ABC Design Method: Implementing adoption of innovation criteria through design heuristics for social design driven innovation projects.

Jorge RESTREPO [1], Marcela VELASQUEZ-MONTOYA [1]

(1) : Universidad EAFIT, GRID
050022 Medellín, Colombia
+57 (4) 2619500 ext. 9712
E-mail : {jrestrgi, mvelas11}@eafit.edu.co

Abstract:

This article explains the experiences of the implementation of a decision support method in product/service design processes. The research focuses on the utilization of a heuristic based method, as a tool to integrate adoption of innovation criteria to product design development phases. All of this, with the objective to enhance the adoption of product/service solutions in social innovation driven projects and support conceptual exploration, providing more detailed information about the relationship between context, user, and product in early stages of the process. Finally, this article is centered on an exploratory validation of the method by the development of two design cases to evaluate the assistance in a conducted design process.

Keywords: Adoption of Innovation - Design Heuristics - Decision Support Method - Product Design - Conceptualization - Social Innovation

1- Introduction

In product-service development processes, designers transform opportunities into solutions to assess a necessity of the market or community, involving hundreds of decisions, many of which can be usefully supported by knowledge and tools (Krishnan & Ulrich, 2001). The influence of this type of choices on the results of a product design procedure is relevant, 70% of decisions taken in early design stages affects the final performance and the life-cycle of the solution (Perry, El Amine, & Pailhès, 2015). Fischer et. Al highlighted the need to provide detailed information in specific moments to designers who must face unknown knowledge fields and uncertain situations. This assistance, as a decision-making method, reduce uncertainty and allow designers to focus on the articulation of knowledge, enhancing creativity tasks and the finding of a new application of existing knowledge (Fischer & Nadeau, 2011).

In social innovation projects, where solutions go beyond from the individual needs and desires and are focused on plurality, the decision-making processes become even more complicated as they are not linked only to an individual need but the behavior of a community. The social environment is defined by uncertainty, due to all unknown variables that influence human behavior and the adoption of new solutions. These factors are also affected by the experience of designers, who must capture information from communities and situations they may not know. As stated by Rogers, the probabilities of the new alternatives being superior to previous practices are not exactly known by the individual problem solvers (Rogers, 2010). This type of uncertainty represents an adverse effect on the sustainability of the solutions proposed and have deep repercussions in communities.

Adoption of innovation theories fulfills this knowledge gap explaining how humans and communities decide to accept and adopt a solution, transforming it into a part of their life's and maintaining it as well or benefit. The addition of an adoption approach through decision-support methods is expected to reduce the uncertainty in design tasks, which is one of the principal aspects that interfere with the designer choices (Beheshti, 1993). These methods can lead the development process, supporting the iterative decision-cycles with relevant information that can be based on previous knowledge (Roozenburg & Eekels, 1995)

This article describes the experiences in the exploration, formulation, and validation of adoption based criteria to assist product-service designers during product development processes. Following the Action Research Methodology proposed by Kemmis et al., this study follows practice-based design research to include adoption knowledge into design processes, through a heuristics based strategy named by authors as Adoption Based Criteria Method. (Kemmis & McTaggart, 2000)

The *practice-changing practice* approach (Kemmis, 2009) focuses on experiences from different individuals and its relations to improve the desired activity, in this case, the designer problem-solving processes. The proposed application of heuristics is a commonly used approach to create a structure for existing information from different sources, experiences and knowledge fields. Finally, the article aboard the experimental validation of the method by its implementation in a set of design processes, with the participation of 60 designers, to explore the

possible benefits for designers in the usage of a decision-making assistance method in social design-driven innovation projects.

2- Exploration: State of the Art

2.1 - Design Methods in Social-Driven Innovation.

The starting point of the solution design process in social innovation driven projects, is a detailed and in-depth understanding of the users and their varying social requirements (Prahalad C. , 2012). The "social" adjective describes a kind of value that is distinct from a financial or economic benefit (Phills, Deiglmeier, & Miller, 2008). This type of value can include one or more very different things such as justice, fairness, environmental preservation, improved health, arts and culture, social empowerment and better education.

Human-centred design (HCD) methodologies are composed by different strategies to assist the solution development processes and assess the social requirements capture. The main base of these approaches is the analysis of motivations, desires, and behaviors of human beings. One of these and most used methodologies is the Lean Startup (Ries, 2011) which establishes a procedure based on iterative validation focused on the interaction between the different users and the proposed solution. In the same field, IDEO based all development processes (products, services, and social entrepreneur initiatives) on human-centered design as a successful approach, with solutions created to maintain people's lives and desires at the core (IDEO.org, 2014). Derived from Design Thinking Methodology (Brown, Design Thinking, 2008) HCD Field Guide (IDEO, 2008) is a design toolkit used by consulting firms, universities, and even non-governmental organizations to capture needs, creating concepts and validating solutions.

The Community-Based method (CBM) is used by Product Design Engineering (PDE) students at Universidad EAFIT in Medellin-Colombia, as an approach to find solutions by in-depth problem analysis in social innovation projects (Velásquez-Montoya, 2016). This participative method, include the community in design processes to facilitate the incorporation of societal activities, desires, behaviors, and motivations. Derived from user-centered design methodologies, CBM incorporates methodological concepts of Design Thinking and Lean Startup using iterative validation to understand needs, desires, motivations, and behaviors, developing solutions in a participatory way with the community.

All these experiential and user inclusive problem-solving processes depend on the designer analysis skills and social dynamics of the specific community. The multiple deprivations and factors as context, history, culture, education, and economy among others, can influence user behavior and so, the designer decision-making processes.

All decision taken by designers during the early stages of product-service design processes, in social innovation projects have a percentage of uncertainty represented in the multiple factors that compose social dynamics. Several approaches, models, and constructs such as Human Centred Design (IDEO, 2008), Design for Activism (Meroni, Fassi, & Simeone, 2013) and Lean Startup (Ries, 2011), among others, have described these social phenomena as variables that must be included in solution development processes to improve the adoption of innovation by users. In this kind of uncertain situations, the heuristics rules could play a significant role with the experience-based knowledge that leads decision making the process more accurately.

2.2 - Adoption of Social Innovation.

Phills et al. defined social innovation as a novel solution to a social problem that is more effective, efficient, sustainable, or just than existing solutions and for which the value created accrues primarily to society as a whole rather than private individuals. By sustainable, they mean solutions whose operation and use continue over an extended period (Phills, Deiglmeier, & Miller, 2008). This definition frames sustainability from a new perspective in which is described from the solution acceptance and usage over time by users. Nakata et al. emphasize the importance to know how to enhance new product adoption to innovate efficiently and ensure new products acceptance (Nakata & Weidner, 2012). Adoption is a process that can be addressed in problem-solving situations from early stages. It begins with the identification of an existing need, continues with the search and development for a specific solution and ends with the decision to address its adoption in implementation (Gallivan, 2001).

Oxford dictionary, define adoption as the action to take up or start to use or follow an idea, method, or course of action (Oxford Dictionary, 2016). Mittelstaedt et al. described adoption as a process determined by two stages: symbolic (cognitive) adoption and material (behavioral) adoption (Mittelstaedt, Grossbart, Curtis, & S. P., 1976). Rogers has developed the diffusion theory of innovation, in which explains why people decide to adopt an innovation and how this choice depends not only on an individual behavior but a social dynamics that affect particular decisions. This approach is the leading model of innovation adoption with a continuous citation and its inclusion as a basis in other adoption constructs. With this perspective, the scenario becomes even more complicated for designers, who are immersed in a decision-making process that involves more than one person and the relationships between them, as is the case of social innovation.

2.3 - Heuristics in Design

The 1905 Nobel prize winner, Albert Einstein, presented his work on the emission of light as "a heuristic point of view" to indicate that his proposal was valuable but incomplete (Holton, 1988). The heuristics are adaptive tools that ignore information to make fast and frugal decisions that are accurate and robust under conditions of uncertainty (Neth & Gigerenzer, 2015). All the knowledge proposed in heuristics comes from the experience capitalization, to assist the discovery and acquisition of a solution by the implementation of a strategy used before. This experience-based orientation support design processes by the use of experiential practices and knowledge that has been previously applied and proven in similar problem-solving situations (Restrepo, Ríos-Zapata, Mejía-Gutiérrez, Nadeau, & Pailhès, 2017).

In a design context, the methodology formulated by Pahl and Beitz, recommends for the concept generation phase to use several tools that empowers solution finding looking for relevant information in well-known solutions, experiences and documented design cases (Pahl & Beitz, 2007). Other creative tools like TRIZ proposed by Altshuller et al. focuses on the study of the exploration of similar solutions and patented products, a

task that represents a significant complication for not experimented designers. (Genrich, Shulyak, & Rodman, 1997). As Daly and Yilmaz stated, design heuristics can support solution development processes giving a unspecific information by suggestive tools that provide cognitive 'shortcuts' to create intentional variation in designs (Daly, Yilmaz, Christian, Seifert, & Gonzalez, 2012). In a more experientially and participative manner, Human Centred Design proposes an iterative process based on multiple validations with different users, experts, and stakeholders to nourish design concepts with experiences, reactions, perceptions and interactions of the market in social innovation processes (IDEO.org, 2014). All this information obtained from the community represent an experience-based knowledge, and so a kind of a heuristic inspiration, but as experiential it depends on the expertise of each designer. This type of situation with high degrees of complexity and a large number of options define an uncertain environment, which is where heuristics work well (Neth & Gigerenzer, 2015). As exposed, several approaches include the implementation of heuristics in solving – problem processes, but its particular approximation to the field of product-service design and community-based social innovation processes is still fuzzy.

2.4 - Method Effectiveness Measurement

2.4.1 Usability Measurement

To assess an evaluation of how useful is the implementation of the adoption-based design method is necessary to evaluate the clarity and specificity of the information delivered through the design heuristics. In the same way, an exploratory study of how designers use the tool and how all of this information satisfy and enhance product design processes in social innovation projects. The concept of usability is a constant evolution, including information from different disciplines, is becoming even more complex and problematic to evaluate (Carroll, 2009). In usability evaluation, the context-of-use is the most important concept (Bevan, 1991). The context-of-use is defined as the relationship between the use-activity-situation during user interaction with a solution (Chamorro-Koc, Popovic, & Emmison, 2009). The solution, in the case of this research, refers to the proposed design tool with which the designer should interact in a problem-solving process. ISO 924-11 suggest the measurement of usability under:

- Effectiveness: Focused on the ability of users to complete tasks using a solution and the quality of the output.
- Efficiency: The consumption of resources in the studied tasks.
- Satisfaction: All subjective users perceptions about the use of the solution.

System Usability Scale (SUS) is a simple and fast solution to evaluate usability, based on a *Likert scale* that indicates the degree of agreement or disagreement of the user, according to ten defined statements related to the solution. This approach gives a global view of subjective assessment of usability (Brooke, 1996). A single usability score can be computed from the ratings and used to compare participant´s perception of the solution (Harvey & Stanton, 2013).

2.4.2 Creativity Measurement.

The evaluation of a problem-solving design process can be addressed by the evaluation of the operating variables that represent the success of the outcome. These can focus on functionality, aesthetics, efficiency, effectiveness, and feasibility among others, to describe how the solution satisfies the needs of the initial task. The inclusion of the variable adoption in a design process, as it definition describes, include the decision to use and implement the solution. As Rogers stated, adoption is measured as the number of individuals who adopt a new idea in a specified period, such as each year. This type of validation demands a real problem-solving situation which would require a great period of exploration, analysis, solution, and implementation. In the other hand the evaluation of the final adoption of a single and particular solution, would not provide specific data on the incidence of the tool in the decision-making processes, carried out by the designers.

Shah et al. explained the differences between process and outcome evaluation, and the importance to focus these studies on the ideas generated by the designers. Taking into account the complexity to directly relate the occurrence of cognitive processes to the effectiveness of an idea generation method (Shah, Kulkarni, & Vargas-Hernandez, 2000). An alternative to assess the impact of a design tool is the evaluation of creativity as an instantiation of the method proposed by Shah plus the evaluation in a heuristics based design (Restrepo, Ríos-Zapata, Mejía-Gutiérrez, Nadeau, & Pailhès, 2017). From this perspective, the evaluation of the goodness of a design tool can be performed under two basic criteria:

- *How well does the method expand the design space?*
- *How well does the method explore the design space?*

Considering the design space as the count of all possible option for a given problem determined by the existent information of the problem, context or situation. Is in this space where information can be provided to assist decision making.

As a strategy to evaluate the incidence of an specific model in a problem-solving process, four effectiveness measures has been proposed: novelty, variety, quality and quantity (Shah, Smith, & Vargas-Hernandez, 2003).

- *Novelty* corresponds to the measure of how unusual is an idea compared with the existing.
- *Variety* is measured comparing the difference between each
- the idea generated by the group.
- *Quantity* is a measure that defines the number of ideas generated.
- *Quality* represents how well an idea fulfills the design specification.

This approach allows the evaluation of the positive or negative impact that a method, tool or approach could have in the creativity and decision-making process, in a problem-solving procedure.

2.5 - Methodological Approach.

Gabriel Tarde exposed the diffusion of innovation as human behavior change, explaining how invention and imitation are elementary social acts (Tarde, 1969).

Rogers has developed the most accepted framework of diffusion of innovation in which explains how innovations are adopted and why some people decide to adopt solutions more. This model describes a set of variables that characterize the human behavior in different categories: Perceived Attributes of Innovations, Type of Innovation-Decision, Communication Channels, Nature of the Social System and Extent of Change Agents (Rogers, 2010). All variables are explained as a strategy to favor the rate of adoption of innovations. In the product/service category, the solution is analyzed under five main attributes:

- *Relative Advantage* is the degree to which solution is perceived by users, as better than the existing solution.
- *Compatibility* is the degree to which an innovation is consistent with the values, past experiences, and needs of the community.
- *Complexity* is the degree to which a solution is perceived as difficult to understand and use.
- *Trialability* is the degree to which innovation benefits could be experimented with limited time of use.
- *Observability* is the degree to which the results of innovation are visible to others.

In search of other perspectives, Wisdom et al. conducted an exhaustive research focused on the exploration of theoretical frameworks to understand the adoption of innovations by analysis of the convergences and divergences between different authors and the clustering of the determinant variables in different environments. The study analyzed 20 models and constructs and concluded with the definition of 4 main contexts that affect positively or negatively the adoption: *External System, Organization, Innovation, and individual*. In Table 1, each context groups different factors that must be taken into account when implementing an adoption (Wisdom, Chor, Hoagwood, & Horwitz, 2014).

Most of the adoption centered theories analyzed by wisdom are proposed under organizational and marketing perspective, and its approach towards product-service development is intended to assist implementation of innovation.

Nakata et al. developed an adoption model focused on social innovation, under Prahalad definition of *The Base of the Pyramid* (Prahalad C. , 2010). Based on Rogers approach, it addresses adoption phenomena from 3 different contexts *new product characteristics, social context dynamics, and marketing environment* (Nakata & Weidner, 2012). Each cluster represents a group of key variables to improve the adoption of new solutions. As is shown in Figure 1 Nakata et al. Adoption Innovation Model. group of variables, support a development process which starts from understanding community deprivations. According to this, it can be defined as a social innovation strategy. However, social innovation is not only focused on the base of the pyramid, as is commonly assumed; social innovation has a holistic and fair view of solutions in which most of a community is included.

Contexts	Features	Outcome
External System	• External environment • Goverment policy and regulation • Social network • Financial incentives	Improved pre-adoption and Improved adoption
Organization	• Absorptive capacity • Leadership of innovation • Network with innovation developers and consultants • Norms, values and cultures. • Operational size and structure • Social climate • Social network • Training readiness • Traits and readines for change	
Innovation	• Complexity, relative advantage and observability • Cost-efficacy and feasibility • Evidence and compatibility • Facilitators and Barriers • Innovation fit with norms and values • Trialability, relevance and ease	
Individual	**Staff:** • Affiliation with organizarional culture • Attitudes, motivations and readiness towards quality • Improvement and reward • Feedback on execution and Fidelity • Individual characteristics • Managerial Characteristics • Social Network	
	Client: • Readiness for change • Capacity to adopt.	

Table 1 Wisdom et al. Adoption Chart

Many theoretical frameworks seek to describe the adoption of innovation processes focused on the implementation phases with less emphasis on development (Aarons, Hurlburt, & Horwitz, 2011). Even when the attributes of new solutions are included in some of these models and the main objective is the implementation and not the product-service development, all these proposals are based on the study of human behavior. Considering this, adoption-based models are the indicated source of information to improve the acceptance of solutions in social innovation projects.

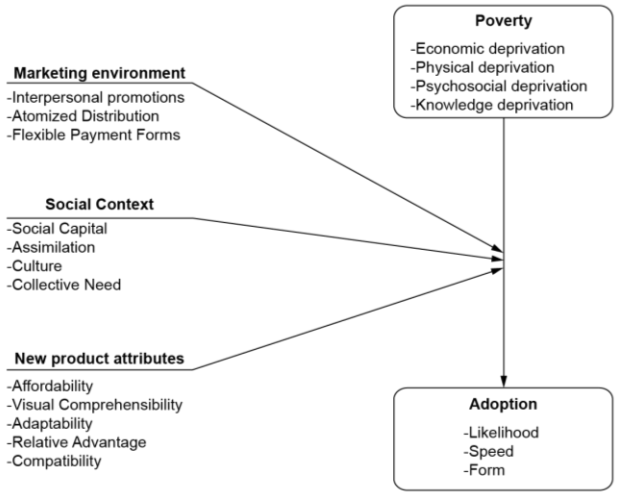

Figure 1 Nakata et al. Adoption Innovation Model

3- Formulation: Adoption Based Criteria

Adoption Based Criteria (ABC Method) is a set of adoption variables, defined to assist design from the early stage of product-service development process. The core was focused on feeding product-service development in social innovation projects, principally, the early stages when a guidance in the capture of product specification is needed. Even when the ABC, is formulated from a thematic analysis and is based in a theoretical table is intended to be implemented as an informative chart that helps designers to keep adoption in mind on their assignments.

3.1 - Theoretical Approach

Criterion is described as a principle or standard by which something may be judged or decided (Oxford Dictionary, 2016). To define adoption based criteria, focused on the early stages of product-service development a *Thematic Analysis* was performed. This procedure allows the identification, analysis, and report of patterns (*themes*) within a specific data, by re-reading and systematically coding information, looking for key features. Themes represent a group of patterned variables or factors (named by literature as codes, factors a) that have relevant information with the research question. Those codes identify semantic or latent content that appears interesting to the analyst (Braun & Clarke, 2006). The research developed by Wisdom et al. was the starting point in the development of this thematic analysis, in which subsequently, other adoption innovation models were included.

Focused on social innovation, the model proposed by Nakata et al. (**¡Error! No se encuentra el origen de la referencia.**) contributes from a different perspective of diffusion of innovations, focused on social dynamics under deprivations. Similarly, C.K. Prahalad proposal to improve BoP markets, target all these whole set of knowledge to social innovation projects (Prahalad C. , 2010). In a different context, BIG BANG Disruption approach, explains human behavior in a digital age and provides a diffusion perspective under the evolution of technology and it relation with communities (Downes & Nunes, 2013).

The inclusion of user-oriented design leads to products that are more readily adopted by users due to better product appropriateness (Veryzer & Borja de Mozota, 2005). The addition of product-service design methodologies to enrich the criteria definition, support the analysis of adoption theories from the perspective of product-service development. HCD (IDEO, 2008), The Lean Startup (Ries, 2011), and Design Thinking (Brown, 2008) contribute with different and detailed strategies, focused on user participative inclusion and iterative validation to assess all stages of the development process. Finally, Business Model Generation (Osterwalder & Pigneur, 2010) add the solution value assessment and the implementation of the solution from a stakeholder articulation standpoint.
After the analysis of 24 adoption-based models and it comparison with 4 product-service development methodologies, 41 factors were obtained. Each code represents a variable or factor that is relevant for adoption of innovation processes. The clustering of these factors into themes facilitate the definition of main topics (contexts) which are intended to assist designers with significant information in solution development processes. The procedure concluded with the definition of 5 contexts (themes): environment, community, product-service, user and business model. Each of these themes groups a set of features that favor adoption of innovation e.g. *Product service contains: relative advantage, compatibility, low complexity, trialability, observability, cost efficacy, feasibility, evolutionary infrast*ructure, desirability, performance, obsolescence, and aesthetics (Table 2).

3.2 - Practical Enquiry

Rogers based his model on the analysis of real implementation cases of new solutions, in which different communities had specific and established practices that sought to be improved by an innovation. These studies allowed the understanding of the real social dynamics that arise when a community is related with a solution over long periods of time.

3.2.1 Adoption Case Analysis

To track the influence of the proposed features on the adoption of innovation is necessary to explore its relevance with real solutions, trough the analysis of case studies in the implementation of new solutions. The case analysis were developed by the categorization, comparison and straction of relevant propositions related with the studied phenomena (Muller-Herbers, 2007). This review of empirical situations provides human behavior experiences to understand how and why some products and services are or not adopted and the relation of these events with proposed features. Pia Piroschka studied the adoption of innovation, trough the analysis of the development and implementation of solar cookers, and defined a model to assess adoption of innovation, based in five main categories: Environmental, Cultural, Technical, Social and Economic (Pia Piroschka, 2013). Each of these categories group a set of factors that positively or negatively impact the adoption of innovation, which is similar with approaches from other authors.

Similar cases like Tata Nano, which explains different factors that interfere with adoption. One of the aspects explained by Chakravarti & Thomas is how a low price reduced the attractiveness of a solution with good performance because people often rely on the popular folk wisdom “you get what you pay for. This type of psychological and behavioral phenomenon is inherent in each community and depends on different conditions that, although can be replicated, depend on a preliminary social analysis. (Prahalad C. , 2010); (Chakravarti & Thomas, 2015).

The studied cases allowed a verification of the proposed features with historical facts of implementation of solutions. Some of these situations coincided with the results of the thematic analysis and were aligned with the situational aspects highlighted by the authors. Some similarities were found between variables, which suggested an integration of variables, as well as dissonances that directed the definition of adoption criteria towards more experiential research.

Contexts	(1) Environment	(2) Community	(3) Product/Service
Features	• Social external environment • Environment	• Readiness for change and capacity to adopt • Social climate • Social network • Community dynamics	• Relative advantage • Compatibility and adaptability • Experience • Viability and feasibility • Broad architecture • Performance
Contexts	**(4) User**	**(5) Business Model**	
Features	• User inclusion • User characteristics • Motivation	• Stakeholders • Operational size and structure • Resources • Market • Channels • Price • Supplier characteristics • Value propositions	

Table 2 Adoption Features Chart

3.2.2 Experts Based Experiences

The Delphi method is a versatile research tool that researchers can employ for forecasting, issue identification/prioritization , generalization of resulting theory and construct validity; Construct validity relies on a clear definition of the construct. (Okoli & Suzanne, 2004). Based on a reliable consensus of a group of experts, this method was used to analyze, merge and redefine adoption based features.

According to Colombian context and its social characteristics, in which social innovations can emerge endogenously or exogenously to communities, the experts were determined primarily by their experience and participation in social innovation projects. In the defined group of experts are social leaders, artists, sociologists, psychologists and product design engineers who have actively participated in solution development processes, from the early stage to implementation phases. As the method proposes, the research questions (RQ) were defined:

- RQ1: *To what extent the criteria affect the adoption of innovation, in a product/service development process, in social innovation projects.*
- RQ2: *In which social contexts would be classified the proposed criteria.*

Both questions were asked for each of the 41 factors found during thematic analysis. RQ1 was conducted to determine the relevance that each of them has with the adoption of new solutions, from the experience of each of the experts; it had a response method a 5-level Likert scale. RQ2 was formulated to validate the categories in were features are grouped with multiple selections with an only one response. The sessions were conducted through a virtual questionnaire, solved in the presence of a researcher.

The process presented a limitation of meaning understanding of some adoption based features. The language and the differences in concept definition between the areas of knowledge confused the participants, whom even knowing the variables exposed, did not understand the statements. Given the misunderstanding of the proposed factors, the Delphi Method was combined with in-depth interviews, focused on the conceptual and experiential definition of the variables. For this, each feature was described as a criterion and accompanied by keywords that would allow product-service developers to delve deeper into each of the concepts. Expert participation allowed the verification and generalization of adoption factors to enhance understandability and then increase the usability of criteria. Even though many experts were professionals in social sciences and had experience in social innovation projects, they did not understand the concepts proposed by the theoretical analyzes also simplified by dissonance with previously known ideas.

The procedure concluded with the synthesis of the 41 criteria into 32, and the re-definition of the five categories (environment, community, product-service, user, and business model) into three more general groups: *Community/User and Context, Product/Service and Business Model* (Table 3)

3.3 - Heuristics Cards

This research focuses on the implementation of the Adoption Based Criteria Method (ABC Method), based on 32 heuristics rules that provides a problem-solving approach, as a decision-making support tool. The design heuristics approach was selected as strategy to assist designers during the exploration of solution spaces, guiding decisions with information that has been proved or evaluated to generate non-obvious ideas (Daly, Christian, Yilmaz, Seifert, & Gonzalez, 2012).

Contexts	(1) Community, User and Context	(2) Product/Service	(3) Business Model
Criteria	• Demographic conditions • Government, Politics and Regulations • Absorptive capacity • Knowledge, abilities, usual activities, capabilities, demographic factors • Training and preparation • Social climate • Social leaders • Social dynamics • Constant feedback • Attitudes, motivations and incentives • Financial incentives	• Relative advantage • Adaptability • Low complexity • Experimentation • Desirability • Feasibility • Open architecture • Performance	• Strategic alliances • Facilitators • Operational size • Key resources • Environmental resources • User segments • User relationships • Channels • Price • Post implementation support • Value proposal

Table 3 Adoption Criteria Chart

The adoption based criteria, as a valuable theoretical and empirical knowledge, with a high degree of utility for decision making, was translated into semantic propositions through the integration of concepts. Each sentence carries a criterion and suggests an action with a causality and condition that together act as a strategy or proposal to take decisions in design processes, e.g., *Make evident the benefit offered by the new solution compared with the existing and known activity used by a community. The transition from a product to a new one can represent a lot of effort to a user if the advantage is not readily perceived, it is possible that the new solution will not be used.*

The designer is guided by a progressive process divided into the previously mentioned categories, named in the following manner:

- *A: Community/User and Context.*
- *B: Product/Service.*
- *C: Business Model.*

The proposed division, align the ABC Method with product/service design methodologies, which are defined by phases. Prescriptive design models are those that prescribe a pattern of the design activities (Nikulin, Lopez, Piñonez, Gonzalez, & Zapata, 2018). Pahl & Beitz proposed a design model divided into four phases: Planning, Conceptual Design, Embodiment, and Detailed Design. Similarly, Ulrich & Eppinger stated a six-phase partition, in which include a validation and Ramp-up production phases. In the same way, as exposed before, Design Thinking, Human Centred Design, and LeanStartup present a phase division, to prioritize the specific objectives strategically at different moments of the development process, in social innovation projects. The partition proposed by these approaches is similar, in which initially, at the first stage (Inspiration), the process focuses on Humans, communities, Contexts, and Behaviors; this corresponds to the proposed part of the ABC Method A (Community/User and Context). Subsequently, in the second phase (Ideation), methodologies suggest starting the solution conceptualization, which coincides with the B part of the ABC Method (Product/service). Finally, the third phase states as the primary objective the validation and implementation of the solution through an articulation of resources as users, stakeholders, alliances among others, which is related to the C part of the ABC Method (Business Model).

Product/Service design approaches are formulated from an iterative perspective to enhance the evolution of the solution. In social innovation projects, this iterative behavior represents a key factor to validate concepts and continuously retrieve feedback from real users and stakeholders. This cyclical improvement strategy maintains a bi-directional flow of information between each of the phases proposed by mentioned methodologies.
The ABC Method suggests a procedure that provides information in an accumulative way to nourish the subsequent design phases with heuristics from the previous stage (**¡Error! No se encuentra el origen de la referencia.**).

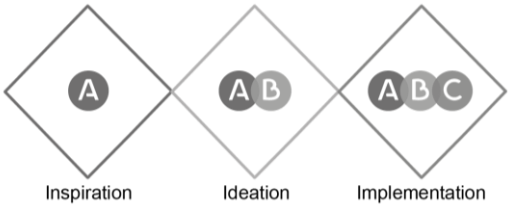

Figure 2 ABC Method Phases Approach

As proposed by Daly et al., the definition of heuristics into design heuristic cards, supports the application of the information in design processes. The ABC Method main tool (ABC Cards) is composed of thirty-seven cards, of which thirty-two expose adoption-based design heuristics, and five contains instructions for use. The adoption criteria heuristics are supported by definitions of key words related with the adoption criteria (Figure 3).

Figure 3 a. ABC Cards Kit b. Heuristic Card Example.

ABC Method is a proposal focused on solving the permanent knowledge gap in product/service development processes, giving information that is regularly unknown in social innovation projects. The assistance is proposed from the convergence of relevant concepts from different knowledge fields in operational criteria to be used in processes under various prescriptive methodologies (Figure 4).

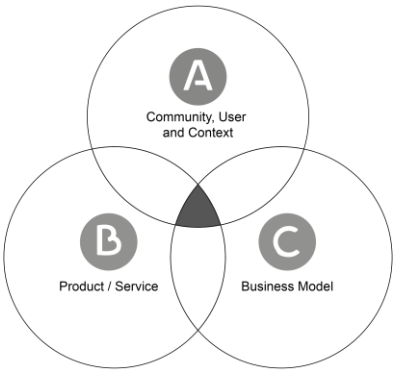

Figure 4 ABC Convergence Map

4- Validation: Case Studies

The social dependence of adoption of innovation processes increases the complexity of the validation due to the requirement of long periods of time to carry out tests. According to this condition, this study is focused on the early stages of product/service development processes and proposes an

exploratory evaluation of the ABC Method through its implementation in an academic design process. As an exploratory strategy, this study establishes an experimental framework focused on two main objectives:

- The usability assessment of the proposed method in its implementation with designers.
- The incidence of the decision-making tool, in a creative processes.

4.1 - Context and Background

The landscape of poverty in Colombia is more complicated than merely economic. Colombia, with an estimated population of 48.6 million in 2015, is the third-most populous country in Latin America (World Bank Group, 2016). About 27.8% of this population suffers from monetary poverty, with incomes lower than USD 2 per day, and 7,9% is in extreme financial debt, with a total absence of an official employment. Around 21,9% of the Colombian population, suffer from multiple deprivations such as educational, psychosocial, labor, health and habitability conditions (DANE, 2014).

In Medellin, Colombia, EAFIT University address some of these problems from the development of inclusive solutions in Product Design Engineering Bacherlor Program, with the following undergraduate courses:

- Proyecto 6: Is the 3rd year main design project that addresses the implementation of IoT technologies (ubiquitous computing services) to articulate stakeholders to address social needs. The project is carried out by teams of 5 young designers which in a participative collaboration with different public and private organizations develop concepts to solve community problems and create value.
- GiAnt Project: Is the 4th year multidisciplinary project, focused on the generation of social value by the co-creation between University and different organizations from the industry and government. The design task is focused on the development of product-service solutions under the shared value perspective. The project development groups are defined by five Product Design Engineering students and one participant from the company that is involved in the project, which is the expert that support all decisions from the organization viewpoint.

Both processes are based on the Human Centred Design (HCD) and Design Thinking methodologies (IDEO, 2008) and follow the decomposition proposed in three phases: inspiration, ideation, and implementation. Since 2011, as a result of HCD and CBM in Proyecto 6 an average of 12 solutions per academic semester have been developed, some of them with a high level of technical and social feasibility. These social solutions require the inclusion of communities and different stakeholders to analyze the dynamics of the problems, define product/service requirements, and articulate resources. Some of this relevant information is not addressed during the early phases of a design process and are commonly identified in the implementation phase.

The academic nature of the projects represents a barrier, in terms of time, for the entire development of each of the phases proposed by the HCD methodology and for the assessment of relevant community factors. These types of pitfalls transform those educational processes into situations with an optimal condition to evaluate the proposed method which is intended to support processes giving relevant information. The selected case studies (Proyecto 6 and Giant Project) were planned to be executed in parallel, taking advantage of the existence of resources and personnel to carry it out. The students in each of the cases were separated by academic temporality, which suggests that there was no flow of information between cases (Figure 5)

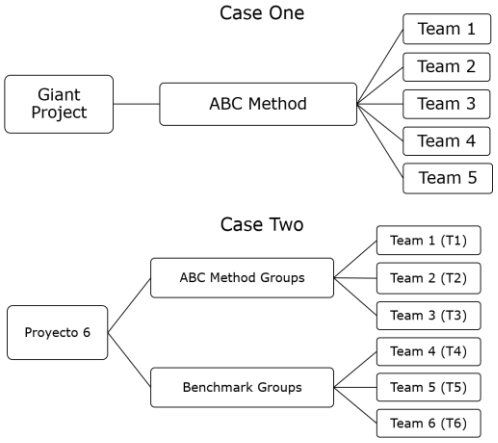

Figure 5 Study Cases Set Up

4.2 - ABC Method Setup.

Before the implementation of the proposed method on the selected case studies, an observatory-evaluation was performed as a fast recognition strategy, to identify critic points for the tune-up of the tool. This procedure was developed through the implementation of the proposed method in two participative workshops. Both processes focused on the fast recognition, evaluation, and concept exploration of a determined social solution. The first experience was carried out with industrial design students, in the Instituto Tecnologico Metropólitano de Medellín. The participants expressed a high complexity in the implementation of the information in the design process, due to the lack of experience with social innovation projects. After the evaluation, it was concluded that the first use of the ABC Method should be accompanied by an expert who resolves the doubts that could arise in the designers.

The second observatory-evaluation was addressed with product design engineering students from Universidad Federico Santa Maria in Valparaíso-Chile, during a creative workshop focused on the implementation of the ABC Method. In this situation with a more detailed initial explanation and constant assistance in the resolution of doubts, students expressed a significant aid given by the method during decision-making processes of development processes. On the other hand, not all the proposed criteria were used. Designers emphasized the need of more time with the community to inquire about the proposed criteria.

4.3 - Case One: Usability

The selected case to assess usability was GiAnt Project with a design task proposed by Bancolombia, one of the most important banks in South America, focused on the development of a product-service to create social value, by the articulation of

different stakeholders under five main perspectives: *Societal, Entrepreneurial, Cultural, Rurality and Sustainabilty.*
Given the breadth of the subject and the absence of the main need, the process started from the *fuzzy front end*, described by Sanders & Stappers as fuzzy because of the ambiguity and chaotic landscape that characterize the early stages in where is not known the nature of the final output. This step requires the understanding of multiple factors such as user behavior, contexts, social dynamics, and technological opportunities among others (Sanders & Stappers, 2008). This description corresponds to an uncertain situation in where designers need information from other knowledge fields that can be provided through decision-support tools like Adoption Based Criteria.

4.3.1 Evaluation Method

The objective of the first case was the analysis of the interaction of the designers with the proposed tool, focused on the assessment of the usability in the three phases of a design process. The study focused on the evaluation of two usability variables (UV), defined according to SUS-Method and an instantiation of ISO 924-11. These variables are:

- *UV1:* How users understand and apply the information provided by the tool?
- *UV2:* Which are the subjective perceptions about the use of the solution?

The implementation of the ABC Method was performed according to the following setup:

- The design case was developed by five teams, formed by five product design engineering students from 4th year and one participant from the bank. All were instructed with the same methodologies such as Design Thinking and Service Design.
- A training process was performed to explain the theoretical and practical foundation of the method and its application, aligned to the different processes and design phases.
- The support and evaluation process was carried out by four students from 5th-year of product design engineer, to avoid the bias of the results.

Giant project started with a Summit, in which students had the opportunity to listen to different speakers related to the main focus areas of the project. For this moment, all the groups had already an orientation on the use of the proposed tool, but they were still inexperienced in the information capture. An adoption-based mindmap template was developed as an assistance strategy for students.

As said before, the case focuses on the generation of solutions from the early stages of the design process, in which designers must analyze and understand different users and contexts. All teams had the guidance from different types of experts whom helped to define a base line for the project.

4.3.2 Usability Experiment

According to the objectives of the experiment and the different phases of the problem-solving process, various methods have been proposed to assess the evaluation of usability (Table 4). The ABC method was implemented, according to the proposed approach strategy, exposed in section 3.3 - Heuristics Cards of this article.

Case Phases	Inspiration	Ideation	Implementation
ABC Phases	A	A,B	A,B,C
UV1	Survey	Survey	Survey
UV2	Observation	Interview	Group Session

Table 4 Case One Evaluation Strategy

4.3.3 Surveys and Interviews.

Procedures were defined by structured questions that evaluated different features from the tool and allowed to go deep in the relevant perceptions through open-answer surveys. This method was focused on the assessment of the congruence between the meaning of the information provided and what user understand.
Initially, designers were enquired with a Likert-based questionnaire (Table 5) to value each of the different proposed criteria in every design phases. Subsequently, designers were interviewed to inquire about the meaning and implementation of the criteria, to compare this information with the one proposed in the ABC Method.

Criterion 1	**Demographic Conditions**				
How clear was the information on this criterion?	Very Clear	Clear	Moderately Clear	Less Clear	Without Clear
How useful was this criterion to address community exploration?	Very Useful	Useful	Moderately Useful	Less Useful	Without Useful

Table 5 Inspiration usability Likert questionnaire

4.3.4 Observation

In the inspiration phase, an observation analysis was performed to assess the behavior and the opinion of the designers during the usage of the tool. During ideation and implementation phases, observation couldn't be conducted, because all teams were working separately and any attempt to schedule an observation meeting might bias the natural use of the cards (Visser, Stappers, Van der Lugt, & Sanders, 2005).

4.3.5 Group Sessions

Used to inquire about user perception in a collective and participative way, are based on the analysis of patterns and the convergence of opinions related to the tool including a situational context. Sessions produce varied and rich views, anecdotes, and explanations about the explored context which include the use situation and the users' concerns, memories, feelings, and experiences surrounding it (Visser, Stappers, Van der Lugt, & Sanders, 2005). The sessions were planned to obtain information about the implementation of the ABC Method and its relation to the development process in the presence of other methods and methodologies. In the same way, the participative sessions allowed the analysis of emotional reactions in the usage of the method.

4.3.6 SUS Survey

Questionnaires were composed of an item scale questionnaire, based on the SUS Method (Brooke, 1996) selected by it

efficiency and shorter execution time. The forced-choice questions are intended to be answered with an indication of agreement or disagreement with the 5 level Likert scale from 0 to 5. Questions are constructed as propositions that indicates perceptions of complexity, inconsistency, and understandability among other perceptions as follows:

a) I think I would like to use the ABC method frequently.
b) I found the ABC method unnecessarily complex.
c) I thought the ABC method was easy to use.
d) I think that I would need the support of a technical person to be able to use the ABC method.
e) I found the various phases in the ABC method were well integrated.
f) I thought there was too much inconsistency in the ABC method.
g) I would imagine that most people would learn to use this method very quickly.
h) I found the ABC method very cumbersome to use
i) I felt very confident using the ABC method.
j) I needed to learn a lot of things before I could get going with this method.

Previous propositions are an instantiation of the ones proposed by Brooke, as a model to evaluate the usability of a system. At the end of the design process designers were addressed to develop the proposed questionnaire.

4.4 - Case Two: Creativity

To assess the incidence of the ABC Method a comparison experiment was carried out through its implementation in the course Proyecto 6. In 3rd year, product design engineering students develop social solutions using the Comunity-Based Method (CBM) and Design Thinking approaches. The objective of this course is the convergence of needs, desires, and requirements from different stakeholders to create social value. Proyecto 6 start from the analysis of sample context with an identified problem and focuses on the comprehension of social dynamics, needs, and desires to create adoptable solutions. All processes are developed in the company of the municipality which is the primary stakeholder and the one who defines the sample context.

4.4.1 Evaluation Method

The main objective was the evaluation of the incidence of the ABC Method implementation, in a product/service design process. This assessment was carried out through the comparison between two problem-solving processes, using Proyecto 6 as a case. The comparison was focused on the appraisal of four variables, based on the evaluation approach defined by Shah et al. (2003), in which the effect of a method is proposed to be measured evaluating the outcomes of the different phases of a process. This technic was implemented by Restrepo et al. in the assessment of creativity in a process under an heuristics-based approach, under the perspective of the evaluation of a decision-making process to improve technical product requirements. For this study, creativity assessment must focus on social driven inspiration, to assess the implications of the method implementation in the design space. Given the differences between social innovation-driven projects and the complexity of the product/service requirements, the comparison could not be evaluated with technical specifications; hence the following Creativity Assessment Variables (CAV) were defined:

- *Novelty:* corresponds to the measure of how unusual is the idea compared with the existing solution implemented in the related community.
- *Detail:* explains the level of depth of the proposed solution related to the context comprehension and stakeholder articulation in social value.
- *Technical feasibility:* represent how well a concept fulfills design specification for its function, use, and implementation in a situational context in terms efficiency and efficacy.
- *Social feasibility:* corresponds to the measure of how well a concept is aligned with the values, behaviors and social situations of a community in the specific context.

These variables are not operationalized in defined evaluation factors, because of the difference required in the groups of experts, in which the most relevant characteristic is the knowledge field in which each is experienced. Each expert valuated the variable from its experience in social projects implementation and fulfill an open comment box in the survey to define its perspective of the assessed variable. The expert evaluation will be explained deeply in the next sections.

The experiment was executed under the following setup:

- The design case was carried out by six different teams, composed of five students each (Figure 5).
- The first three teams (T1, T2, and T3) was instructed to use conventional problem-solving approaches (Community-Based Method and Design Thinking) and the ABC Method. These groups were defined as ABC Teams.
- The other three teams (T4, T5, and T6) was instructed to use conventional problem-solving approaches and were named benchmark teams.
- The design task given to all teams was the development of a product/service that addresses the solution that improves the experience of the visitors of a specific place in the downtown of the city. The final concept must include an implementation strategy (not a detailed business model) that articulate different stakeholders through ubiquitous technologies. This case corresponds to a real situation of social innovation in which a problem may have multiple causes and solutions, and must include different users, participants, and resources.
- Each team had the same access to experts, community leaders, citizens and stakeholders as a source of relevant information and validation of concepts.
- The support and evaluation process of this research, were carried out by four students from 5th-year of product design engineer, to avoid the bias of the results.

4.4.2 Creativity Evaluation Experiment

Creativity evaluation was carried out by the implementation of expert assessment sessions, in which professionals with experience in social development (Engineers, Designers, Psychologists, Sociologists, and Architects) valued each of the concepts proposed by ABC and Benchmark teams. As said

before, Social innovation-driven projects are defined by different factors which include technical, social, psychological, and governmental among others perspectives; under this parameters, the selection of experts was guided by the inclusion of different knowledge areas of analysis and evaluation of social innovation solutions. The number of experts involved in each of the phases was different, due to their availability of time that should be synchronized with the academic process of the case (Table 6).

Sessions were performed during the presentation of the three milestones established by the course methodology, corresponding to each of the transition moments between phases (Inspiration, Ideation, and Implementation). During development process, ABC teams were assessed through surveys and interviews, focused on the usability of the heuristic cards and the user perceptions of the information proposed (Table 6).

	Case Phases	Inspiration	Ideation	Implementation
	ABC Phases	A	A,B	A,B,C
	Number of Experts	3	4	9
Decision Making	CAV	Expert Evaluation 1	Expert Evaluation 2	Expert Evaluation 3
Usability	UV1	Survey	Survey	Survey
	UV2	Interview	Interview	Interview

Table 6 Case Two Evaluation Strategy

4.4.3 Expert Evaluation

The process started with a theoretical explanation of the CAV (Creativity Assessment Variables) to each group of evaluators, establishing a clear base for the procedure.
For both types of teams, ABC and Benchmark Team, each of design phases was evaluated by the assessment of the outcomes, through a four-item questionnaire. This survey was based on a five-level Likert scale that inquired about the expert's perception of what extent a solution address novelty, detail, technical feasibility and social feasibility. Each criterion allowed the evaluator to write comments about the qualification to obtain extra information and verify the congruence with the CAV (Figure 6).

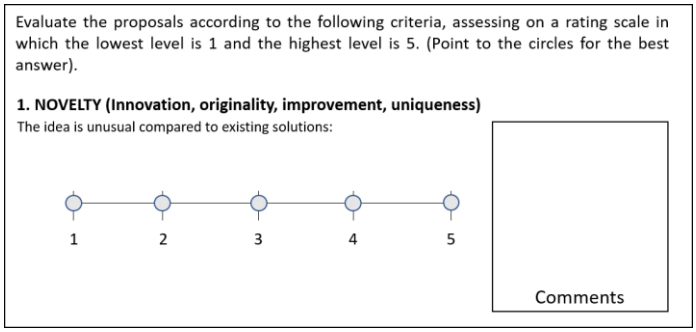

Figure 6 Novelty Assessment Item

The evaluation process depended on the coincidence of the project development schedule and the time availability of the experts. Given this, the number of experts was different in all phases: three for inspiration, six for ideation, and nine for implementation.

4.4.4 Usability Assessment

Even when the second case was mainly focused on decision-making assistance evaluation, a usability analysis was performed to enquire about the assistance provided by the tool. As an instantiation of the model proposed by Shah et.al., this assessment follows the perception evaluation model proposed in the first experiment with an Likert-based open survey (4.3.2).

Surveys were conducted before the milestone presentation of each phase and were focused on the evaluation of the relevance and clarity of the information provided by the heuristic cards. Relevance was analyzed through a five-scale Likert inquiry, in which designer defined how important/useful was the heuristic provided. Similarly, congruence was evaluated with an open-answer question to compare criterion definition with its application. Figure 9 exposes one assessment item of the survey which is repeated for each criterion.

Criterion 12	**Relative Advantage**				
What benefit does your solution or product offer that differentiates it from what the community already knows?					
In the ideation phase, how important was this criterion?	Very Important	Important	Moderately Important	Less Important	Without Important

Figure 7 Usability Assessment Survey Fragment

5- Analysis of the results:

5.1 - Case One

As described in subsection 7.1, usability variables were defined as how users understand and apply the information provided by the tool (UV1) and Which are the subjective perceptions about the use of the solution (UV2). Design Thinking methodology guided the development process in which the usability variables was immersed and in the same way the process of how the ABC Method was applied. According to this, the analysis of the results is determined by each of the development phases.

5.1.1 Usability Variable 1

UV1 is focused on the study of the understanding and the subsequent application of the provided adoption-based criteria.

Inspiration

During Inspiration phase, designers were guided to use the A category (Community, User, and Context) which corresponds to the strategy proposed. (Figure 2). The ABC criteria were used to cluster the information provided by experts and facilitate the convergence of perspectives. With the implementation of the surveys and the participative inquiry, it was perceived that many criteria were not understood by the students until they were mentioned and exemplified by the experts. Once the relevant information was obtained, the students proceeded to use the heuristic cards to determine possible missing data. In this procedure was observed that some cards were more precise than others because they were associated with past experiences or already known information. The ABC cards allowed the students to investigate more deeply when they conducted interviews with users and stakeholders.

The students surveyed were asked to assess, using a Likert scale, the ease in the analysis of information through the use of the tool. In response, 7 of 17 participants considered that the cards facilitated the process, 4 of 17 did not perceive any significant contribution, and 6 of 17 expressed a considerable difficulty in the use of the Heuristics Cards, associated with the complexity to apply unknown criteria. However, it was expressed by the users that the unknown concepts led them to look for more information to understand them and thus to be able to replicate them.

Ideation

Students received the instruction to use the A (Community, User, and Context) and B (Product/Service) categories during ideation phase to establish a solution strategy. Through the Likert-based survey performed during ideation phase, the evaluator team found:

- Three of five groups surveyed, rated the tool as essential and used the proposed criteria to define solution requirements and verify the information obtained up to that point of the project. The two remaining groups used another type of methods and emphasized the great difficulty that represents for a group of students having multiple tools.
- Five of the evaluated teams, consider that the ABC Method provides crucial information for the definition of evaluation matrices to assess solution concepts.
- It is important to highlight the additional explanations needed by students, to clarify some criteria that represented a high complexity in the understanding and application. The most cited ones were: social leaders, social groups, social dynamics, and dissemination.

Implementation

In the final phase, students were guided to develop an implementation strategy for each proposed solution by the articulation of different users, stakeholders and the convergence of value for each one with a vested interest. The approach proposed by the ABC Method was the analysis from the three categories perspective: A (Community, User, and Context), B (Product/Service), and C (Business Model). As said before, the accumulative proposal allows the constant analysis of the adoption-based criteria in a parallel and evolutionary way, aligned to the nature of the project development.
In the implementation phase, only four of the twenty people surveyed declared to have used the heuristic cards for the development of their business model. The tool was used to define stakeholders and possible strategic allies that facilitate the dissemination of the solution in the selected community.
Students developed the implementation phase using a participative approach through an iterative validation with experts and stakeholders. By the development of abstract prototypes, they have enquired external information sources to develop a preliminary business model. After a general explanation, all teams recognized that some of the adoption-based criteria correspond to the information obtained from other approaches.

5.1.2 Usability Variable 2

UV2 is oriented to inquire about subjective perceptions related with the use of the ABC Method.

During the inspiration phase, the students felt confused with some criteria which they were not familiar. In the same way, the adaptation time to understand how to use the tool limited the fluency of the work a little. However, the criteria provided relevant information for the stakeholder definition and strategies to address the proposed problem.
In the Ideation phase, the students emphasized in the ease and excellent performance of the tool to define product/service requirements and criteria determination to evaluate solutions; all of this from a social point of view. This information not only facilitated the development of the phase but also allowed reaching a significant level of detail. Students expressed the importance of the tool to give a theoretical foundation to situations that, from their intuition, they thought necessary, but they did not know how to explain or define. Oppositely, dissatisfaction was related with the interface of the tool, focusing on the density of the information. Some of the users proposed a digital interface or an initial filter to indicate which cards could be most relevant to the characteristics of an specific project. Finally, during the session, the perception converged on the need of an exemplification of each of the proposed criteria.

SUS Scoring

Following the SUS scoring method, proposed by Brook in which SUS yield is a single number that represents a composite measure of overall usability of the method being studied (Brooke, 1996). Ten questionnaires were implemented to assess the method, delivered to the five teams at two different times to be answered in the group. This strategy to obtain a generalized assessment from all groups avoiding the possibility that a person who may not have had contact with the tool contaminates the measurement (Table 7).

SUS	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Score	40	55	50	55	32,5	50	22,5	60	50	83
Average	49,75									

Table 7 SUS Scoring

With this score, the tool can be evaluated according to the average proposed by Brooke that correspond to a score of 68.

5.1.3 Analysis

During the inspiration phase, which is one of the most uncertain moments of the development processes, the students used the proposed tool, not only to define relevant information and understand essential characteristics but also to base their decisions and strengthen strategies; this gives indications of assistance in the decision-making processes by the ABC. Even though some users opted for other tools, that correspond to a real design situation in which there are multiple options, and it is the designer who decides how to articulate them in a solution process. It can be inferred from this situation that there is an ABC compatibility not only with the GiAnt case methodology but with the other proposed design approaches. However, there is an implicit limitation in this circumstance, given the inexperience of the designers, who felt confused by the different possibilities of choice; this affected the implementation of the ABC since was the one being the least common and with unknown information.

The ideation phase had a much more remarkable use of the heuristic cards, having a significant participation as a source of product/service requirements and evaluation of design concepts showing a continuity in the compatibility with other tools, at different moments of the development process. This incremental use of ABC can be explained by the experience of the students to translate new information into product/service design requirements and evaluation charts. The practice obtained from past experiences gives the designer a confidence that allows the use of known strategies to take advantage of new information, even in uncertain situations.

During the implementation stage, only one group used the proposed method to review their proposals before proceeding with the validation. This decrease in the utilization of the ABC is a consequence of the application of a participatory approach in which, through the inclusion of experts and stakeholders, the preliminary characteristics of the business model were defined. These types of strategies, being more experiential and providing latent information, stimulate the development process by contributing with information already validated by the ones involved in the solution. In the GiAnt case, with a defined chronogram, this procedure added speed to the definition and validation of the final concept, which represent an added value for the approach used. In the other hand, the ABC was focused on suggestively providing information, through a heuristics-based approach which possibly includes unknown theories; from the exposed perspective, the proposed method did not have how to compete with the agility of the alternative tools, which was more efficient in a matter of time.
In the SUS scoring, the tool received an average score of 49,75 points, indicating that it is below of the average of 68 points proposed by Brooke. Given this rating, it can be inferred that although the groups used the tool at different times and a benefit was perceived in all processes, the ABC was highly complex and this interfered with the understanding and application of the adoption based criteria (Brooke, 1996).

5.2 - Case Two

5.2.1 Creativity Evaluation

Given the necessary conditions to analyze the product/service adoption, in which is required different resources, and time plays a transcendental role, the presented study is not focused on obtaining conclusive data about the phenomenon. On the contrary, it has an exploratory approach which is based on a qualitative perspective of the performed evaluation.

The comparative analysis was carried out by the classification of the assessment results following the group division explained in section 8.1, in which ABC Group was the integration of the three teams who used the tool, and Benchmark Group by the other three teams that followed the Community Based Method. Given this, the analysis was developed by the comparison of the defined variables (*Novelty, Detail, Technical Feasibility and Social Feasibility*) in each of the three phases of the development process following the strategy proposed by Shah et al. focused on the evaluation of the outcomes. The evaluation was carried out by the qualification of each variable with a rank from 0 to 5, were 0 was the lower level and 5 the higher level of accomplishment of the evaluated parameter.

Inspiration

After the analysis of the qualifications, it was obtained that the benchmark group had a similar average score in the variables novelty and detail, compared with the ABC team. Conversely, the teams that used the proposed tool obtained a notorious superiority compared to the control group, in the technical and *social feasibility* parameters as can be perceived in the Figure 8.

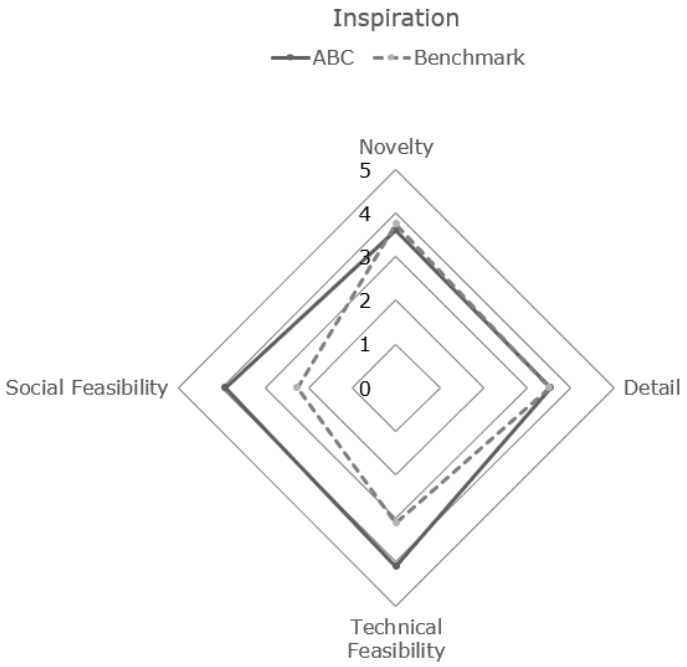

Figure 8 Creativity Assessment: Inspiration Phase

More profoundly, from the analysis of the scores assigned by each one of the experts the following results it can be inferred that the lowest score for the ABC is given for the *novelty* parameter and was designated by the technical expert. Subsequently, in the same variable, the Benchmark group obtained the highest score rated by the social expert. Conversely, for the *detail* variable, the team that used the tool achieved the highest score and the control group the lowest, both assigned by the technical expert. The other assessments tend to be similar for each of the studied groups. All these differences between the ABC and Benchmark groups about *novelty* and *detail* variables seem to be a consequence of the difference in the knowledge fields of the experts more than a significative distinction between methods.
Technical and social feasibility variables presented a more significant difference in the score, suggesting a superiority of the ABC group over the Benchmark. The analysis of the individual results delivered by each of the experts shows superior results in the processes in which the tool was implemented, even though each of the experts belongs to different areas. More precisely, *technical feasibility* shows a high overall rating for the ABC compared to the control group showing an advantage in the evaluation of each of the experts. However, in the parameter of *social feasibility*, is where the ABC has a more considerable advantage not precisely valued by the social expert but from the technical and innovative approaches (Figure 9 Inspiration phase: technical and).

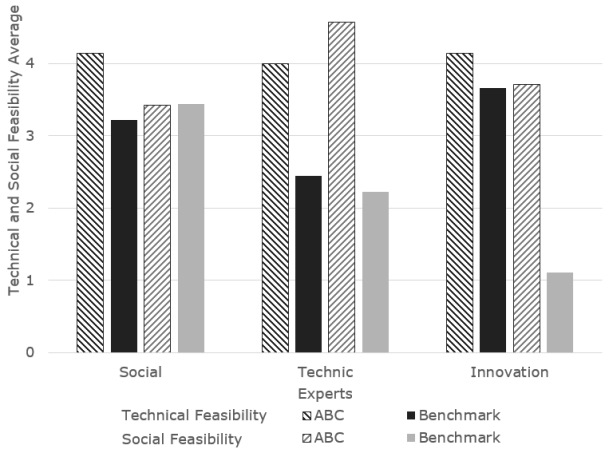

Figure 9 Inspiration phase: technical and social feasibility assessment.

The results obtained in last variables suggest a positive impact on the feasibility of the solutions, given by the implementation of criteria based on adoption.

Ideation.

The ideation phase concluded with a representative difference in the comparison of the averaged scores, which is a suggestion of generalized advantage in the ABC implementation.
In contrast with the inspiration phase, the gap between the results is more noticeable in 3 of the variables defined. On the other hand, the score in the novelty parameter was the least favored, even below the control group (Figure 10Figure 10 Ideation Phase).

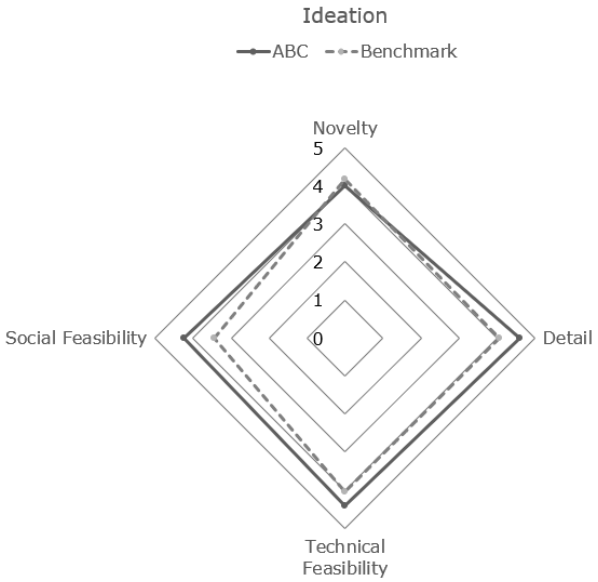

Figure 10 Ideation Phase: Creativity Assessment.

In the analysis of the individual qualifications, a notorious advantage is perceived, even when the variables were evaluated from different perspectives and areas of expertise. This type of results suggests the relevance of the method to which this study refers. The lowest scores were examined, and it was found that in addition to a coincidence with the previous phase in the novelty variable, the assessment results did not expose much difference with respect to the control group, and even exceeded it in the rating granted by innovation and community experts. The social expert contributed the lowest score (Figure 11).

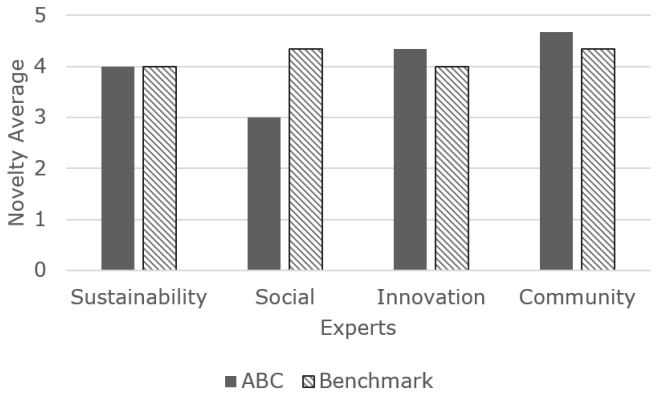

Figure 11 Ideation Phase: Novelty Assessment

The highest results of the evaluation were obtained by the ABC group, in the detail parameters and technical feasibility, under the qualification of the experts in innovation and social respectively; however, the scores were very even for both groups. The social feasibility variable was where the most considerable advantage was shown by the group that used the tool (Figure 12).

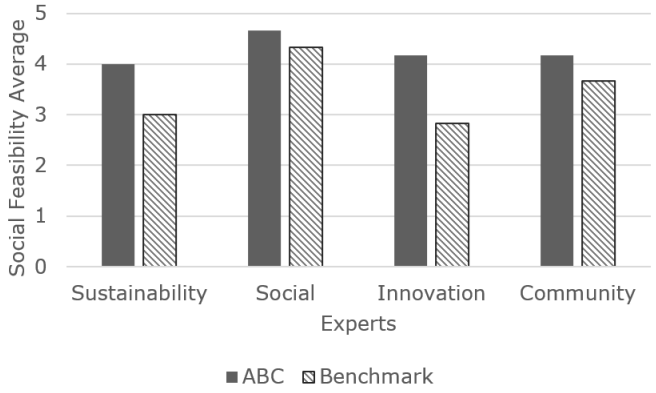

Figure 12 Ideation Phase: Social Feasibility Assessment

Although both teams obtained a rating that tends to be positive, the results obtained up to the ideation phase suggest a contribution in the decision making made by the students in the solution development process.

Implementation

In the implementation phase, the evaluation was performed by nine different experts, which not only enriched the comparison between the processes developed but also allowed access to qualitative data from the perspective of the diverse knowledge fields that are involved in social innovation-driven projects.

The averaged results obtained in the implementation phase show a generalized advantage, under the four variables analyzed, in the processes developed with the ABC compared to the control procedures.

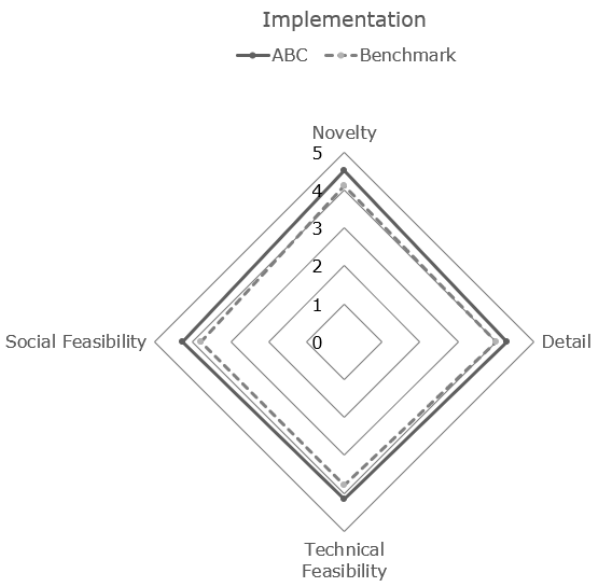

Figure 13 Inspiration Phase: Creativity Assessment.

In the final phase, the advantage of the ABC group in the novelty variable was remarkable, considering the qualifications obtained in previous stages. The analysis of the individual scores suggest a superiority based on the positive assessment made by seven of the nine experts involved. This favorable rating was assigned by experts mostly related to social issues. The other two evaluations correspond to a tie designated by the innovation expert and a disadvantage concerning to the technical expert point of view. All this, recognizing that the novelty was defined as the difference of a solution compared to what currently exists in the environment (Figure 10).

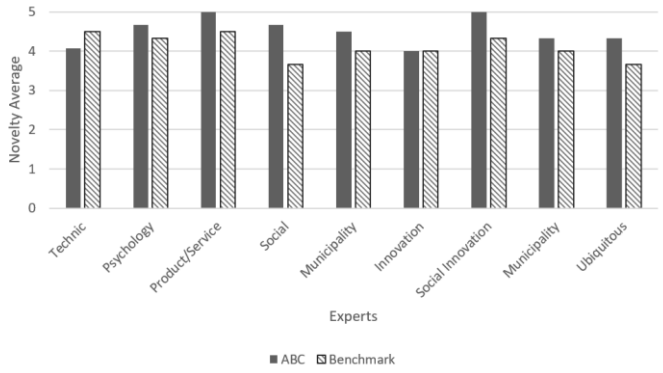

Figure 14 Implementation Phase: Novelty Assessment

The highest scores of the ABC group were obtained in the social feasibility variable, in which the majority are presented in a significant advantage in the scores compared to the control group (Figure 15).

Given the favorable conditions for the evaluation with the presence of nine experts, it can be inferred that the implementation of the ABC Method helped to make decisions in the processes carried out by the three groups of students of Product Design Engineering.

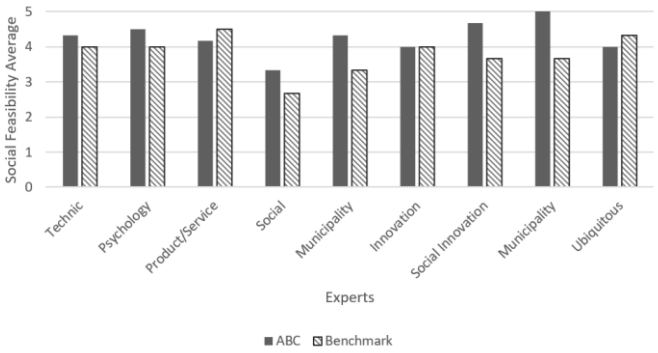

Figure 15 Implementation Phase: Social Feasibility Assessment

5.2.2 Usability assessment

The usability study was focused on perceptions about the utilization of the tool, inquiring each of the thirty adoption-based criteria, about its usefulness and clarity.
For the inspiration phase, the most relevant criteria were those related to the context rather than users. The highest score in the five-scaled survey was the card that provided information on government issues, policies and regulations. The users gave as an argument the lack of training and experience in the legal issue. This situation is an example of assistance in decision-making situations in which designers must solve problems that include areas of knowledge unknown to them.

The perceptions of nonconformity were focused on the complexity of the proposed keywords that the users did not understand. In the same way, The Training and Preparation Card was the most complex criterion, which was understandable but not applicable for students.
In the ideation phase, users highlighted a better performance of the ABC Method, supported by an explicit knowledge of product requirements. Adoption Based Criteria were applied to solutions and used as concept evaluation parameters. The most used criterion was Relative Advantage, perceived by users as a concept that invites designers to compare preliminary solutions with existing product/services to maximize value. The similarity between several criteria was a pitfall, which, although useful, can be integrated to provide further clarity.

During implementation, the tool was less used in comparison with other phases. Users attributed the fewer use of the ABC to the lack of clarity in some concepts that they did not know how to apply. The most used card was one referred to the Strategic Alliances, and the least valued were those that emphasized the definition of operating costs.
Finally, the evaluator team inquired about the general use of the tool and found that the students did not follow the suggested application strategy, in which the phases are used cumulatively. On the contrary, Category A was attributed to Inspiration phase, category B to Ideation and C to Implementation.

5.2.3 Analysis

In the inspiration phase, a higher score was shown in the feasibility variables and, in a contrary manner, a low score in novelty. This situation suggests an assistance in the decision-making processes made by the designers who used the ABC Method. Apparently, during this first phase, decisions were focused on the feasibility of the solutions by the use of

information that led processes towards possible products/services; This constitutes an evidence of correlation with a lower perception of novelty, by establishing a limit in the divergence of non-possible solutions.
The previous situation implies compliance with the initial objective of the study, which sought to deliver relevant information in the early stages of product development, to strengthen the creation of solutions.

The improvement of the technical feasibility of a solution can be analyzed from the resources articulation perspective, which could be defined as a contribution to the efficiency of the product. Similarly, a strategy to increase the social feasibility of a concept means that the final solution is aligned with the values, dynamics, cultures, and behaviors of a community, which contributes to the adoption of the solutions. The combination of these two factors can be translated into a possible improvement in the sustainability of a product/service, from the first stages of development.

Including the perception study, carried out in parallel with the evaluation of experts, it can be inferred that the improvement in the scoring of the variable detail in the ABC group can be a consequence of the increased use of the tool for the definition of product/service requirements. In the same way, superiority in technical and social feasibility was perceived, similarly with the inspiration phase. As users emphasized, the high complexity of the criteria was a constant in the entire process, that's why the increase in the use of the cards may not be related to the clarity of the information. This increase in the utilization of the Adoption Based Criteria, can be related to the ability of students to operationalize knowledge and translate it into product requirements.

Finally, in the implementation phase was perceived a generalized advantage of the ABC group over the control group. Although the students did not follow the strategy suggested by the method, the information that was delivered systematically had an impact on the results of the process.
Continuing with the observed in other phases, the highest score was presented in the social feasibility variable, which suggests an assistance in the decision-making process, based in the primary objective of the ABC Method: Provide adoption based criteria to improve adoption of solutions in social innovation-driven projects.

Even when third-year Product Design Engineering students do not have experience in the development of a business model, the application of the C category supported the definition of strategies to define alliances and articulate stakeholders; all this based on the testimonies of the participants of the course and the qualification made by the experts.
The assessment made by the experts could not be analyzed conclusively given the differences in the areas of knowledge. This characteristic provides a qualitative strength to the evaluation, according to the convergence of multiple perspectives in the assessment, concerning the defined variables.
In terms of creativity, it can be concluded that the ABC Method favored creativity to help students expand and explore the design space.

6- Conclusions and further research

The ABC Method works as a checklist and is intended to act as a guide to preserve designer experiences, obtained during the interaction with the community. As social innovation design methodologies propose (HCD, Design Thinking, and The Lean Startup), these anecdotes are an essential information to develop solutions that fit into society. In these early stages, as an awareness guidance and decision-making method, is where ABC Method is needed.
Based on the experiential knowledge, the adoption-based models are the indicated source of information to improve the acceptance of solutions in social innovation processes. The presence of information that supports the perceptions of the designers and that facilitates the clustering of factors favors the design process, resulting in solutions that include not only technical specifications but also integrate social dynamics and context conditions as resources

There is a gap in implementation strategies to include information from different knowledge areas into product-service design methodologies. This Absence can be fulfilled with heuristics-driven models. The translation of high complexity criteria into systemic propositions facilitates the application of information into existing problem-solving approaches; in this case, heuristics act as proactive strategies but are subject to user interpretation before the application.
The heuristics approach held in the process of inclusion of different perspectives the two cases assessed in this research, but this knowledge was still confusing for inexperienced users, which can be any designer in an unknown community or context. It is necessary to complement the heuristics-based information with examples of its utilization in real projects, to provide more details on the implementation of the knowledge. In the same way, a suggested procedure to enhance the comprehension of a decision-support method is the execution of an experimental situation in which, with detailed and practical analysis, designers can acquire the experience to apply the provided information before addressing the specific project.

The adoption of innovation models has not been explored thoroughly in the product/service development area. The application of human-based factors in the existing prescriptive methodologies is a process that depends on the experience of each designer.
Based on the evaluation performed by different types of experts, in which the ABC Group obtained a notoriously superior grade, it can be concluded that there is a contribution of the ABC Method to the design process. As is explained in the subsection 2.4.1 of this article, the design space is defined by all possible option for a given problem determined by the existent data. The inclusion of adoption-based information from various experiences and knowledge areas that are not recurrent in designers suggests that the ABC Method expands and explores the design space. The space expansion occurs when designers study and understand the adoption based criteria. Subsequently, the space exploration happens when the provided information is applied and during the search of opportunities (Inspiration phase), the formulation of solutions (Ideation phase), and the validation of design concepts (Implementation phase). Is in this application of knowledge when designers establish relations and convergence points between different community-based

knowledge and address problems with more detailed and adoptable solutions.
As cited in section one, the best strategy to face uncertain situations is the acquisition of detailed and specific information from different knowledge fields. Given this, the implementation of adoption-based criteria from early stages of the design process can reduce the uncertainty in problem-solving situations and improve the design task.

The major limitation in the execution of this research was the insufficient time and lack of resources to deliver the developed solutions to the community and evaluate the adoption in a determined lapse of time. This experimental validation is a suggestion for further research and method improvement.
In the usability case, the implementation of the proposed method was shared with other methodologies and knowledge sources such as experts, companies, and stakeholders which in a collateral manner affected the utilization of the ABC Method. This complexity simulates real situations were different organizational and social perspectives diverge. The students, as young designers, expressed an overwhelming feeling related to all these conditions and highlighted that at some moments of the process the method was not used. The application and evaluation of new methods in the design process are affected by the nature of the project and the inner participants' dynamics.
Based on the usability experiment, explained in the subsection 4.3, in which multiple subjective perceptions were analyzed, it can be concluded that even when designers perceived the benefit of the implementation of the ABC Method, some of them decided to guide its process with known approaches due to the high number of tasks to develop. This behavior suggests a high dependence of the method utilization with the readiness of participants to use new proposals when the implementation occurs in a not mandatory case.
The implementation of the ABC Method in the creativity case had an evolutionary behavior focused on social parameters. In the three design phases (Inspiration, Ideation, and Implementation) designers addressed the analysis and definition of product-service specifications in social factors, guided by the criteria proposed by the ABC Method. This situation delayed the functional design but supported every decision taken, and reduced possible reprocesses. This suggests that the implementation of a new design method could affect some secondary tasks of the development process, but its contribution could be seen in the final outcome.

The designers' assistance, with decision-making methods, reduce uncertainty and enables the articulation of knowledge from different areas of expertise, enhancing creativity, by the finding of a new application of existing knowledge; in the case of the ABC Method, the application of adoption based criteria through experiential knowledge (heuristics).

Some relevant questions must be included in future experiments to determine the incidence of some factors such as designer experience, gender, and possible language misunderstood that in this precise research, was not included.

To the best of the authors' knowledge the research concluded with an indication of advantage in the implementation of the Adoption Based Criteria Method, to support decision making in social innovation development processes.

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