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Quasi-experiment to measure the suitability of design innovation in service processes - The case of autonomous vehicles for mobility service

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Abstract

Different methodologies exist to foster innovation. The well-known ones are Design Thinking, User-Experience Design and Service Design. What all these methodologies have in common is the user-centered principle and the iterative process. These recommend frequent testing of the product or service under development with users during the innovation process. While these tests are certainly useful, they are not sufficient to properly validate the innovation. Therefore, in this paper, the combination of pre-experimental and quasi-experimental methods is proposed to validate an innovation and its implicit assumption that the innovation corresponds to a problem solving that significantly improves the life of users. In this research, authors demonstrate how to use pre-experiment and quasi-experiment in the design process to validate progress from one iteration to the next. This is illustrated by a case study of an autonomous vehicle as public transportation service for people with disability and reduced mobility in a touristic context.

Keywords: Quasi-Experiment, Pre-Experiment, Innovation, Service Design, Universal Design, Validation

Introduction

Numerous methodologies exist to foster innovation, open innovation or co-innovation. Three important ones are Design Thinking, User-Experience Design or Service Design. All these methodologies for innovation have in common the user-centered principle. They place the user at the center of the innovation process and at each step they call on him. The goal is to get insights on the needs of the users in order to ensure the success of the innovation. All three mentioned methodologies are also based on the concept of iterative work. Furthermore, each methodology recommends testing frequently the product or service in development with users during the innovation process. As an example, usability evaluation and usability testing are used in software development. Usability evaluation are performed by experts who use a checklist (e.g. Nielsen's 10 usability heuristics) to audit an information system. Usability tests are done with users. Data like time to perform a task, number of steps to achieve a goal or number of errors are collected.

These tests are important to improve the service or product in development. However, they are not enough to validate the innovation. Therefore, this paper proposes to use pre-experiment and quasi-experiment methods to go further in the iterative process in order to validate or invalidate an innovation, in other words such as research hypothesis. Indeed, the implied hypothesis of an innovation is that the new product, service or technology must be a relevant problem solving that changes the users' lives. Innovation and its added value must be validated by users on performance measures as well as on perceptions. It can be done through a pre-experiment and quasi-experiment.

To illustrate the use of pre-experiment and quasi-experiment to validate an innovation, this paper presents the case of autonomous vehicles as public transportation service in a touristic context. This case focus on the mobility of people with disabilities and reduced mobility, one of the numerous challenges faced by these users. Indeed, improving the mobility of people with disabilities give them autonomy and reduce the risk of social isolation (Simplican et al., 2015). People suffering from reduced mobility primarily use wheelchairs. According to the World Health Organization (WHO), the prevalence of disability ranges between 12 - 18% of the total population and the majority of people with mobility issues use wheelchairs[1]. Our quasi-experiment tests then the hypothesis that the use of Autonomous Vehicles (AVs) improves the mobility of people with disabilities.

We are using thus pre-experiment and quasi-experiment methods to test that the autonomous vehicles improve the autonomy of people with reduced mobility.

[1] WHO. (2017b). World report on disability. http://www.who.int/disabilities/world_report/2011/report/en/

This paper is organized as follows. In section 2, a brief literature review is made. Then, the methodology is described in section 3. Findings are exposed in section 4. Finally, a conclusion with future plans is proposed.

Literature Review

In the Oslo Manual, innovation is defined as "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (OECD, 2018, p. 20). Impact evaluation relates to the analysis of the causal effect of an intervention. It is linked to the notion of counterfactual analysis. The outcome has to be compared with a sample without intervention (Ballon, et al., 2018) and the developed intervention must create value for its intended users (Ståhlbröst, 2012).An innovation is no more than the hypothesis that the service or the product will have an impact on the users' life. The hypothesis can therefore be tested to validate or substantiate the innovation from such an angle.

With the emergence of user-centered design in the late 1980, "Usability evaluation with real users became a key part of product development" (Oulasvirta, 2012, p. 1). Qualitative and quantitative data collection techniques are used to assess the effectiveness of technologies (Bassoppo-Moyo, T. C., 2010). In the field of Information & Communication Technologies and smart home technologies, many research projects run experiments in physical spaces (room, building or district) where artifacts (devices, technologies or services) are tested by users with or without their direct intervention (Bendavid, et. al, 2012; Perentis, et al., 2017). However, these evaluations or tests are not designed as experiment.

In the field of disability and special needs, universal design (M.S, 1998) is used to develop media, products, buildings, infrastructure and services for all. Universal design is based on seven principles. For each principle, there are several guidelines. Performance assessments are based on criteria to judge the design or products (Preiser, 2008) but are not designed as experiment. Helle, et al. (2013) conduct a study to validate housing standards through activity-based approached. They used observation and self-report to assess accessibility issues. However, this latter study was not designed as a pre- or quasi-experiment.

An experiment is, according to William Ralph Inge, "a test under controlled conditions that is made to demonstrate a known truth, examine the validity of a hypothesis, or determine the efficacy of something previously untried" (Shadish, et al., 2002). For innovation (product or service), it is impossible to conduct pure experiment. However, it is possible to conduct pre-experiment and quasi-experiment. Knemeyer and Naylor (2011) have identified the necessary conditions for quasi-

experiments to establish the causality of two tested variables. First, with all other things being equal, solely the independent variable is changed, and second, the independent variable might or not affect the participants, and thus the dependent variable might also change.

Schuurman et al. (2013) propose a quasi-experimental approach for Living Lab projects. To this end, they include a pre-measurement, an intervention (a real-life experiment) and a post-measurement. However, these authors do not use pre-experiment and quasi-experiment in the design process to validate progress from one iteration to the next.

Methodology

We can describe pre-experiment and quasi-experiment as a process containing the four following main steps:

1. Hypothesis formulation. We start by formulating a hypothesis related to a given human behaviour. This hypothesis is the answer to the stated research question. In a Living Lab process, the hypotheses are formulated during the co-creation and the exploration phase.
2. Hypothesis "operationalization". We then "operationalize" the hypothesis through a simulation of the ecosystem under study to obtain a prediction of it. This corresponds to the experimentation phase of the Living Lab process.
3. Data collection and analysis. We collect and analyse the data of the experiment (e.g. a simulation of a passenger in wheelchair waiting in line at a bus stop). This is the evaluation phase.
4. Conclusion. We compare the statistical results to the prediction and also to other findings in the literature to assess the validity of the hypothesis.

For the pre-experimental design, a single group design is used after treatment (Thyer, 2012).

$$X - O_1$$

Here, users try the innovation (X). Then, data are collected (O_1).

Then, if the results are convincing, a quasi-experiment can be conducted. In that case, the posttest only no-treatment control group design is proposed (Thyer, 2012).

Group 1 try the innovation	$X - O_1$
Group 2 do not try the innovation	O_1

The same protocol than for the preceding pre-experiment is used with the addition of a second group of users who do not try the innovation.

The Figure 1 illustrates the way pre- and quasi-experiments are used in the design process to validate progress from one iteration to the next.

Insert Figure 1

For the data collection, observation is used. Indeed, when the experimental approach is implausible, naturalistic inquiry offers an alternative for researchers. In a naturalistic experiment, data is collected under natural conditions, i.e. not in the lab (Guba, 1978). In quasi-experiment, researchers are not able to control all the variables present in the experiment, as it is the case with pure laboratory experiments. As pre-experiments and quasi-experiments are conducted with users, their consent is required. Similarly, if there is a risk to their physical integrity, they must be informed and consent to take that risk.

The scientific literature provides a lot of information for the calculation of sample sizes used in pre-experimental and quasi-experimental mode (Sackett, P. R., & Mullen, E. J., 1993). In our approach, we consider the interest of relying on pre-experimental research designs that require small sample sizes with essentially a feasibility check purpose to evaluate the passage from one iteration to the next.

To operationalize the hypothesis (H0) – the use of Autonomous Vehicles (AVs) do not improve the mobility of people with disabilities – we recruited three users with reduced mobility who used a wheelchair. The three users had to use the AV in the Sion old town route. In the AV, only one user in wheelchair can embark at the same time. The experiment was run three times. Each time, two same observers collecting data during the whole experiment accompanied the three different users. The collected data are pictures, movies, observation notes and phenomenological quotes. Then, these data were analyzed with the help of the software RQDA.

Findings

Based on observation, the results of the pre-experiment are: 1) Without the help of a third person, it is impossible for a people with disabilities to use the AV. Indeed, the ramp to embark and disembark has to be installed manually (this feature will be automatized in the next generation of AVs) and is too steep. 2) In many bus stops it was impossible for the user to embark or disembark due to the lack of space between the bus and an obstacle (e.g. building). Consequently, we are not able to confirm the hypothesis that the use of Autonomous Vehicles (AVs) improves the mobility of people with disabilities.

For the next pre-experiment, the use of the AV in a touristic context still needs to be tested. Indeed, during the first pre-experiment users mentions that the use of autonomous vehicles would be

interesting for a touristic visit of an old city with paved streets. If the next iteration is convincing, a quasi-experiment will be conducted on this scenario. This will be done in spring 2020.

Conclusion

To foster innovation, methodologies like Design Thinking, User-Experience Design and Service are used. All these methodologies have in common the user-centred principle and the iterative process. They also recommend frequent testing of the product or service under development with users during the innovation process. To validate an innovation and its implicit assumption that the innovation corresponds to a problem solving that significantly improves the life of users, this paper proposes to use the combination of pre-experimental and quasi-experimental methods. In particular, authors show how to use pre-experiment and quasi-experiment in the design process to validate progress from one iteration to the next.

This research is illustrated by a simplified case study of an autonomous vehicle (AV) as public transportation service for people with disability and reduced mobility. The first pre-experiment does not confirm the hypothesis that the use of AVs improves the mobility of people with disabilities. However, users with reduced mobility involved in this pre-experiment gave ideas for a second pre-experiment, either to test the hypothesis that AVs improve their mobility in a touristic context, especially the touristic visit of an old town with paved streets. In spring 2020, this hypothesis will be tested through a pre-experiment. If the result will be convincing, a quasi-experiment will be conducted to validate the innovation.

As we can see, the use of pre-experiment does not require much effort. However, it is practicaland answers an important question: do the expected innovation solve a problem for the users and improve their situation? Furthermore, the observation data collected during the pre-experiment also provides insights for a new iteration based on co-creation. Even if these results based on qualitative data (observation) are interesting, the collection of quantitative data during quasi-experiment is essential to ultimately validate the innovation through statistical testing.

In order to validate the use of pre-experiment and quasi-experiment, it is necessary, following the presentation of the simplified case study, to set up a test bench so that statistical conclusions can ultimately be drawn from it.

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Figures

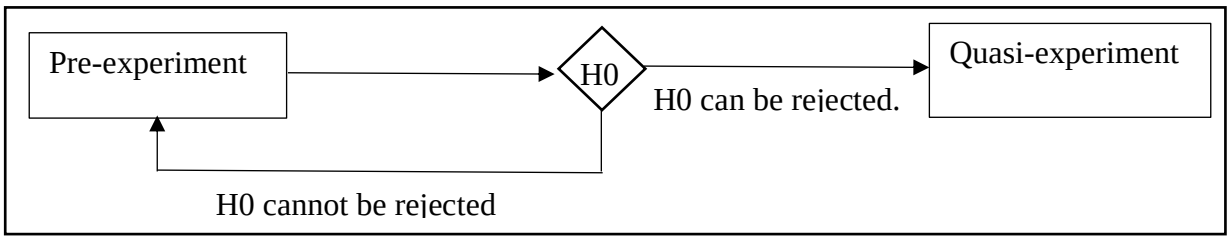

Fig. 1 – Illustration of the iterative design process with pre- and quasi-experiment