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DEFINING MORE SUSTAINABLE AND INNOVATIVE SOLUTIONS THROUGH CHOOSING BY ADVANTAGES

Randi Christensen[1]

ABSTRACT

The nature, characteristics and traditions of the Architect, Engineer and Construction (AEC) Industry can be a challenge for enabling innovations and development. As projects are limited in time and scope and often under cost pressure, it can be difficult to prioritize time to innovate. However, as we recognize the negative impact our industry has on e.g., climate changes, loss of biodiversity and social inequalities, the industry needs to change and develop at a higher pace. If we want to be part of the solution and not the problem, we need to ask some very important questions on e.g., the methods we work by, the solutions we design, and the materials we use. Lean methods like Choosing by Advantages (CBA) have proven to enable cross disciplinary and collaborative decision making. But CBA could also set the framework for targeted innovation and development within a project setting. This paper presents the idea of how CBA could support targeted innovation within project constraints. The method was tested on a case, where the client was seeking improvements within specific areas compared to a 'standard' solution.

KEYWORDS

Sustainability, Choosing by Advantages (CBA), Learning, Action Research, Innovation

INTRODUCTION

Many look to the AEC industry for changes these years. Our industry has an enormous impact on our society, and while the industry will deliver many solutions for us to deal with climate change and support an increased standard of living for billions, we also slowly realize the significant negative impact the industry has on the planet and the climate.

A NEED FOR CHANGE

The build environment has a significant role to play in reaching the national and regional goals set around the world to reduce carbon emissions. 11% of the global carbon emissions stems from materials manufacturing, transportation, construction and end of life handling of materials in the construction industry (World Green Building Council, 2021). At the same time, the industry right now holds some golden opportunities. To recover from the COVID pandemic governments across the globe seek to stimulate the economy through investments in the construction industry. The EU has launched investment opportunities in Deep Renovation in Europe (United Nations Environment

[1] PhD, Sustainability Director COWI, Co-Founder of collabdecisions.com. rmch@cowi.com, https://orcid.org/0000-0002-3377-7057

Programme, 2020), and the Biden Administration in the US have launched a $1.2 trillion Infrastructure Framework as part of the Build Back Better (The White House, Briefing Room, 2021). These investments can intensify the green transition of the AEC industry, if the industry actively seeks to make real changes and embrace the green transition.

Engineers are perceived to hold the tools and knowledge to support this green transition of the industry (Danish Association of Consulting Engineers FRI, 2018). But the engineering companies need to take this responsibility, integrate core skills and disciplines, set up the right framework for collaboration and innovation, and challenge clients and societies to become more sustainable (The World Federation of Engineering Organizations (WFEO), 2002).

With this in mind, we need to develop new solutions, materials, and technologies to support the growing population, help raise the standard of living, while at the same time reducing the negative impacts like the carbon emissions in relation to construction activities. Best Practice develops rapidly, hence we need to adapt quickly and integrate new knowledge and technologies into our designs and by this supporting a culture for innovation in the industry.

MORE INNOVATIVE METHODS ARE NEEDED

Freeman defines innovation as the use of nontrivial change and improvement in a process, product or system that is novel to the institution developing the change (Freeman & Soete, 2017). Innovation therefore includes both incremental and more radical changes and can be ideas and technologies known elsewhere but adapted to a new context. But innovation is more than just a change, the change also needs to provide value (Tidd & Bessant, 2014). Innovation is hence a term for everything from incremental changes to radical changes, both on a component and systematic level.

The AEC industry has for long been perceived as lagging other industries when it comes to the rate of innovation (Renz & Zafra Solas, 2016). Some of this is due to the characteristics of the industry like: temporary organisations (Bresnen & Marshall, 2000), one-of-a-kind production (Koskela & Vrijhoef, 2001), a conservative mindset (Renz & Zafra Solas, 2016), separation of responsibility and division of powers (Scarbrough et al., 2004; Winch, 1998). This also means that innovation models invented elsewhere might not apply to the AEC industry (Winch, 1998). Where some research focuses on how to bring innovation into best practice (Koch-Ørvad, 2019), this paper will focus on innovation culture and processes within a project setting.

If we want to support innovation in the AEC industry, we need to consider the characteristics of the industry as well as remember that we can't rely on normal management processes when it comes to managing an innovation process (C. M. Christensen, 1997). If innovation is tied up in a project setting with a paying client, there will be a constant tension between delivery towards the expected outcome (incl. time, resources and risks), versus the free, risky and innovative thinking (C. M. Christensen, 1997). While this tension between innovative thinking and time and resource constraints might not be ideal for blue-sky thinking of how to make radical innovations to e.g., reduce carbon footprint of a project, it is the reality for most projects in the AEC industry. Therefore, this paper will focus on how to best utilise innovative thinking within a design team. The focus will be on the processes behind enabling innovation within a project setting through a project case. Therefore, the process and not the specific product is in focus.

METHOD

The idea of using Choosing by Advantages (CBA) as a driver for structured innovation came from the authors' combined experiences in training CBA (Arroyo et al., 2019) and using CBA as an integrated decision and value engineering method, where the project team systematically used CBA to choose from design alternatives in preliminary design as described in (Schöttle et al., 2018a). The structured process and cross-disciplinary collaboration led to optimised solutions and ideas for improvements as a 'bi-product' of the decision process on previous projects. This sparked the interest to investigate how CBA could support innovation and development within a project setting.

The study is based on a case, where a client specifically asked for innovative thinking on a desk study, where a known and already completed construction project, should act as baseline and a team of engineers should come up with new ideas for a solution. The author was brought into the team to support the innovation process through application of CBA. Therefore, this study qualified as action research (Dickens & Watkins, 1999), bearing in mind that the key focus was to deliver towards the client's expectations not to conduct research. Being part of the project allowed for situated learning through integration with the team (Sense, 2007). Literature review and discussions within a Community of Practice (Wenger, 2004) focusing on Choosing by Advantages (Collabdecisions.com) have enabled reflections on the topic and elimination of some of the potential bias from being actively part of the case.

As the team wasn't familiar with the CBA process, it was decided to evaluate the process for internal learning. A survey was carried out within the consultant team, asking open questions with a Plus/Delta format: What went well? Ideas for Improvements? Data from the survey (5 out of 9 responses) formed a basis for a semi-structured interview with the senior responsible from the client's side to understand their perspective on the process. The purpose here was also to examine the teams' perception of innovation and how well CBA supported this process. An interview with the project manager from the consultant side was finally carried out to get insights and clarification. Both interviewees and the team members have had the opportunity to read and comment on this paper.

CASE: INPUT TO AN INNOVATION STRATEGY

The case was a project for a public client, managing the development, operation, and maintenance of major urban transportation infrastructure in Europe. The client was in the process of developing a standard internal innovation process to give input to ideas to be tested out in desk studies. See draft sketch of the innovation process below based on (Interview with Russel Saltmarsh, 2022).

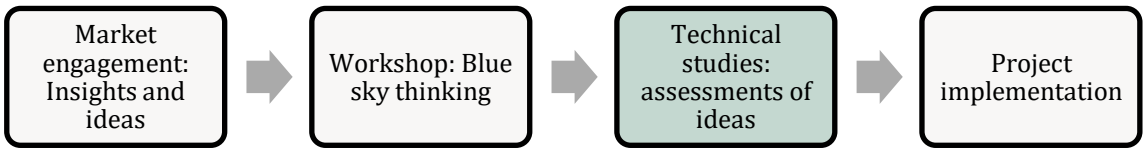

Figure 1: Innovation process of the client

The market engagement gave input to internal workshops. In the workshops blue sky thinking resulted in ideas for further clarification e.g., change in design. These ideas should then be further assessed through technical studies. COWI, an international

engineering company with headquarter based in Denmark, was in this case requested to come up with alternatives to design for a typical project for the client and assess these on certain parameters. The client brought some ideas on how to reduce CO2 footprint and wanted an assessment of the ideas and input on how to mitigate potential risk and challenges. This paper focuses on this technical study, here carried out as a desktop study.

The study considered a holistic approach reviewing reduction of CO_2 emissions. It assessed changes in the structural elements, materials, and construction methods, whilst the architectural functionality, look-and-feel and finishes were unchanged. The design of an existing project was selected as baseline, and suggested alternatives should maintain the same boundary conditions e.g., geology, space constraints, O&M requirements, M&E requirements, neighbouring buildings typology, etc.

The engineering team consisted of experienced senior specialists within underground structures, geotechnic, concrete, sustainability, metro station and tunnel design. The team selected 8 reference projects as inspiration and as background for new technologies and ideas within the specific context, and as input selection of factors and criteria and the risk assessment. In summary: the task was to come up with innovative design ideas for a metro station, leading to a 'greener' solution with less CO_2 footprint compared to an existing station. As the project was unusual in nature, having no specific project brief – but with expectations to be innovative, some time was used discussing the baseline, criteria, and what process to use, and it was suggested to use CBA as a framework for this discussion.

CBA FOR IMPROVEMENTS

Choosing by Advantages was developed by Jim Suhr (Suhr, 1999) to support his work in the U.S. Forest Service. Through the work of many Lean practitioners, but for this study in particular referring to Paz Arroyo, the method was made operational for the AEC industry in Europe (Arroyo, 2014), (Arroyo et al., 2019). The method is a multi-criteria decision method to facilitate assessment between two or more alternatives based on the perceived advantages of the alternatives. This is particularly relevant when the different alternatives have advantages within different parameters not directly comparable. For example, a decision could be between two design alternatives of a tunnel design where one would result in a lower carbon footprint, while another design alternative might preserve more biodiversity. For decisions like this, it is important to have a structured and transparent method that enables collaboration and inclusion, while also enabling consistent documentation of the outcome and the related risks and presumptions (Schöttle et al., 2018b).

CBA include a range of different tools all based on the same principles, but from the tabular method follows the below steps (Arroyo, 2014):

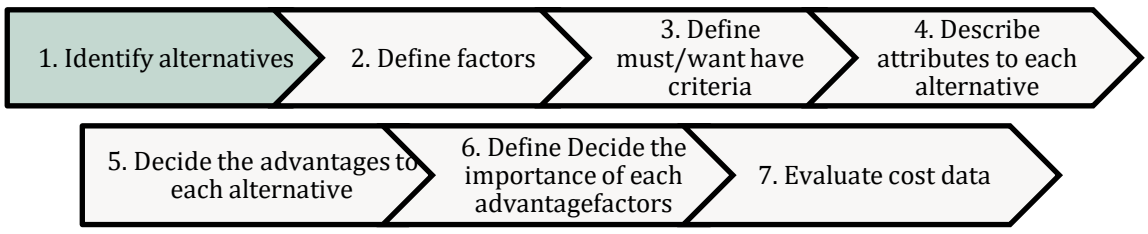

Figure 2: CBA process

1. **Choose the alternatives**. What is the decision? What design alternatives could be chosen?
    a. For example: two different station designs.
2. **Define factors**. What are the expected main factors for the decision?
    a. For example: carbon footprint or low risk.
3. **Define criteria** and select must have/ want to have criteria for each factor. For example:
    a. Want to have criteria: lower CO2E including phase A1-A5 in a Life Cycle Assessment is better
    b. Must have/Want to have criteria: Technology Readiness Level (TRL) needs to be 7 or above, higher is better.
4. **Define attributes** for each alternative. For example:
    a. 12 kg CO2E per functional unit
    b. TRL: 8
5. **Describe the advantages**. For each criterion, there will be one or more least preferred alternative, and one or more alternatives that are better. For example:
    a. 1.2 kg CO2E less per functional unit is better
    b. One level higher on TRL scale is better
6. **Decide on Importance of Advantages (IoA)**. What advantages are perceived more important?
    a. For example: discussion on whether 1.2 kg less CO2E per functional unit is more important than 1 level on the TRL scale to reduce risk?
7. **Cost evaluation**. Weigh the accumulated extra benefits against potential extra capital cost.

As CBA had previously inspired project teams to innovative thinking, it was decided to test the method out on a project case, where the client asked for innovative thinking and a holistic assessment of one or more alternatives. But the project context made it necessary to modify the method.

MODIFIED CBA TO CREATE ALTERNATIVES

This wasn't a 'normal' CBA as there were no defined alternatives. Instead, there were some loosely defined success criteria and a baseline. It was therefore decided to design and follow a process to first create alternatives. Hence, step 1 in a 'normal' CBA process "Identify Alternatives" was extended with the following sub-steps:

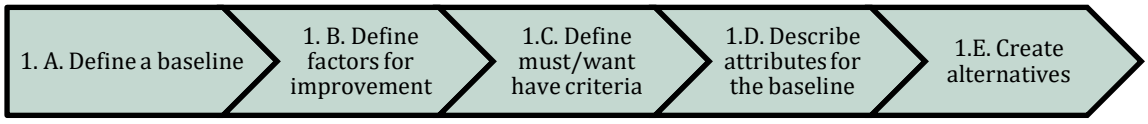

Figure 3: Identifying Alternatives

1.A. **Define a baseline.** A comparable existing project was selected as the basis for the project. A metro station previously designed by the team for the client was selected.

1.B. **Define factors for improvement.** It was discussed with the client within what factors advantages were expected compared to the baseline.

1.C. **Define criteria.** The team defined minimum criteria for the new alternatives and in what areas success should be measured.

1.D. **Define the attributes for the baseline:** By testing out the criteria on the baseline, the criteria were constantly refined by the team.

1.E. **Create alternatives.** Through an iterative process, 6 alternatives were created based on desired attributes with regards to success criteria.

The above steps were iterated over a few weeks during regular progress meetings. The team used a virtual whiteboard with a CBA table to define factors, criteria, and attributes. The alternatives were defined by bringing ideas from reference projects, where these had advantages on some of the success criteria. For example, designs on similar projects have been used in other parts of the world, where less concrete were needed. Some of the ideas were combined in new ways or scale. Based on the constraints and the areas for desired optimisations (success criteria) the team constructed 6 alternatives using a mix of different technologies, to allow for a lower CO_2 footprint. When the alternatives were defined, a 'normal' CBA was facilitated to assess the baseline and the newly defined alternatives including a cost indication. All 6 alternatives were presented to the client in a CBA tabular method, to get the client's assessment on what advantages were more important.

EVALUATION OF THE PROCESS

To learn from the process an evaluation was carried out and through analysing the interviews using heuristic text analysis, some key findings were identified as key takeaways from the team to improve the process:

1. Tension between 'open' project scope and lump sum contract
2. Some team members found the early phase inefficient
3. The team was well organised with reg. to technical competencies
4. Lack in innovation management competencies
5. Collaboration with Client is needed

TENSION BETWEEN AN 'OPEN' PROJECT SCOPE AND LUMP SUM CONTRACT

The team has been used to having a specific problem, or project at hand – defined by the client - where *a* solution needs to be defined within given constraints. This time, the team was asked to challenge the constraints while at the same time drafting solutions within constraints. The word 'innovation' was also frequently used in the beginning, which might have meant something different for the participants. This gave, for some, too many moving parts in the project, while at the same time there was a pressure to deliver on time and budget.

Some of the team members found it frustrating that the scope of the project wasn't clear so they could start defining solutions. They felt they wasted time in the early meetings, which was also a clear concern of the project manager: "*We started with a blank page, with no clear expectations of the outcome…. As a project manager I was concerned about the budget*" (Project manager). This tension between project delivery and creating

new solutions was difficult to navigate for both the team, the project manager, and the client.

SOME FOUND THE EARLY PHASE IN-EFFICIENT

Both the project manager and the client felt that both sides weren't clear on how to manage expectations within the context of a project in a continuum of innovation and project delivery. Both parties stated that this was a new way of working and that learning was a part of the process. "*The team were very enthusiastic, often ending in long discussions, disciplines to focus on specific tasks would reduce the hours spent, and still maintain the innovative process*" (Team member)."*We are trying to formalise the process, but it's definitely a learning experience because we haven't gone through anything like this before.*" (Client)

The team was primed to use technical expertise and come up with solutions to known issues, the client was focused on getting challenged on solutions while also getting value for the money spent on the innovation project, and the project manager was focused on delivery within constraints. Communication and hence the understanding of the project scope was challenged by differences in the team and among the partners when it came to syntactic (language), semantic (meaning) and pragmatic (motivation) (Carlile, 2004). Where some were very focused on the product and details, others were focused on the business case and risk mitigation. Therefore, the parties could benefit from a shared evaluation, not only on the project delivery but also on the process and collaboration, to ensure more efficient use of time in the future.

THE TEAM WAS WELL ORGANISED WITH REGARDS TO TECHNICAL COMPETENCIES

This project was of high importance to both the client and the engineering team, and therefore very experienced specialists were allocated to the project. "*The team delivered on the technical aspects of the study, from design to constructability, identifying areas of improvement to the current specs*"(Team member). The team members all had +15 years of experience within the field and could therefore include many significant reference projects from all over the world and bring these experiences into the specific context. They also included knowledge of challenges with existing assets owned by the client and knowledge of the client. As some of this knowledge was deeply context dependent it was unclear what should be included in the study and how possible constraints should be mitigated.

LACK IN INNOVATION MANAGEMENT COMPETENCIES

It was the first time the team was asked to think innovative and deliver a solution where the outcome shouldn't lead directly to delivery of a project. Because of the importance, the consultant selected the most experienced and competent technical experts, and very early the team started to focus on the details without having agreed on the overall framework. This was partly because of the time pressure, but also because the team quickly confined itself to known work processes. "*More training to leaders about innovation processes, not all seemed to know (the) project was about innovation*", (Team member). Also, the client acknowledged the project was a learning experience and that they too need to adapt to a new way of working to allow for innovative thinking. "*We*

didn't even think about innovations to start with, but we know we wanted to somehow bring the UN SDGs[2] in" (Client).

It became clear that while the team was experienced and skilled in some areas, they were beginners and inexperienced when it came to contributing and leading such a process. We learn from childhood that it is important to be competent, and when being put in an uncertain situation people react in different ways (Flores, 2016). This inner conflict between being a beginner and at the same time an expert was uncomfortable for the team.

COLLABORATION WITH CLIENT IS NEEDED

During the process interim meetings were held to inform the client and get feedback on the process. Also, the client was guided to make the final assessment of the Importance of Advantages (step 6), but the client wasn't formally introduced to CBA. The client found certain aspects of the results in the final report interesting, and some ideas were clearly new to the context. It is the authors' perception, that the communication with the client was centred around technical issues and solutions, whereas the process and way of collaboration was less defined and discussed. It was subsequently recognised that closer collaboration would have been beneficial for all. As the expectations for the level of innovative thinking in the project were unclear at the beginning, it was also perceived by the project team that the level of details and assessments wanted by the client changed as everyone became more knowledgeable.

CBA CAN SUPPORT INNOVATIVE THINKING

CBA was introduced as a method to structure the process and allow specialists to contribute with their technical skills while also thinking creatively. With more clear constraints of the solution space, it was expected that creativity could be channelled to areas where the client was looking for improvement. In the beginning where few unclear constraints were put on the creative process, the team ended up forming solutions based on their knowledge and experiences. The constraints from the process provided focus and creative challenge to come up with improvement in very specific areas (Acar et al., 2019).

Also, by addressing the project as a decision, the team could present their technical knowledge in a structured way and then allow for the client to assess what mattered. The client would then get information with consistent data and uncertainties outlined and based on this get a more informed basis for decisions (Mullan, 2018). This was also the perspective from the team. The method helped them focus and align while also setting the area for innovation and improvements compared to the baseline.

However, as this was the first time for many of the team members, the project didn't get the full benefit. Also inviting the client into the process might have been useful. As one team member put it in the survey:

"*A systematic approach to decision making was good, as we normally just go ahead and design what we think is needed and then hope it would fit into a decision, instead of aiming at the start on something that would matter to the client. A clear process and a clear goal (provide basis for evaluating*)", (Team member).

Using CBA for this type of assessment, however, might bias the members of the team to look for advantages but overlook the challenges and how to deal with these. The client had expected a more thorough assessment of the alternatives including a more balanced

[2] Red: United Nations Sustainability Development Goals

assessment of negative and positive impacts by the ideas proposed. The client expected the team to focus more on mitigations to remove some of the perceived constraints. For example, it was expected that instead of dismissing an idea that wasn't aligned with codes and standards, they would have liked to know what a diversion would be demanded.

However, by continuously using CBA as a driver for innovation on more projects, the terminology and process can become more familiar for the participants and the process of reaching a shared view on a decision becomes more efficient (Arroyo et al., 2019). This could compensate for the loose scope in the beginning of the project and set a framework to channel the knowledge and skills for the technical experts into innovative thinking within a project setting.

CONCLUSION

The AEC Industry needs to change, and we need radical innovations to be able to reach national and regional climate targets and ambitions (Koch-Ørvad, 2019). We also need to foster an innovation culture within our industry and our project delivery context. As learning and innovation is context dependent (R. Christensen, 2008), we therefore need to apply methods within our project context to utilise the full capabilities from our specialists to come up with innovative solutions.

In our industry, innovation and implementation goes hand in hand and cannot be separated (Winch, 1998). One challenge is therefore, to support innovative thinking within a project setting with constraints on time, scope, and resources. We need to apply efficient methods that allow our technical specialists to contribute to making sustainable solutions efficiently. Another challenge is that our industry lacks competencies to manage the creative phase of innovation, where communication across different disciplines is key.

In the case we showed, Choosing by Advantages could be used to create new alternatives based on desired areas of improvement. The methods directed the creative energy of the specialists to areas within their profession and therefore allowed them to contribute while still being able to see the bigger picture. The structured way to handle uncertainties in developing alternatives and to assess the alternatives, made the process more effective and the experience can be used also on future projects.

Design and problem solving shouldn't be considered alone from the technical domain, both need to be multidisciplinary and get input from all stakeholders and experts to solve the issues we face. Our industry is one of the most fragmented, and we need to focus on how we support a seamless collaboration across the value chain (World Economic Forum, 2012).

By training our teams in thinking in alternatives and criteria, we train our teams in applying innovative thinking and come up with new and more sustainable solutions within an agreed framework suited for a project delivery context. This study was based on a single study but should be tested on more projects to test the validity of the conclusion, and I therefore encourage more studies of applied CBA where focus is on innovative thinking and added value.

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