calls in manifestos, more than 25 years ago, to improve the quality of reporting and to evaluate MCDA interventions and their outcomes (Bouyssou et al. 1993; Montibeller 2005). In fact, post-project evaluations can be of interest to several stakeholders: *Facilitators* and *MCDA analysts* are interested in learning about how the process they facilitated was perceived and what can be improved. *Participants* wish to express their views of how the model building process was conducted and share their experiences. *Actors impacted by the decisions* need to understand how a decision was made to ensure legitimacy, transparency and accountability. *Model and tool (artifact) users* need to adopt and continuously improve their artifacts and therefore to identify the strengths and weaknesses of those artifacts. *Academics* are interested in better understanding how the participants perceived MCDA group workshops and how they interact with the artifacts.

Post-project evaluations (also called ex-post analysis, a posteriori evaluation or evaluation) may be defined as the rigorous approach of carefully analyzing the development and application of an MCDA or operational research (OR) method, as a function of what is meant by a "successful" project (theoretically or empirically). Various key characteristics can be examined in such an evaluation: the process (in reference to the *how of the artifact development*), its outcome (in reference to the *what of the artifact*) or its adoption and use by professionals (in reference to the *how of the artifact adoption and use*) (Rowe and Frewer 2000, 2004; Keren and de Bruin 2005; White 2006). Although many authors agree on the importance of such post-project evaluations (Rouwette et al. 2002; Midgley et al. 2013), MCDA papers containing these evaluations are scarce, as was highlighted in reviews on the joint use of problem structuring methods (PSM) and MCDA (Marttunen et al. 2017) and on the application of MCDA in sustainable energy systems (Braune

[1] The term artifacts (Simon 1996) will be used in this paper as a global term that refers to the set of new objects (models, tools, or decision support systems) that are created and designed in an MCDA or OR project (Dresch et al. 2014). In more particular cases, the specific term such as "the model" or "the tool" will be used.

et al. 2009). In the rare cases where a post-project evaluation was conducted, its description was often condensed into one or two paragraphs in the paper's results or discussion section. There are, however, some notable exceptions where a more complete evaluation was presented such as in Paschetta and Tsoukiàs (2000), Mustajoki et al. (2004), Barcus and Montibeller (2008), Greene et al. (2010), Lienert et al. (2011), Ferreria et al. (2011) and Henao and Franco (2016).

Post-project evaluations are also rarely found in the broader OR literature, where a small number of studies has investigated the applications of OR methods in practice and the use of OR artifacts in organizations (Becker 2016; de Gooyert et al. 2017). Our observations are not new and echo Ackoff (1962, 1979a, b) and Churchman (1970) who have argued more than 50 years ago that OR needs to observe and analyze its own practices to better understand the artifacts' building processes and implementation and, therefore, to enhance future OR practice. The same observations have sparked, in recent years, the revival of interest in behavioral operational research (BOR), (Kunc et al. 2016; Franco and Hämäläinen 2016).

Nonetheless, some frameworks to design post-project evaluations are found in the OR literature, namely to evaluate group decision support systems (Eden 1995; McCartt and Rohrbaugh 1995; Eden and Ackermann 1996), to measure the value and effectiveness of PSMs (White 2006; Rouwette et al. 2009; Midgley et al. 2013), to evaluate the effectiveness of group model building (Rouwette et al. 2002) or to assess decision quality (Yates et al. 2003; Keren and de Bruin 2005). It is, however, not the case for MCDA projects. The scarcity of post-ex evaluations may therefore be due, in part, to this lack of general frameworks providing a clear guidance on how an evaluation should be designed and conducted, and what should be measured in an MCDA project.

The situation is quite different for public participation processes in urban planning and environmental planning where a rich literature was developed to ex-post analyze these processes and outcomes. Public participation may be defined as the practice of consulting and involving stakeholders and the public in the agenda setting, decision-making and policy-forming activities (Rowe and Frewer 2004). In fact, several authors have proposed evaluation frameworks for public participation exercises. For example, Rowe and Frewer (2004) built a framework to evaluate public participation based on published post-project evaluations. Fung (2006) developed a three-dimensional framework to study mechanisms of participation based on who participates, how participants communicate together, and what types of links exist between discussions and policy actions. Jones et al. (2009) proposed an evaluation framework for cross-case analysis based on two components: the facilitator's questionnaire (i.e., facilitators are referred as designers in Jones et al. (2009) paper) and the participants' evaluation guide.

In order to fill an existing gap and provide the MCDA community with a flexible framework that may be use to design post-project evaluations, we turned to the public participation literature. This literature is

relevant to our work since it shares many characteristics with group MCDA. Both research streams aspire to improve traditional decision-making by including diverse stakeholders in order to reduce conflicts and enhance stakeholders' shared knowledge. Also, both can take various forms; from a small group of stakeholders during facilitated workshops to many stakeholders surveyed through questionnaires. Our framework is adapted from Chess (2000) who proposed a flexible and simple framework revolving around five key questions for designing a public participation evaluation.

The aim of this paper is two-fold: (1) to propose a post-project evaluation framework for MCDA projects based on Chess (2000) and (2) to apply it to the evaluation of a case study in transportation planning in Quebec City, Canada. The goal of this case study was to develop an MCDA model and a spatial decision support system (SDSS) to help identify, in the Quebec urban area, the streets with the highest potential to become Complete Streets (Marleau Donais et al. 2019), a popular movement advocating to design "streets for everyone" in North America (Smart Growth America and National Complete Street Coalition 2018). We chose this particular case study since, despite the fact that the SDSS has been adopted and is in use operationally since 2018, considerable challenges and issues were encountered during the MCDA process (Marleau Donais et al. 2017a). Our results provide empirical evidence that support claims in the literature pertaining to benefits and challenges associated with MCDA group workshops (Phillips and Phillips 1993; Banville et al. 1998; Salo and Hämäläinen 2010; Phillips 2011). The lessons learned in this research allow us not only to formulate several suggestions that may improve MCDA modeling practices, but also to aid students and MCDA practitioners who wish to learn about other real-life experiences.

This paper is organized as follows: Section 2 presents the proposed MCDA group workshops evaluation framework. Section 3 introduces the case study in Quebec City. Section 4 explains how the framework was applied to our case study through the development of an interview guide and a series of individual interviews. Section 5 summarizes the results of the individual interviews such as the perceived benefits, difficulties and challenges related to the MCDA model development, the SDSS's adoption and use, as well as the anticipated future of the SDSS. Section 6 proposes some recommendations to improve practices based on the feedback provided by the interviewees and on our experience. It also discusses the limits of our post-project evaluation and explores future avenues for research. Section 7 concludes the paper.

2 A post-project evaluation framework for MCDA projects

Chess (2000) proposed a framework for designing an evaluation method of public participation in an environmental planning setting, based on five key questions: (1) *why evaluate?* (2) *what to evaluate?* (3) *on what is the evaluation based?* (4) *how to evaluate?* and (5) *who is involved in the evaluation?* (Table 1).

More specifically, this was based on the theory of evaluation and the practice of evaluating environmental public participation programs within USA government agencies.

In this section, we present our adapted framework to design the evaluation of MCDA projects. For each key question, we define and present examples from the MCDA literature of how the questions could be answered and applied to design a post-project evaluation (Table 1). To better reflect the practices in the MCDA field, we provide some additional potential answers to the key questions *what to evaluate?* and *on what is the evaluation based?* while retaining the answers proposed by Chess (2000) for the three remaining questions. It is worth noting that other answers to the questions are also possible. For example, in a framework to evaluate PSM, Rouwette et al. (2002) included the context of the intervention (i.e., context variables such as geography or characteristics of the problem as a possible) as a possible answer to the question, "what to evaluate?"

Table 1 Key questions and adapted answers to design an ex-post evaluation of a MCDA project (adapted from Chess (2000))

Key questions	**Adapted answers to design an ex-post evaluation for MCDA project**
Why evaluate?	Summative evaluation, formative evaluation or impact evaluation
What to evaluate?	Process, outcomes, artifact's adoption or uses
On what is the evaluation based?	Theory, participants, past experiences or goal-free analysis
How to evaluate?	Quantitative method, qualitative method or mixed methods approach
Who is involved in the evaluation?	External actors (external evaluation) or internal actors (participatory evaluation)

2.1 Why evaluate?

There are different reasons for evaluating a project. One such reason is to learn about good practices and to validate the artifacts (*Summative evaluation*). This is usually done in a closing session, at the end of the last workshop or through a follow-up questionnaire. Some authors in MCDA have used this approach for different purposes: to see whether the stakeholders agree with the MCDA results (Schuwirth et al. 2012), to understand the usefulness of MCDA to support decision-making (Lienert et al. 2011) or to identify the strengths and weaknesses of the process (Ferreira et al. 2011). One could also evaluate an ongoing project to correct and improve practices and make them more effective in the subsequent workshops (*Formative evaluation*). For example, participants could be asked to complete a survey at the end of each workshop, or

an open discussion between the participants and the facilitators could close each workshop. Furthermore, an evaluation could take place a few years after the project's completion and focus on the project's impacts in the long-term (*Impact evaluation*). This type of evaluation is more complex to implement and requires a commitment from the evaluators over an extended period of time (Brown and Chin 2013).

2.2 What to evaluate?

Three aspects of MCDA projects may be analyzed: the modeling process (artifacts development), the outcome (produced artifacts) and the adoption and uses of the resulting artifacts. More specifically, process evaluations aim at analyzing the construction phase of the artifacts to understand the unfolding of the group modeling process, as well as the context in which the process is inserted (e.g., attitude of the stakeholders toward the process, organizational culture). Outcome evaluations serve to determine not only the artifacts' validity (for example, a mathematically sound artifact applied according to OR best practices), but also whether the participants and the strategic stakeholders consensually agree with the results, which makes them organizationally acceptable and ensures the artifact's legitimacy (Landry et al. 1996). Finally, evaluating the artifacts' adoption and uses seeks to understand how the artifacts are used and what could be improved to better support the users in practice. Moreover, analyses may be conducted at three different levels: the individual level (e.g. developing new knowledge, documenting how professionals use the artifacts); the group level (e.g. creating a shared language, developing a common vision); or at the organizational level (e.g. analyzing the commitment to the process and the outcomes).

2.3 On what is the evaluation based?

The set of criteria used for evaluating a project varies according to what constitutes a "successful" process, outcome, or artifact adoption and use. The different perspectives of how a "success" is defined reflect three of the four pretensions to validity initially identified by Habermas and cited and applied by Genard and Pirlot (2002) to decision-aiding. These pretensions to validity are (1) the truth, characterized by a descriptive or observational statement (e.g., are things like you say they are?, why it is like this?); (2) the justness, characterized by a regulatory or prescriptive statement (why are you doing this?, why did you not act differently?); and (3) sincerity, characterized by an expressive statement (why are you feeling like this?). The different pretensions to validity imply that different sets of evaluation criteria may be used depending on whether they are based on theory, on past experiences, on the users, or if they are goal-free, as explained below.

Evaluations based on theory use normative criteria that may be applied universally across studies and that reflect a specific theory such as the competing values approach for group decision processes (McCartt and Rohrbaugh 1995) or the elements of decision quality (Matheson 2013); this is an objective representation

of the world with claims to uncover the truth. This approach facilitates the replicability of the evaluation method and, consequently, the comparison between the results from different studies since the same evaluation criteria could be used between studies. However, it may create leading question biases in the evaluation (e.g. if respondents are directly asked if they developed a shared language during the project, it will more likely lead the respondents to answer positively) (Choi and Pak 2005).

In evaluations based on experience, criteria are defined by reviewing past evaluation experiences in the literature or by asking a group of experts or MCDA practitioners to define the criteria according to their experiences; this is a social representation of the world with claims to justness.

Evaluations based on the users require that they define the evaluation criteria at the beginning of the project according to their own goals. In this context, users can be either the facilitators (criteria defined based on the facilitator's own experiences), the participants (personal objectives or organizational objectives) or the artifacts users. The evaluation thus reflects the various goals of the users (facilitators, participants or artifacts users); this is a subjective representation of the world with claims to sincerity.

Finally, goal-free evaluations aim at gaining information (e.g., increasing understanding of artifact development to identify strengths and weaknesses) without constraining the evaluations by framing and focusing the evaluation on specific goals or theories.

2.4 How to evaluate?

An evaluation method can follow a qualitative design, a quantitative design, or a mixed methods approach. Online surveys (Mustajoki et al. 2004) or questionnaires during a workshop (Marttunen and Hämäläinen 2008; Geldermann et al. 2009) are quantitative methods that can provide, for example, the percentage of stakeholders that agree or disagree with a statement. However, such surveys are not well suited to achieve an in-depth understanding of the respondents' positions since they consist of questions that are often closed, limiting further investigation. As an alternative, group discussions with workshop participants (Schuwirth et al. 2012) or a series of individual interviews (Barcus and Montibeller 2008) are frequently used in qualitative approaches. Once interviews are conducted, different qualitative methods (e.g. thematic analysis or phenomenology analysis; Paillé and Mucchielli 2016a) can be used to analyze the results. However, the external validity of the research is lower since the results are less generalizable. A mixed methods that uses data triangulation (i.e. collecting data using different means on the same topic, e.g. interviews, questionnaires, etc.) is another possible approach (Midgley et al. 2013). For example, a mixed methods could be a facilitated plenary discussion with the participants followed by a questionnaire to be completed later (Greene et al. 2010). Nonetheless, the choice of one approach over another is often guided by different

epistemological choices such as, for example, a positivist, an interpretive or a critical paradigm (Mingers and Brocklesby 1997).

2.5 Who is involved in the evaluation?

Since there are different perspectives in an MCDA project, various actors can participate in an evaluation. These actors can take on various non-exclusive roles such as designing the evaluation, evaluating the project, or analyzing the results. If external actors (i.e., actors not involved with the artifact: external researchers, evaluation consultants) design and evaluate the project or the artifact, the evaluation is referred to as an *external evaluation*; whereas if some internal actors (i.e., actors involved with the artifact: participants, artifact users, facilitators) design and evaluate the project or the artifact, it is referred to as a *participatory evaluation*. Other actors such as decision-makers or people impacted by the decision linked to the artifact could also be involved in a participatory evaluation. External evaluations aim at minimizing the interactions between the evaluator and the internal actors to maintain objectivity, while participatory evaluations aim at empowering the internal actors by encouraging them to think about their own practices rather than judging what is right or wrong (Chess 2000).

3 Case Study

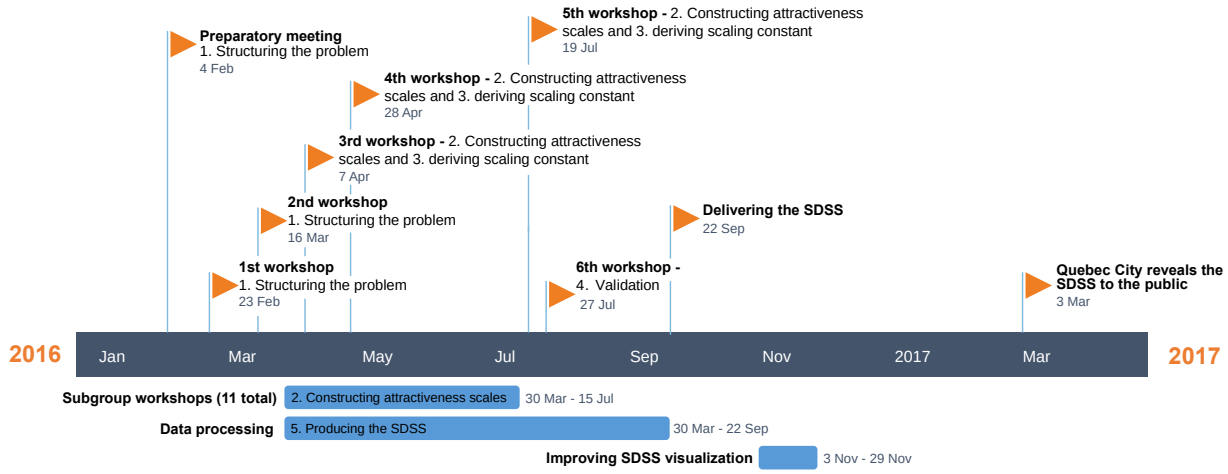
In 2015, our research team at Laval University received a request from the City of Quebec, Canada, to help with the prioritization process for the rehabilitation and redesign of streets as Complete Streets. With approximately 531,000 inhabitants, Quebec City is the capital of the province of Quebec, is located in the south east of Canada, and is one of the oldest cities founded by the French in North America, in 1608 A.C. (Communauté métropolitaine de Québec 2013; Statistique Canada 2017). As in many other North American cities, the engineering department in Quebec City had been single-handedly choosing the streets to be rehabilitated on the basis of an infrastructure obsolescence criterion (Hess 2009; McCann 2013). This often led to rebuilding streets similar to the way they were before the intervention and overlooking new street design approaches such as Complete Streets. Nonetheless, professional practices in Quebec City had been increasingly geared toward the principles of Complete Streets and a few streets had already received a special design treatment. However, the selection process of these few streets was still subordinated to the engineering department and represented a high cognitive burden for Quebec City professionals. Consequently, mistakes were made, some projects were overlooked, and professionals were frustrated and disappointed by the results. Aware of these limitations, Quebec City professionals aimed for a more structured, rigorous, and transparent decision process, conducted in collaboration with professionals from different fields (i.e., transportation, infrastructure, urban planning, etc.), that takes into account the various viewpoints, preferences and objectives.

3.1 Project Description

Quebec City's identified need for an improved decision-making process led to a collaboration between our research team and a Quebec City team in 2016. 11 Quebec City professionals from different backgrounds were gathered in group workshops to develop a new multicriteria based decision process. The professionals consisted of a transportation engineer, an infrastructure engineer, three urban planners from different departments, a project manager, an urban designer, an environmental planner, a landscape architect, an advisor in public participation and the sustainable development project director. In total, six group workshops and 11 subgroup workshops (smaller workshops that gathered between two and four professionals with a specific expertise) were held over a period of six months. The workshops allowed us to develop an MCDA model, implemented in a geographic information system (GIS), to assess the 20,000+ street segments in Quebec City. This spatial decision support system (SDSS) is referred to as a "cartographic tool" by the professionals. The development process involved five iterative steps: (1) structuring the problem following the Value-Focused Thinking approach (Keeney 1996) to develop a set of objectives and criteria; (2) constructing interval level attractiveness scales and (3) deriving scaling constants for the calculation of a weighted average based priority index, using the MCDA method MACBETH (Bana e Costa et al. 2016); (4) validating the model with the professionals using a subset of the alternatives; and (5) producing the SDSS as a set of street priority maps in a GIS (Marleau Donais et al. 2019). The workshops were led according to decision conferencing principles (Phillips 2007). The attractiveness scales and the scaling constants were revisited several times during the project. In addition, the data processing leading to the development of the SDSS was conducted in parallel to the various workshops.

During the group workshops, two to three MCDA analysts acted as facilitators. The first facilitator (a master's student at the time and the first author here) led the discussions, the second facilitator captured the information using the M-MACBETH software (Bana e Costa et al. 2005), and the second and the third facilitators (professors) advised the first facilitator and analyzed the workshop discussions. The objectives of the group workshops varied from one workshop to another. As for the subgroup workshops, they were aimed at constructing, with smaller groups of professionals, interval level attractiveness scales for one or two specific criteria. Only professionals with an expertise linked to the criterion being constructed (e.g., urban planning, environment, urban design, cycling transportation, etc.) were gathered. Figure 1 presents the timeline of the project and the objectives of each (sub)workshop. Since data processing was required to develop the attractiveness scale for some criteria, a gap of two months between the fourth and the fifth workshop was required. Marleau Donais et al. (Marleau Donais et al. 2017a, 2019) describe in more detail the process leading to the development of the SDSS.

Fig. 1 Timeline of the project



3.2 Implementation of the SDSS in Quebec City

In March 2017, the mayor of Quebec City revealed the city's Complete Streets strategy to the population and the media. Subsequently, the SDSS was integrated as one of their strategy's key elements (Ville de Québec 2017). The SDSS is, since then, used operationally and several streets have been rehabilitated and redesigned. In order to ensure the transition from an academic project to an operational SDSS, our research team expanded the model to the whole city in 2017. A follow-up collaboration was conducted in 2018 to enhance the Quebec City's team's understanding of the SDSS and to resolve some technical issues. As a result, the SDSS was recognized as one of the 12 best initiatives toward Complete Streets in 2017 (Smart Growth America and National Complete Street Coalition 2018). The project was awarded the OR Practice Price in 2019 by the Canadian Operational Research Society (CORS 2019), a first for Laval University since the creation of the prize 37 years ago, and was a finalist for the Practice Award in 2019 by the Decision Analysis Society section of INFORMS (Decision Analysis Society 2020).

Despite the acclaims received after the project's completion, the road to success was not a smooth one. In fact, we faced many challenges during the group workshops (Marleau Donais et al. 2017a). This led us to conduct a post-project evaluation to learn about and compare the challenges from the participants and the SDSS users' perspectives. Furthermore, we were interested in their suggestions on how to improve our facilitation of MCDA group decision processes and the resulting artifacts.

4 Method

Based on the key questions introduced in the section 2, we developed the present method to conduct a *summative evaluation* (**why evaluate?**) since our goal was to follow up on the adoption by Quebec City, of

the MCDA tool we developed, especially in light of the challenges we and the participants faced during the decision modelling process. The evaluation took place two years after the delivery of the first version of the developed artifact (the SDSS) to Quebec City's professionals. The objectives of the evaluation were twofold (**what to evaluate?**):

1. to better understand the modeling process and, more specifically, the perceived strengths and the weaknesses from the workshops' participants perspectives (*process evaluation*);
2. to document the appropriation and adoption process of the SDSS by the professionals, how it is used and how it could be improved in the future (*artifact adoption and use evaluation*).

It is important to note that in this paper, we do not aim to analyze the micro-process of the group facilitated workshops (Ackermann et al. 2018) and understand the various interactions between the facilitators and the participants as other authors had done (Papamichail et al. 2007; Tavella and Papadopoulos 2015a, b; Franco and Greiffenhagen 2018; Franco and Nielsen 2018; McCardle-Keurentjes and Rouwette 2018). In addition, prior to our post-project evaluation, an *outcome evaluation* had already been conducted to validate the model with the participants by ranking anonymized alternatives and comparing the model's ranking with the participants' best estimated ranking (Marleau Donais et al. 2019).

The evaluation was *participatory*, based on a series of individual interviews with the professionals involved at different steps of the project (**who is involved in the evaluation?**): the workshop participants, the Complete Streets project leaders, and the SDSS users. The evaluation was conducted by the main facilitator since the aim of this evaluation was not to establish the quality of the SDSS, but rather to be a learning process for the facilitators to better understand Quebec City professionals' perspective about the project and improve their future MCDA practices. In addition, Chess (2000) points out that involving internal actors (here, the participants and the SDSS users) renders the evaluation more useful and credible by better answering the needs.

We adopted a qualitative research approach (**how to evaluate?**) rather than a quantitative one to unravel and articulate the reasons behind the challenges encountered by the facilitators. This is in line with Becker (2016), who suggests that, in order to develop a better understanding of OR interventions, OR analysts should study the application of OR techniques based on the concepts and methods of social sciences. Furthermore, it echoes the GDSS literature suggesting that open-ended methods, such as in-depth interviews and qualitative analyses, may produce richer and more relevant data than questionnaire research (Eden 1995; Eden and Ackermann 1996). The interview guide was designed as a goal-free evaluation (**On what is the evaluation based?**). Considering the few MCDA post-project evaluations in the literature, we did not want to limit our evaluation and questionnaire to theory or to past experiences, rather, we wished to gather as much information as possible regarding the various impacts of the project. We wished for the

professionals to share their experience about the process and the SDSS with their own words, thereby minimizing leading question biases.

Once the different key questions were answered, a method in three steps was followed during the post-project evaluation: developing an interview guide (section 4.1), conducting semi-directed interviews (section 4.2) and analyzing the interviews using thematic analysis (section 4.3).

4.1 Developing an Interview Guide

Prior to conducting the interviews, we developed an interview guide to reflect our two evaluation objectives. The guide consisted of some common questions to all professionals along with some specific questions for each professional category. It consisted of five sections: (1) previous experiences with MCDA; (2) process to develop the artifacts (model and the SDSS); (3) use of the SDSS; (4) future of the SDSS; and (5) open questions about MCDA. To avoid leading question biases, no question was directly asked about the advantages usually linked with MCDA (e.g., structuring a problem, developing a common language, learning, etc.). The questions were open-ended (e.g., *can you share with me your experience with the MCDA project and the different workshops?; what do you like about the SDSS? dislike?*). The interviewer prodded for more details when the interviewees were not explicit enough (e.g., *can you tell me more about this specific aspect? what do you mean?*). Nonetheless, some questions about the OR intervention approach, i.e. expert mode versus facilitation mode (Franco and Montibeller 2010) were asked more directly. The full translated interview guide is available as supplementary material.

4.2 Semi Directed Interviews

The Quebec City professionals were interviewed in January and February 2019. The main facilitator from the group workshops acted as the interviewer and followed a semi-directed interview structure. All of the interviews were recorded, were in French (the language of use in Quebec City) and lasted approximately one hour. Of the 11 group workshop participants contacted, seven accepted to be interviewed. The four others declined since they felt that they had not been involved enough in the process or were now working in another department and did not have the time. Two of the interviewed participants are now project leaders for the implementation of the Complete Streets strategy in Quebec City. Following the participants' interviews, snowball sampling was used to recruit eight SDSS users. Five accepted to be interviewed and three declined the interview since they felt that they had not yet used the SDSS extensively enough to form an opinion.

4.3 Interview Analysis

All the interviews were transcribed and analyzed according to a thematic analysis approach that consisted of coding text samples using N-Vivo 12 software (QSR International 2019). A thematic analysis is a

systematic process to pinpoint, regroup and analyze themes from a corpus (e.g., transcribed interviews, organizational documents and notes from observations; Paillé and Mucchielli 2016b). In practice, it consists of: (1) becoming familiar with the raw data by listening to the audio records and reading the transcriptions and personal notes about the interviews; (2) generating initial themes (common aspects relevant to the research objectives covered in the different interviews) by coding text samples (associating a theme to a text sample) from the transcriptions and notes; (3) documenting the connections, convergences or divergences between the themes, and progressively grouping the themes into a hierarchy starting from the specific to the more general and abstract; and (4) organizing and structuring the various themes and categories under the form of a tree (i.e., similar themes are gathered in the same tree branch). In an iterative analysis, the codes, the text samples, the themes and the hierarchy are revisited several times, as it was the case in this study. For the post-project evaluation, the corpus consisted mainly of the transcribed interviews. Nonetheless, the notes that were taken during the workshops over the duration of the project were also analyzed to corroborate the results of the interviews with the professionals.

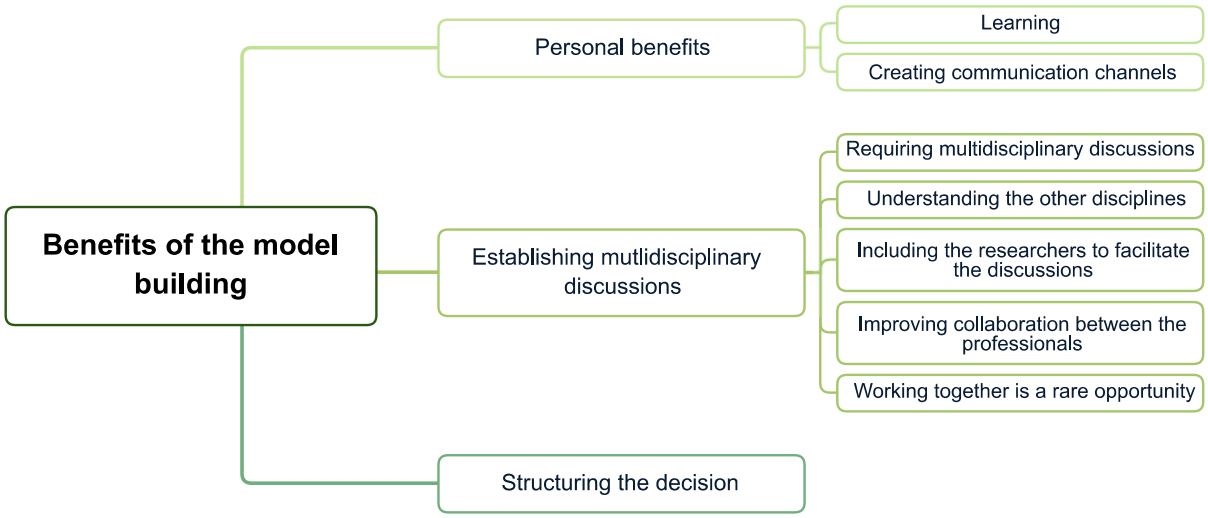
5 Results

In order to make the results more legible, the tree summarizing the results of the thematic analysis was split into several trees (Figures 2 to 6). The analysis was further grouped into five categories: benefits of the model building (section 4.1), difficulties and challenges of the model building (section 4.2), benefits of the SDSS's adoption and uses (section 4.3), difficulties and challenges of the SDSS's adoption and uses (section 4.4), and future of the SDSS (section 4.5). All the quotations reported in this section were translated from French into English. The names given to the quotes are there to aid the reader and were anonymized using the most common names in the province of Quebec.

5.1 Benefits of the model Building

The professionals involved in the workshops identified several benefits to the model building process (Figure 2).

Fig. 2 Benefits of the model building as reported by the interviewed professionals



5.1.1 Personal benefits

On a personal level, the participants expressed that the project enabled them to not only learn about the domains, the language, the backgrounds, the needs, and the technical issues of the other participants, but also about MCDA and how they can use it in their practice.

> "I think that it is a learning experience about the other disciplines because often, we do not know what they do. We do not know the impact of an action we might take on the other [colleagues]" (M. Tremblay)

Moreover, some professionals mentioned that it created or strengthened communication channels among them, and subsequently led them, later, to collaborate more often on projects.

5.1.2 Establishing multidisciplinary discussions

The participants perceived positively the multidisciplinarity of the workshops. They stated that multidisciplinary discussions were a requirement in order for the project outcomes to be adopted by the professionals in their practices. It enabled them to understand the impacts of their own practices on others and to break professional silos. In fact, the project was the first experience where they were able to meet on several occasions over a long period of time, and to develop a new decision process in a multidisciplinary setting. They were used to only occasional collaborations with other departments on specific projects (e.g.,

the redesign of a given street). Furthermore, according to the participants, the inclusion of facilitators, external to the organization, in this case university researchers, had motivated them to collaborate and improved the project's credibility and their trust in the resulting artifacts. After being asked to summarize one good move of the project, one of the professionals answered:

> "A good move, it is the innovation, the trans-disciplinarity, the working together. It is about changing cultures, it is major! And this, it allows us to come together around a tool. It is everyone's tool." (Ms. Gagnon)

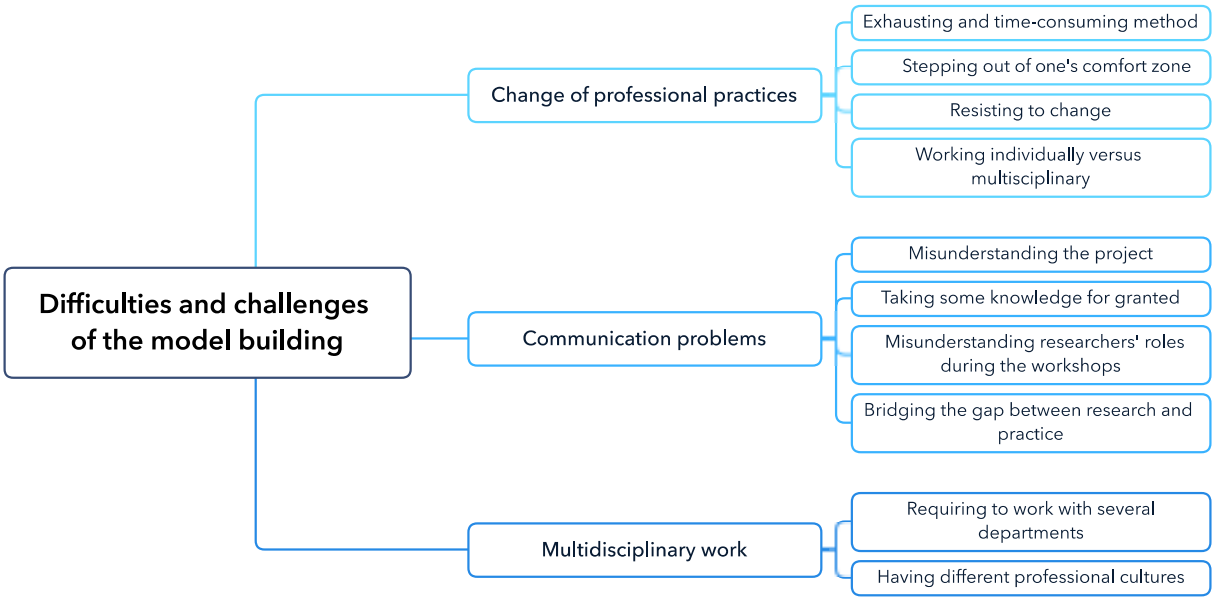
5.1.3 Structuring the decision

The participants reported that the modeling phase helped them to construct a holistic view, to find compromises between their professional visions, and to structure the decision by interconnecting the different ideas.

5.2 Difficulties and challenges of the model building

The participants also reported some difficulties and challenges encountered during the model building process (Figure 3).

Fig. 3 Difficulties and challenges of the model building as reported by the interviewed professionals



5.2.1 Change of professional practices

The process was perceived as long and intellectually exhausting. Each workshop lasted between two and three hours; the participants felt they had to answer a large number of questions. It was particularly

demanding since they had to explain, discuss and justify their points of view to other professionals with different discipline backgrounds and objectives. In fact, some professionals stated that they did not wish to confront their ideas, felt that working in a group was ineffective, and expressed that it was easier for them to work individually. Professionals specified that a better management of change within the organization for the whole process could have eased the modeling phase; the project changed the working methods that Quebec City professionals were used to for several years. When asked to name one bad move associated with the project, one participant answered the following, referring to their own internal organizational process:

> "A bad move, we have discussed it, it is in managing the process, not only the tool and the method, but from A to Z. To manage it in terms of change, to be a little bit more visionary, but that is basically all of us who should have been a little bit more...but we learn." (Ms. Roy)

Furthermore, several participants felt outside of their comfort zone. They were not enthusiastic about having to change their practices. Interestingly, for some, the project was more "rational" than usual since it removed some professional freedoms, while for others it was too "subjective" since there were no true or objective answers during the model development.

> "Honestly, we had doubts, was this really going to work? [...] we thought: « It is a more rational approach». It could be seen as a way of taking away…how to say that … the creative side ... and maybe some of the personal or professional judgments»" (M. Côté)

> "At first people were like, «Ahhh … this is a soft process. Does it have any real value? We could have changed the people around the table, and we would have had ten other [street evaluation] criteria», that is the kind of statement that came out." (M. Bouchard)

5.2.2 Communication problems

The participants also identified communication issues as a challenge. The Complete Streets strategy was in its infancy at the time and the Quebec City's strategic objectives were still fuzzy. The participants had difficulties understanding the project at the beginning; some wondered why they were invited to the workshops and were doubtful about the potential results of the project. A lot of background work was required to structure their knowledge. One participant even stated feeling like a "*tourist"* at the first workshop. In parallel to our MCDA project to identify *where* to design Complete Streets, some professionals had already been working on a project pertaining to *how* to design Complete Streets. It resulted in a confusion between the goal of prioritizing streets to become Complete Streets and the goal of designing Complete Streets. However, this is not an issue of MCDA, but simply an issue of coinciding projects. Furthermore, due to the project's nature as a partnership between Quebec City and academia, some

participants were doubtful and feared that the project would be too theoretical and not represent reality. Despite our conscious efforts to act in a facilitator mode, some participants still felt that we sometimes acted more as domain experts than as facilitators. They believed there was a gap between our academic perspective, working on a research project, and their organizational perspective, working on an operational project, which took several workshops to fill by creating a common language.

> "I'm going back to the original goal, bridging science and operations for [Quebec] City. At first, I think that it seemed more like the experts would explain how it works, and we were almost lab rats for a university project. And that upset some people at first. Afterwards, it really fell into place, but I think that this aspect may have upset a few people." (M. Bouchard)

Furthermore, the participants indicated that the facilitators might have overestimated the participants' knowledge relevant to the project and their knowledge about the technical domains of their colleagues. As a consequence, some participants restricted their interventions in the group discussion. One participant stated: "I had difficulties giving an opinion since I had the feeling that I was not competent enough compared to the others" (Ms. Gagnon).

Finally, since the main facilitator was a student, some participants reported that the roles of the facilitators were not always clear; it should have been stated at each workshop that this was also a learning process for the student-facilitator who might sometimes hesitate or make some mistakes, and that the professors-facilitators would help and correct the student-facilitator during the workshops, when deemed necessary.

As a solution to minimize future communication problems, some of the interviewed participants suggested that examples be presented from other similar MCDA projects to explain what the final results could look like in order to reassure them and increase their confidence with respect to their own project. They also suggested that, as facilitators, we should spend more time explaining the project, the method that would be used, and the SDSS's potential impacts on professional activities. Further to that, they suggested that each participant should better define his/her expectations, objectives, and background at the first workshop. In addition to the summary that we presented at the beginning of each workshop, one participant expressed the wish to have, before the workshop, a meeting account of the previous workshop in order to refresh their memory.

5.2.3 Multidisciplinary work

Not surprisingly, since the project involved participants from different professional and departmental cultures (engineering, environment, transport, urban planning, public participation, etc.), their objectives and concerns were different and sometimes contradictory. To reach a consensus or a compromise, the professionals reported that they had to defend their positions and actively listen to others to understand their

perspectives, which resulted in longer deliberations and negotiations. They confirmed our previous observations that the project's duration was long, and that the group workshops were lengthy and laborious. Nonetheless, the participants still thought that facilitated group workshops were required to get to a consensus. As one of the participants declared: "*just having so many departments sit at the same table and forcing them to make a decision is in itself a success*" (M. Bouchard). The participants, as we had also noted, confirmed schedule and attendance problems were mainly due to the numerous departments involved. Furthermore, not all participants had enjoyed the full support of their respective department heads to take time to attend the workshops, a direct consequence of some department heads not fully understanding the project. As expressed by some participants, a stronger support from the different heads and a clearer explanation of the project to the department heads could have helped.

5.2.4 Repeated absences

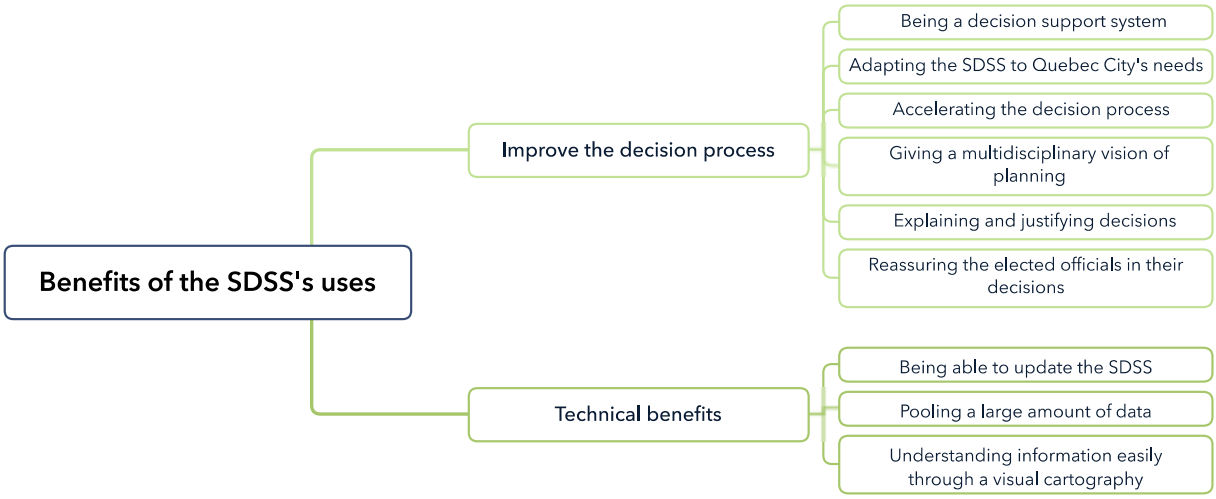
All the interviewed participants reported that they disliked the fact that not all the participants attended all the workshops, and that it affected negatively the project and the group's *esprit de corps*. They rationalized the absences and explained them by the cumulated effects of the difficulties reported above. Five of the seven interviewed participants had remarked that one professional completely dropped out of the group workshops but were unable to provide clear reasons that could justify, in their minds, quitting the process. This is actually one of the participants who declined to be interviewed during the post evaluation project. Such feedback suggest that it is important from the start to have the commitment of participants and explain that if they are unable to continue, that some reason be given to the other participants.

The introduction of subgroup workshops after the first two workshops was qualified as "an *essential step in the project"* by some of the participants. The subgroup workshops aided the participants to untangle and understand the different aspects considered in the project, allowed them to work more efficiently on specific aspects of the model and improved their confidence in the process. Thus, with respect to deliberation over points that are specific to one domain of expertise, the use of subgroup workshops can reduce the time burden on the entire group.

5.3 Benefits of the SDSS's adoption and uses

Since the SDSS's implementation in 2018, the professionals have been using it in their day-to-day operations and have identified several benefits linked to its use (Figure 4).

Fig. 4 Benefits of the SDSS's adoption and uses as reported by the interviewed professionals



5.3.1 Improve the decision process

Quebec City professionals appreciated that the SDSS was presented as a decision support system rather than as a decision-making system. The SDSS suggests different streets with a high potential to become Complete Streets without imposing a decision. They also liked the fact that the SDSS was designed based on their preferences, objectives and needs, and not on the ones found in the literature or in another city. They added that its operational use has accelerated their decision process and the analysis of the different alternatives. One of the Complete Streets project leaders estimated that using this SDSS has resulted in an approximate time saving of six to nine months for each street rehabilitation project. The professionals also indicated that the SDSS created a common vision of planning that considered the numerous plans developed by the different departments throughout the years. Consequently, the SDSS aided the users in the decision process by creating a coherent, well thought-out and structured discourse to explain and justify why a street has higher priority than another street.

The SDSS users reported this as being valuable not only internally, in discussions among the professionals, but also externally, in public consultations with citizens. For example, following a public consultation where analyses based on the SDSS were presented by Quebec City professionals, city residents expressed a high level of satisfaction since they were able to better understand the decisions made by the city. They felt that the city's process had increased in transparency and legitimacy as a consequence of using the SDSS. The professionals also stated that the use of the SDSS reassured the elected officials since it allowed them to have a holistic vision and to take decisions based on a structured process. Such feedback is likely important to relay to individuals new to MCDA (see 5.2.3), as it will reassure them that the outcome of the deliberations will lead to tools appreciated by both decision makers and those who would be impacted by the decision.

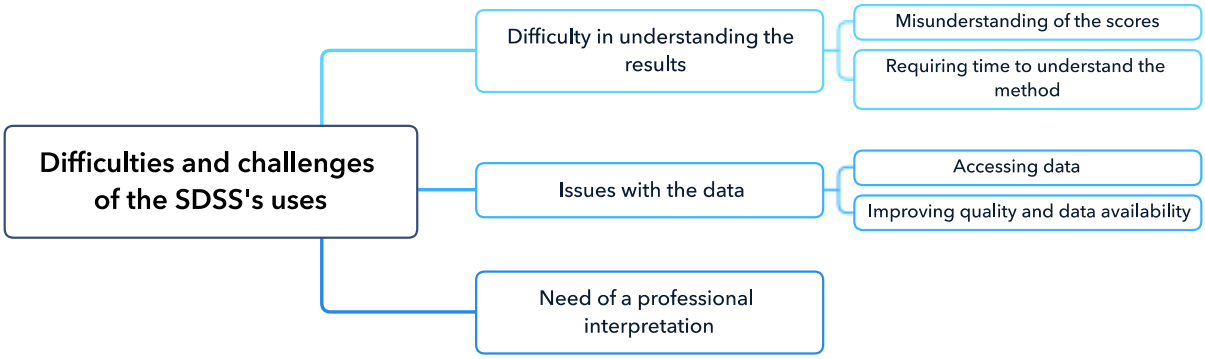
5.3.2 Technical benefits

From a technical perspective, the SDSS users reported that, for the first time, they were able to gather a large amount of data from various fields into one database. They were surprised by the amount of information available for each street segment in the SDSS. They indicated that the intuitive visual cartography in the SDSS ranging from cold colors to warmer ones helped to quantify and frame professionals' preferences in a way that is easily understood by citizens and elected officials. They also praised the ability of the SDSS to be updated with new data.

5.4 Difficulties and challenges of the SDSS's adoption and uses

On the downside, the professionals reported difficulties and challenges in the adoption and use of the SDSS (Figure 5).

Fig. 5 Difficulties and challenges of the SDSS's adoption and uses as reported by the interviewed professionals



5.4.1 Difficulties in understanding the results

The SDSS users had sometimes difficulties in understanding the meaning of the MACBETH attractiveness scores and how they were obtained. The professionals had the impression that they did not fully comprehend the MCDA theory behind the SDSS. This was initially a barrier to the proper adoption and use of the SDSS. Fortunately, they were able to solve this challenge with our support in 2018. Still, one of the professionals, although from an engineering background, mentioned that the MACBETH method seemed too complex for him to take the time to understand how the developed model works and what its limits are.

5.4.2 Issues with the data

Issues with the data were also brought forward. Some professionals found that the access to some of the original data was difficult since it was distributed across different departments. Other users disliked the use of proxies in the model. These were used when Quebec City lacked data for some criteria (e.g., citizen

569 petitions and resolutions were used as a proxy for citizens' concerns). Some participants would have liked
570 that the SDSS use objectively measured data that better reflect reality, which was impossible due to data
571 unavailability.

572 "Sometimes, we had good ideas, but we had no data. Other times, we had one type of data and we had
573 no choice but to work with it, even if we knew that it was not ideal." (M. Gauthier)

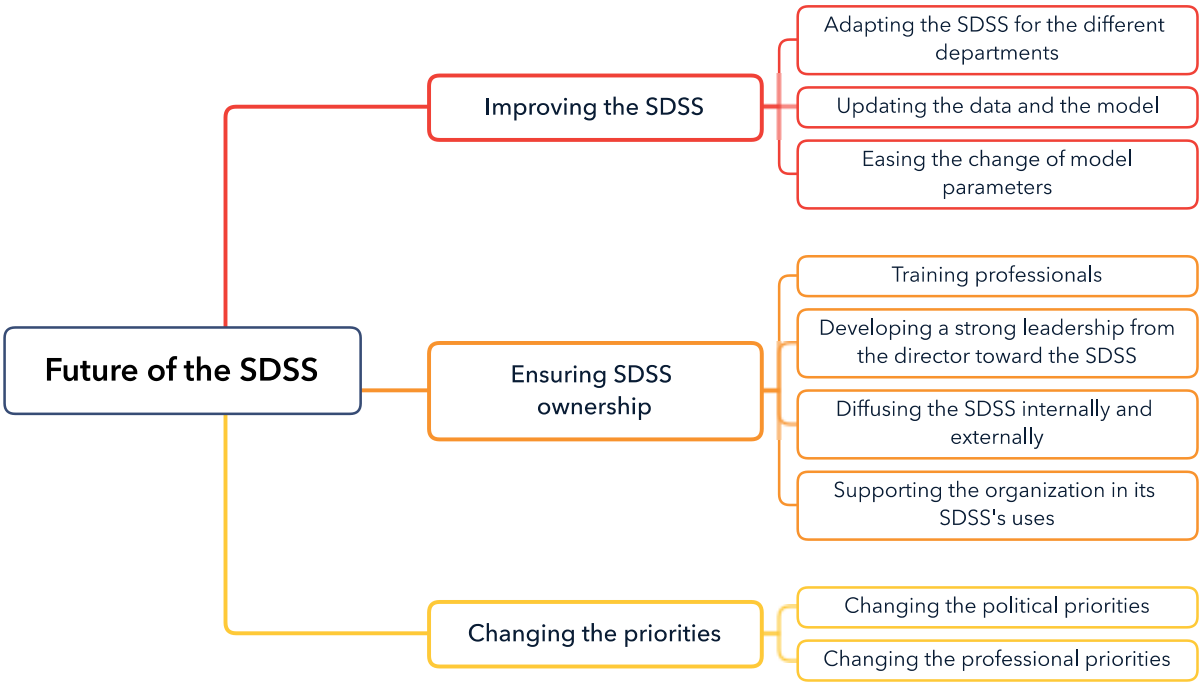
574 ### 5.4.3 Need for professional interpretation

575 Finally, the users and Complete Streets strategy's leaders observed that the SDSS needed some form of
576 professional interpretation and that some caution should be taken in its use. For example, a rehabilitation
577 project usually affects several street segments, but the SDSS scores each street segment (i.e., the portion of
578 a street between two adjacent intersections) individually. Therefore, the professionals still need to examine
579 and interpret the SDSS results according to their professional judgment when comparing various possible
580 rehabilitation projects. One of the strategy's leaders mentioned that in one specific case, the interpretative
581 nature of the map was exploited by a professional, external to the project, to deliberately misinterpret the
582 map and push a non-priority project. To avoid such situations in the future, the SDSS could include an
583 improved visualization interface that allows one to compare alternatives based on their performances on all
584 criteria simultaneously (performance profiles), in their original units as well as in the MACBETH
585 attractiveness units. At the current time, performances can be visualized one criterion at a time as a layer in
586 the GIS.

587 ## 5.5 Future of the SDSS

588 During the interviews, the professionals invoked different ways to ensure the continued use of the SDSS in
589 the future (Figure 6).

590 **Fig 6** Aspects to ensure the future of the SDSS as reported by the interviewed professionals



5.5.1 Improving the SDSS

The SDSS users reported that the MACBETH attractivity scores on the various criteria within the database were difficult to express in lay language and should be made more explicit since they could not make the link with the original value (e.g., an attractivity score of 140 and a street width of 20m). It was also expressed that, to keep the SDSS relevant, the model and the data should be updated regularly. Several professionals mentioned the projected tramway to illustrate why the SDSS should be updated regularly and why it should be easier to update. In fact, Quebec City is currently developing plans for a structuring public transit network that includes a new tramway which would have major impacts on Complete Streets prioritization. The structuring public transit network was first planned as a tramway in 2011, was changed to a bus rapid transit in 2015, was outright canceled in 2017, and was then resurrected as a tramway in 2018 with major changes to the initial route. In 2020, the project is still subject to heated debates and its projected route has recently been slightly altered again. To ease data update, the MACBETH method could be integrated as a plugin in a GIS software. A first set of tools to help the computation of MACBETH score in ArcMAP (ESRI 2014) was developed for the project (Marleau Donais et al. 2017b). However, the professionals wished for a full and dynamic integration where information can move seamlessly between the GIS and the MCDA modules in one interface according to the user's needs (Chakhar and Mousseau 2017).

Furthermore, some users expressed concerns that to change the model parameters (adding criteria, changing planning objectives), new group workshops would be required. This situation is problematic since Quebec City does not have the expertise to facilitate MCDA workshops which makes them dependent on qualified facilitators external to the city's workforce.

5.5.2 Ensuring SDSS ownership

Ensuring the ownership of the SDSS can help its long-term viability. Since it is a multicriteria SDSS, the professionals expressed that they would require training in geomatics and potentially in MCDA to improve their understanding so they can maintain the SDSS in the future. The professionals also suggested that a strong leadership from the higher management would be required to ensure that the proper resources are allocated to maintain the SDSS up to date.

> "The fact that people take ownership of it, the fact that at a higher level, I would say, the directors believe in it, that they assign the human resources, that they assign the right people to be able to feed it. That for sure will create a winning situation […] where people really take ownership of it." (Ms. Gagnon)

The ownership of the SDSS also requires better information dissemination among the professionals (e.g., workshops to present the SDSS's benefits), but also to the elected officials and citizens (e.g. public participation events). One professional suggested that the internal Complete Streets team should periodically present the SDSS to refresh the other professionals' memory of how it works. Moreover, they expressed a wish that our research team remain available to support the employees of Quebec City sporadically as needed. The SDSS users also suggested customizing the SDSS for the various departments to ease its integration within the different professional practices.

5.5.3 Changing the priorities

Finally, the professionals indicated that the change of priorities in the organization could in the future impact the SDSS's sustainability. The election of new officials, the change of political priorities or the rise of a new planning approach could lead to a shift in priorities and to shelving the SDSS.

6 Discussion

As previously indicated, few papers in the literature include an ex-post evaluation of their MCDA project. The post-project evaluation executed in this paper, as a formal follow up to an MCDA project, has been an enriching experience for our research team to better understand the perspective of participants and users in an MCDA project. Based on the results above, we offer in section 6.1 some recommendations and tips for improving practices for other MCDA projects. In section 6.2, we explore the limits of this evaluation and propose future research avenues.

6.1 Implication of our results for other MCDA projects

Our results indicate that several of the benefits and positive aspects formulated by the professionals regarding the development process, the artifacts' adoption and its use confirm conclusions from other studies on group MCDA processes. Indeed, the participation in group workshops helped participants to achieve a feeling of ownership, to learn about other participants' perspectives and to build a shared understanding of the problem (Phillips and Phillips 1993; Banville et al. 1998; Salo and Hämäläinen 2010; Phillips 2011; Henao and Franco 2016). In addition, the perspectives provided by the interviewees helped us better understand the reasons behind the challenges encountered as facilitators during the process (e.g., attendance problem, participants' difficulties to express preferences, etc.) (Marleau Donais et al. 2017a).

Considering the challenges and recommendations expressed by the professionals and our own experience with the project, we identified various good practices (section 6.1.1 to 6.1.5) that are relevant to other MCDA projects in contexts like ours, namely within a western culture and where participants and users are from the same organization but have different backgrounds (e.g., engineering, transportation, environment, urban planning). However, decision situations involving actors from different public organizations (e.g., municipalities, provincial governments, and the federal government) or involving public-private relationships add political and governance issues that were not present in this case study and that might impact our recommendations.

6.1.1 Laying the foundations for the project at the first workshop

Considering the comments expressed by the professionals during the post-project evaluation, it would be beneficial at the first workshop to ask the participants some specific questions during the introduction. These questions should allow each participant to express his/her expectations and objectives about the project and tell about his/her professional background and experience with MCDA. This suggestion is consistent with the "hopes and fears" script in group model building where participants express their greatest hopes and fears for the project (Andersen and Richardson 1997; Hovmand et al. 2012). As a consequence, this could help the facilitating team to better manage expectations and possible challenges.

Another common practice in group facilitation is to explain the project, the method, and the potential results during the first workshop. Considering the participants' comments, we suggest that it could be useful to also present some similar case studies. This would help the participants understand what they can expect from an MCDA project and inform them of the challenges that the group may face during the project. Once the participants have introduced themselves and the project has been presented, participants should understand why they are involved in the project, what their role will be and what they can expect from the

project. These recommendations to lay the foundations might lengthen the start of the project, but will allow to accelerate the process as a whole by answering questions that usually emerge at a later stage.

6.1.2 Recalling the project's status and activities

To help the participants recall the project's status and activities, especially when some time passes between workshops, a summary of the project's status at the beginning of each workshop should be presented. It should include the objectives, the global method, the achievements accomplished since the beginning of the project, the tasks to complete during the workshop and the roles of the different facilitators during the workshop. This is in line with Andersen and Richardson (1997) who suggested clarifying the purpose and the group products (i.e., what has been produced during the group workshops) in group model building.

The development of a workshop logbook to continuously share the project's progress between the facilitators and the participants, during the process, is another possible solution (Leleur 2017). This logbook should include a summary of the project and of each meeting, a glossary of the shared language developed and the definition of each criterion. However, our experience in different projects has shown that few participants read the documentation that we send before the workshops.

6.1.3 Subgroup workshops

The addition of subgroup workshops midway into the process helped the participants to better understand and improve their confidence in the project and was identified as a successful approach by the professionals. The shorter workshops (30 to 60 minutes) allowed us to move forward quickly for subparts of the model, such as defining the scales for a specific criterion, that involved smaller groups with a specific expertise. They allowed the participants to have more time, in a less formal setting, and to think more freely about their preferences, as compared to group workshops. This use of subgroup workshops, also identified as thematic workshops in the literature, is an approach that has been highlighted in the literature on decision conferencing (Phillips 2007) and cognitive mapping (Damart 2010). However, from our perspective as facilitators, their use raises questions about the lack of discussion within the group as a whole.

6.1.4 Attendance problems

Attendance problems were the only negative aspect consistently mentioned by all the interviewed participants. The interviews revealed that this was a consequence of the cumulated challenges that occurred during the project. Facilitators facing this situation should discuss this issue openly during a workshop to enable the participants to express their frustrations and identify possible solutions to reduce and, if possible, eliminate the various causes of these absences in future workshops. In our case, a stronger leadership from the different department directors could have helped convince the professionals who were less open to changing their practices to stay in the workshops.

6.1.5 Difficulties in understanding the results and the MCDA method

The difficulties expressed by the SDSS users in understanding the final scores computed by the model and the mathematics behind the MCDA method are a reflection of criticism found in the literature sometimes portraying MCDA methods as black boxes (D'Este 2009; Browne and Ryan 2011; Quinet and Meunier 2012). This issue highlights the difficulties in communicating MCDA methods in a lay language to audiences who are not familiar with MCDA. The solution we adopted in our subsequent projects has been to create a standalone presentation that explains in more detail the principles and logic behind the MCDA method without going into the mathematical details. This presentation is shared to the participants who express a will to learn more about the method.

All of the above tips and solutions were implemented by our team in one form or another in subsequent projects (mostly with the public sector, but in different fields such as water management, architecture, impact assessment, asset management and public health).

6.2 Limits of the framework and lessons learned

Our proposed MCDA post-project evaluation framework is simple and easy to understand, which should encourage practitioners and academics to adopt it in their future practice. Nonetheless, it has its limits.

When designing post-project evaluations, one can imagine different frameworks based on a different set of answers to the key questions (see Table 1), which may or may not lead to similar designs. For example, a post-project evaluation could be designed using a mixed methods approach (in reference to *how to evaluate?*) and based on theory and participants' goals (in reference to *on what is based the evaluation?*). Also, frameworks developed in the OR literature such as the one proposed by Midgley et al. (2013) or Rouwette et al. (2002) could be adapted to evaluate a posteriori MCDA projects.

Although we adapted a framework from the public participation literature, it was not within the scope of our project to organize public consultations. Nonetheless, a possible extension of this study would be to include city residents in the evaluation. Their involvement could help assess the perceived legitimacy of the artifact outside of the organization. Nonetheless, it is worth mentioning that Quebec City did organize public consultations where the results of the SDSS were presented to residents. In those consultations, residents gave very positive feedback regarding the SDSS and the transparency of the decisions (see 5.3.1).

As for the interviewer, a person who is external to the project rather than one of the project's facilitators, could have been chosen to avoid or minimize socially desirable answer biases (e.g., not wanting to hurt/offend the person who conducted the original work). This type of bias might have influenced our results and it is difficult to evaluate its impact precisely. Moreover, as shown in the literature on group model building (Scott et al. 2013), the time lapse between the workshops and the follow-up, as well as the

successful use of the SDSS, may also have positively biased the workshop participants. Still, both positive and negative aspects were easily and freely expressed by the interviewees as it was clearly communicated to them that the objective was to evaluate and improve the process and resulting artifacts.

Another limit is the lack of involvement of the professionals who declined our invitation to participate in the evaluation process. Having them on board might have allowed us to document additional benefits or challenges around the model building. However, we believe that they would not have significantly contributed new information to the evaluation since we had already reached a saturation point in the last interviews, where no new aspects or issues were added by the participating professionals.

Furthermore, one of our limits is methodological. Our interview results could have been analyzed using other methods such as causal mapping to clearly identify the causes-consequences relationships and therefore better highlight the elements that caused positive and negative outcomes and perceptions, and consequently identify good practices.

Finally, the lessons learned from this project could be enriched by the results of an observational study that examines and analyzes the practice of facilitation, similar to the work of Papamichail et al. (2007), Tavella and Papadopoulos (2015a, b), Franco and Greiffenhagen (2018), Franco and Nielsen (2018) and McCardle-Keurentjes and Rouwette (2018). Although such a study, combined with a post-project evaluation, would provide valuable insight for MCDA analysts and facilitators in practice, it was outside the scope of this paper.

7 Conclusion

The design of an MCDA post-project evaluation framework and its application to a case study has enabled us to learn about the perceptions of the participants and the users regarding the process itself (the group workshops) and the produced artifacts (MCDA model and SDSS). From our perspective as facilitators, this qualitative evaluation allowed us to acquire a broader picture of the project's impact and to document the advantages, disadvantages and challenges perceived by the participants as well as their suggestions for possible improvements. The interviewees appreciated this follow-up activity because it enabled them to reflect on the project in retrospect, a too often neglected phase, particularly in MCDA projects. They identified issues and proposed several solutions worthy of further exploration.

The contributions of this paper to the field are two-fold. First, we were able to fill a gap in the MCDA literature by proposing a flexible and simple framework for post-project evaluations design based on clear questions. Second, the application of the framework to a case study allowed us to provide empirical evidence, not only regarding the benefits and challenges associated with MCDA group workshops (e.g.

766 structuring the decision, change of professional practices and potential communication problems), but also
767 regarding the acceptance, adoption and use of a multicriteria SDSS (e.g. improving the decision process,
768 difficulty in understanding the results, ensuring SDSS ownership).

769 Several future research avenues can be envisaged. One is to explore the links and applicability of Design
770 Science Research evaluation frameworks to MCDA (Venable et al. 2016). In addition, a better
771 understanding of the behaviors of the individuals involved in the modeling process, the outcomes, the
772 artifacts' adoption and their use, as pursued by behavioral operational research, would also shed light on
773 what makes MCDA artifacts successful, or where it fails to flourish in an organization. Furthermore, future
774 studies could explore how to realize a post-project evaluation that is less time-consuming and that does not
775 require organizing several individual interviews. In our more recent MCDA projects, for example, we have
776 integrated formative evaluations at the end of our workshops where the participants are asked to answer in
777 writing four open-ended questions. Other possibilities include a group interview or a survey right after the
778 project report has been delivered to the client organization.

779 In essence, to improve practices and develop MCDA artifacts that will meet an organization's needs, more
780 case studies should evaluate a posteriori the development and use of MCDA artifacts. This paper allowed
781 us to propose several recommendations to improve practices based on the successes and challenges
782 encountered in a case study. As a consequence, we have since adapted some of our own practices (e.g.,
783 subgroup workshops, project goals reminder) and are further exploring new avenues to overcome these
784 challenges in future research projects. The value of our post-project evaluation can be summarized in the
785 words of one of the Complete Street strategy leaders in Quebec City:

786 *"I am glad that we are doing this together because it is an aspect with which we felt helpless at first. We*
787 *felt that it was a great research project, but that once it was done, it was done. "Yeah…, but wait. For us,*
788 *it was not finished." There is a life after the research project, and this, I think, is an aspect that you were*
789 *able to catch up in the last year, but it is something that has to be taken into consideration in all [research]*
790 *projects. If you are supporting other cities or if a new student takes over the project, this step should not be*
791 *forgotten. It is not because a project is done that everything is functional and that an organization will*
792 *necessarily work with it."* (M. Bouchard)

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