

USER EVALUATIONS: APPLYING A COST-BENEFIT APPROACH TO HUMAN COMPUTER INTERACTIONS

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Abstract. *This study suggests a framework that analyzes individual preferences towards interactive systems by modeling users' evaluations of the cognitive costs and the benefits of using the systems. A graphical cost-benefit approach, which was originally applied in the area of system analysis and design to help decision-makers select computer systems for organizations, is applied in the area of human-computer interactions (HCI) to predict users' preferences of alternative application designs. We tie the HCI design methodology of personas to the cost-benefit model. Currently, we mainly propose the applicability of the original model into the field of HCI, and suggest a series of studies that will show that a user's preference can be predicted using the model. Initial results from a study on a backpack purchasing website already supports the relevance of the original model in HCI and indeed encourages further research to examine the model's applicability.*

KEYWORDS: HUMAN-COMPUTER INTERACTION, COST-BENEFIT, USER EVALUATIONS, PERSONAS.

1 Introduction

Cost and benefit considerations play an important role in many areas of our lives. A cost-benefit lens was previously used to explain different phenomena related to how people act in different tasks or contexts (e.g. [1], [2] and [3]). In this research we present a cost benefit approach to predict users' evaluations and preferences of interactive applications. We follow a previous cost-benefit approach that is applied in the area of systems analysis and design in the feasibility stage of selecting the optimal computer system among alternative proposals [4, 5]. While the original model refers to the costs of purchasing or developing a system for organizations in monetary terms, the current research is concerned with costs in terms of an individual's perceptions of the cognitive resources he or she needs to consume when using a system, such as effort and time spent. While the original model refers to the overall benefit of the system to the organization, which is derived from a list of relevant criteria (e.g. quality of the development team, reliability of the hardware, business processes and customer service improvements, etc.), the current research is concerned with the benefits that a user predicts he or she would achieve during or after using a system. The original model deals with organizational goals, but a system must fulfill also personal goals. Our framework takes the original model of cost-benefit considerations a step further from a macro-level (organizational) perspective to one that is micro-level (individual and cognitive).

Indeed, monetary costs are important when choosing among alternative systems, but we are more interested in user perceptions of the cognitive costs involved in using a system for a certain goal. Therefore, we consciously leave financial considerations out of the

scope of this study; but of course we cannot ignore the fact that financial constraints can tip the balance and determine which system will be finally selected. Our scope is most relevant to situations in which system use is voluntary, such as choosing among different websites, different mobile applications or different versions of a system.

Every system action has costs and benefits that may be perceived differently depending on the user or the circumstances [6]. Users' personal characteristics (traits), together with his or her current usage situation (state) such as motivation or current context, are important factors to affect the cost-benefit comparison process.

Previous theories have already studied the acceptance and use of technologies, and among them are the well-known TAM (technology acceptance model; [7]), and its extensions TAM3 [8] and UTAUT (unified theory of acceptance and use of technology; [9, 10]) models. While these models encompass a wide scope of vital antecedent determinants important for system acceptance, in this study we narrow our focus to looking at user preferences through a cost-benefit lens, and therefore we incorporate certain variables from these models that play an important role in users' cost and benefit considerations.

Using an application can lead to positive outcomes, such as reaching a high level of task performance or having a pleasant engagement with the application, but also can lead to less desirable outcomes, such as perceiving a high level of cognitive load, or spending a lot of time and effort on the expense of other tasks. It is reasonable to expect that users, if given a choice, would prefer applications with high benefits and low costs. Since many applications require the devotion of many user resources to reach

desirable outcomes, it is most interesting to know how much cost a user would invest to achieve a certain benefit, or in the terms of the original model, what is the weight distribution of costs and benefits [4, 5]. Previous studies had already looked at the impacts of cognitive costs and benefits on technology usage [6], [11]. While they measured cognitive effort as an objective variable (e.g. number of clicks or text entries), we measure costs and benefits in subjective terms since costs that may be perceived high by one individual may be perceived low by the other. The same can be said about benefits. In addition, the current context of use determines the user's momentary goals and motivations; affecting the cost that the user will be willing to invest to achieve them.

We integrate the well known user-centered design (UCD) method of personas, developed by Cooper [12], in the original cost-benefit model to show that the model is able to predict user preferences of systems or interactive modes. Since personas represent a cluster of users that share similar behaviors, attitudes, needs and desires, it is reasonable to believe that these characteristics and motivations affect their evaluations of the costs and the benefits of using a certain interactive computerized system.

2 Means for solving the problem

We intend to demonstrate the applicability of the cost-benefit model is in the field of HCI by conducting a series of studies, and we are currently testing the model with different decision support systems (DSS) for product customization by online customers such as a backpack purchasing application, a cake purchasing application, and a trip planning application.

In each study, we design experimental prototypes that are different versions for a system or an application, varying in terms of cognitive costs (e.g. effort) and benefits (e.g. utility). We expose our participants to the different designs, and collect their evaluations by measuring the perceived costs and benefits of the different prototypes on Likert scales.

We classify participants to certain persona types, based on the relative importance they give to cost versus benefit (also derived from user's ratings on Likert scales).

For each participant, according to the original graphical cost-benefit technique [5] and based on his or her cost and benefit evaluations, we graphically draw graph lines for each application. As we explain below, we predict that the graphs will follow the same pattern at the individual user level, as the one at the organizational context level. We describe the process of creating the graphs in the following section.

3 Method

We are currently conducting a series of studies to test and to demonstrate the applicability of the cost-benefit model is in the field of HCI, in the context of decision support systems (DSS) for product customization by online customers. In the current paper we describe and demonstrate our methodology using a backpack purchasing application.

In our initial study we used two backpack purchasing applications that represent decision support systems (DSS) for product customization by online customers. We designed the two applications so that they would differ in the levels of cognitive complexity (a cost factor) and utility (a benefit factor). Application 1, hereafter the "choose" app, proposes the user a list of 21 preset backpack designs, to choose among them and application 2, hereafter the "design" app, enables the user to design a backpack 'from scratch' by interacting graphically with objects such as colors, text, and images. The basic distinction between the applications was adopted from a previous study [13]. For the specific design we used print screens from an existing website of bag customization (<http://www.makecustombags.com/>).

In terms of cognitive costs, the difference between the choose and the design applications is in cognitive resources consumed: while the choose app is a system for purchasing a backpack in minimal time and effort, the design app is relatively more complex since it involves more actions (object manipulations) and is more time consuming. In terms of benefits, the choose app is relatively low on utility, since a user can only select a backpack from a limited predefined set of designs. On the other hand, the design app is a system of higher utility, which allows the user with means to experiment with various combinations of objects until he reaches a satisfactory customized (user "tailored") backpack design, therefore optimal to meet his specific aesthetic desires. Figure 1 presents print screens of the backpack applications.



Fig. 1. The backpack purchasing applications

Following the original cost-benefit approach, the overall cost and benefit of each application can be calculated for each user according to his or her perceptions and then graphically presented on two vertical axes, one for the cost and the other for the benefit. In the original cost-benefit model, the cost values of the alternative computer systems are transformed onto a normalized-cost scale (using various transformation methods) to enable a comparison between two variables that are measured differently; costs are measured in monetary terms whereas the benefits are measured in subjective terms. However, this transformation is not required in the case of cost-benefit considerations of users that select a system among alternative designs, since perceived aspects that reflect cognitive costs can be measured on the same type of scales (e.g. Likert scales) as the perceived aspects that reflect benefits.

We exposed participants to each application, and afterwards we conducted a survey to capture their evaluations of the costs and the benefits. We follow the graph creation process of the original cost-benefit approach [4, 5], but made adjustments to HCI, to focus on user perceptions and interaction preferences of systems through a

cost-benefit lens. While in system analysis and design, the costs and the benefits of each alternative system are defined for a certain organization at the feasibility stage by IS experts (using different methods such as normalized-cost scales), we calculate the overall cost and the overall benefit of an application separately for each user by the average of his or her ratings on Likert scales that measure variables borrowed from TAM and its extensions (TAM3 and UTAUT) such as perceived ease of use and perceived usefulness (reflecting cost and benefit, respectively). We marked the overall cost and the overall benefit on the designated vertical axis and then we drew a connection line between the two marked values to graphically form a line for each alternative application. The horizontal axis is the weights scale that expresses the relative importance of costs and benefits, also derived from user's ratings on Likert scales

Using the personas method, we demonstrate how different types of users are positioned on the cost-benefit weight (relative importance) axis. When purchasing a backpack, some individuals are highly motivated to have the "perfect" backpack and would be willing to spend a lot of time and effort to create it, and on the other hand, others may be willing to settle for a "good enough" backpack, by investing a relatively small effort to have it. Accordingly, we designed two respectively personas, Dana and Ronen, who have personal characteristics and motivations that are relevant to the task of backpack purchasing. As presented in figure 2, for each user, each application can be positioned on a cost-benefit graph, according to its overall cost and overall benefit perceptions. Figure 2a demonstrates a possible graph predicted for a user represented by Dana that we expect to be positioned at any point on the weight axis to the right of the intersection with a preference to the design app. Figure 2b demonstrates a possible graph predicted for a user represented by Ronen, expected to be positioned at any point on the weight axis to the left of the intersection with a preference to the choose app.

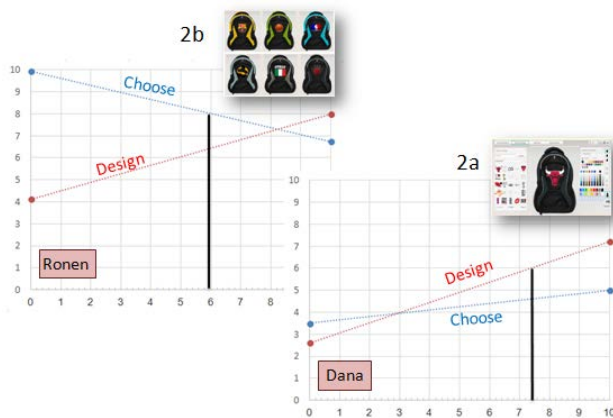


Fig. 2. Cost-benefit graphs for backpack applications including personas

2a example for the persona Dana; **2b** example for persona Ronen

As aforementioned, in each of our series of studies we expose participants to alternative applications and according to their ratings on the previously mentioned Likert scales we draw a cost-benefit graph for each user on the vertical axes. Using additional Likert scales that capture the relative importance of costs and benefits, we position each user on the horizontal weights axis. At the end of the

survey, we also ask them to choose among the applications which one they prefer. We expect to receive graphs that are similar to the original cost-benefit approach, showing that users prefer applications that are designed to meet their needs and current motivations. In other words, and following the original cost-benefit model, we predict that the location of a participant user on the horizontal weight axis (cost-benefit relative importance) will be somewhere in the range where the maximum values on the vertical axis belongs to the exact application that he or she preferred. This will prove the model is suitable for the field of HCI.

4 Results and discussion

The backpack study was the first in a series of planned studies, which initially examined the feasibility of the cost-benefit model in HCI. Sixty 3rd and 4th year industrial engineering & management students from an academic engineering college in Israel participated in the study, as part of an HCI course; user computer interface design. There were 25 male and 35 female, with the average age of 26.

Table 1 summarizes the results, and shows that a significant majority of the participants had a preference to the design application. Also, results show, that female participants preferred the design application more than male.

Table 1. Backpack study results – application preferences

	Female	Male	Overall	
Design	31	13	44	73.3%
Choose	4	10	14	23.3%
Indifferent	0	2	2	3.33%
	35	25	60	

Our main objective was to test the feasibility of the cost-benefit model in HCI. In 47 cases, which are 78.3%, the graphs behaved as expected; in other words, the location of the majority of participations on the weight axis was somewhere in the range where the maximum values on the vertical axis belonged to the application that they preferred. This strongly supports our idea that the cost-benefit model can effectively predict which application would be preferred by a user, according to his characteristics, needs and current motives.

Though our initial results show that the cost-benefit model can be successfully adjusted to the area of HCI and applied to explain and predict user preferences of applications or choices between different versions of an application, a limitation of the current study is that the cost and benefit perceptions are based on non-interactive evaluations. While the backpack study involved simply presenting the applications to the participants using mockup prototypes, we plan to continue to empirically test the applicability of the cost-benefit model in the field of HCI in future studies that are designed to involve working prototypes and therefore will have users evaluating the systems after conducting certain tasks using them. These studies will test the model's applicability more precisely, since interactive user judgments of a system are based on more tangible and realistic experiences.

5 Conclusion

Understanding how users choose among systems is important theoretically and practically. In our series of experiments, the theoretical objective is to test whether the 'macro-level' cost-benefit approach for selecting alternative systems for organizations can be applied to the 'micro-level' of predicting individual users' acceptance of alternative applications. Modeling the cost-benefit considerations underlying user preferences can set a bridge between IS system acceptance models to HCI system acceptance models. Specifically, we intended to show that the relation between cost-benefit considerations and the user's traits and state, reflected in personas, can be presented graphically. Practically, the model can improve the prediction of user preferences with respect to certain personal characteristics and motives, which emphasize the relative importance given by the user to the cognitive costs during system use versus the perceived benefits of using it.

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6 References

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