

The influence of 3D modeling and rapid prototyping techniques on customized objects in industrial design.

This research verifies whether 3D modeling and rapid prototyping techniques could reintegrate customization into the design process.

The purpose of this work is to develop customized objects that more adequately satisfy users' needs and tastes. Customization is herein considered according to two definitions:

1. When the designer can adapt or propose many possible solutions to satisfy different expectations and needs of individuals.
2. When the consumer configures the object's various parameters, adjusting, adding or removing some components, manually creating the product.

Results of the study seem to demonstrate that customization could be reintegrated into the design process. Participants also showed interest in redoing this experiment with other objects. This study used a new approach for customizing objects by integrating computer tools in the design process.

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INTRODUCTION

This study questions the design of everyday objects in our society. The production and manufacturing of objects is evolving rapidly, leading to the premature discarding of many objects. This phenomenon is commonly explained by the constant renewal of the design of objects on the market. This study will try to demonstrate the following hypothesis: *3D modeling and rapid prototyping techniques allow the reintegration of customization in the design process, the same way that the craft industry used to work before the introduction of mass production.*

An attempt was also made to establish if this method of reintegration of customization into the design process influenced the attachment an individual feels for the objects he or she uses.

To understand every aspect of the study, all of the important elements will be explained briefly. The nature of the objects under study will be described and their choice justified. The research methodology will then be explained in detail in order to understand how the study was progressed. Finally, the procedure and the observations of the study will be explained in detail, concluding with a quick review of the important notions and the findings of the study.

2. TERMINOLOGY:

This section explains four important elements in this study.

2.1 Customization

Customizing objects means to give them personal character. Clients are directly integrated into the design process and possess a certain liberty concerning the appearance and/ or the contents of the object. Customization can be made by a variety of propositions given to them or by them [5]. Also, it can be made in sections by decomposing the object into modules. It is important to consider individual differences in the elaboration of new products [1, 7].

Researchers Anderson and Crayton support the importance of customized objects and propose some methods to achieve characterized objects. Two definitions are used for this article:

- In the first, customizing means adapting or proposing different possible solutions to satisfy differences, expectations and needs of individuals.
- In the second, customization is present when a consumer can adjust, add or remove some components, manually creating the product and giving it a singular, personal feel.

2.2 3D Modeling

Computer assisted design (CAD) helps to transform ideas into reality [15].

Nowadays, designers do not consider computer screens as drawing tables but rather as virtual windows. The use of CAD programs assist in the creation of digital three-dimensional models. All the important information is

integrated into those models. Some modifications can include addition of colour, rounding of edges, lighting, movement and integration of different types of materials. It is even possible to modify some smaller detail inside an object virtually. These techniques are used to visualize the volumes and perspectives of the project for conception and final presentations [8, 15].

2.3 Rapid Prototyping

Rapid prototyping (RP) could be described as a new technique (computer, chemistry of materials, laser, etc.) to reduce the time to produce three-dimensional models in a variety of fields [6, 11].

Complex prototypes can be made with rapid prototyping techniques in a much faster and effective way. 3D prototypes permit better communications and more interactions between associates and between associates and clients. Also, those physical models help to see, understand and analyze characteristics of the final product. It is possible to accelerate the manufacture of physical models to evaluate functionality in real conditions [19]. These criteria allow designers to focus more attention on the important aspects of the object such as ergonomics and tool manufacturing.

The company **Materialize** exploits this approach to create unique lamps [16]. This process, called *rapid manufacturing*, is slowly integrating into the commercialization cycle. Because of rapid manufacturing, there are no more shape or complexity constraints. Also, it is possible to customize objects for consumers, eliminating all tooling manufacturing and the need for companies to store large inventories which represents a large economy of time and money [25].

2.3 Attachment

This section aims to explain the possible ways of developing an attachment for a product that we purchase. This research, tries to discover whether or not customization affects the attachment of a person to a product.

By “attachment” we mean to express the engaging, lasting relation between two individuals. A feeling of security, confidence, and autonomy can be achieved when attachment is developed. It also contributes to socialization and the development of affective feelings. Attachment therefore, is the affection felt or sympathy experienced for someone or something [11, 21].

During the past 30 years, our relationship with manufactured objects has evolved. Objects are very present in our daily lives. Used as a tool for work, learning, and relaxation, they facilitate many tasks. They can also generate frustration or dissatisfaction because of operational problems. In spite of these negative feelings, if attachment between the user and the object is strong, the object might not suffer from premature rejection.

Designers need to consider some important aspects in the development of a product. Manufacturers require economic products. Stores desire attractive products because they grab the consumer’s attention. As for consumers, they have a variety of expectations. In store, their choices are made on the basis of looks and price. At home, they require easy and precise operation [19]. Objects’ appearances have an important role in the comprehension of their functions. The options offered need to be identified clearly and be easy to use [20]. By combining shape, texture, colour, and good functionality, the appreciation of a product is optimized [12]. Also, emotions play a part in the relationship between a product and its user. After using a product, consumers

evaluate and develop attachment which is based on confidence [22].

There are three important aspects to consider for a product to be chosen by a consumer: price, efficiency, and satisfaction [18]. If we feel a sense of well-being as a result of possessing an object, we will enjoy using it and will develop more attachment for it.

We experience emotions when using objects. The sum of emotions we feel in respect to an object can alter our perception of its usefulness. Appearance, shape, colour, texture and functionality all enter into the mix. So attachment differs from one person to another.

3. DATA AND METHODS:

This study was achieved using the protocol analysis method proposed by Gero [10].

Protocol analysis helps form a better understanding of human behavior. The results are providing stronger foundation on which to base the development of theories, models and designing. [10] It is based on the verbal expression of opinions by the participants. In this study, all the conversations and exchanges were taped. Interviews took place at regular intervals; efforts were made to be able to access participants’ feelings, question their reasoning and to gain insight into their activities [9].

3.1 Selection criteria

Three objects were selected to complete this study: a pen, a plastic spoon and a bookmark. These chosen object had to meet the following criteria:

- **Low cost manufacturing:** The study could not proceed if the production of the object demanded too large an investment.

- **Possible alterations to the product:** Alterations should not change the basic identity of the object. Here, good versus bad design is not a selection criterion, as long as the product functioned properly.

- **Short life cycle:** Time was limited to conduct the study so objects were selected with short life cycles in order to adequately observe attachment.

3.2 Participants

Chosen participants were not to have any relation to the design field. Also, participants who hardly used a particular object would not be assigned to that product.

The group was composed of nine participants.

3.3 Procedure

The study was divided into three sections (A, B, C) based on the different definitions of customization. Participants were distributed by object and by section. Three sessions were necessary to investigate all important elements of the research. To ensure uniformity in materials and finishing, all objects were made with RP techniques.

3.3.1 Section A

This section is based on the first definition of customization. Each object was divided into modules. The participants were then asked to choose between five different propositions for each module. They assemble a complete object from the selected modules, as described by Anderson and Crayton [1, 7]. This way, users exercise a certain control over their choice of products [4].

The pen was composed of two modules: the tube containing the ink and the cap holding the tip in place.



Figure 3: Image explaining the pen's modules

For the bookmark, the modules are a clip and a plate.

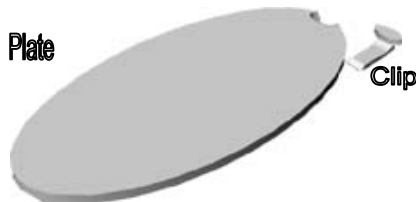


Figure 4: Image explaining the bookmark's modules

The modules of the plastic spoon are the handle and the egg-shaped end used to scoop food.



Figure 5: Image explaining the plastic spoon modules

In addition to choosing the modules, participants have an option among five ornaments in the design of their objects. Those ornaments can be engraved or raised.

The company **Swatch** adopts a similar approach in its marketing. A few years ago they produced a modular Swatch watch. Users were buying a box containing the watch mechanism along with an assortment of bracelets and covers.

Another firm, called **AVC** offers a wide variety of modular stairs, furniture, and partitions. Users can select within a wide range of materials and lighting. This approach is very similar to the one proposed in section A [3].

3.3.2 Section B

This section is based on the second definition of customization. Whereby each participants interacts directly with the design process and can affect the appearance and the contents of the product.

To define their customization, participants adopt a similar approach to the one given in section A. However, all modifications are made on demand with a 3D modeler program. Users visualize the results of their customization and provide more changes if necessary. Thanks to the computer visualization, they immediately see the impact of their choices.

This approach captures the essence of the direct relationship between the craftsman and his clients: the artisan helps in the decision-making process while respecting the taste and the needs of the customer [13].

The company **Saturne** put in place a project call "**Les Saturniens**". The project proposed a partnership between different companies to produce modular vehicles. Clients would select their car components by choosing within a wide range of options. All the information about the final

component selections would be transmitted electronically to the companies concerned. Unfortunately the project was unsuccessful for reasons of cost as well as failing to obtain ascent from the labor unions concerned [17].

Another company, **Acces-sit**, specializes in custom lounge seating. Potential customers can first visualize 3D virtual models of their seats and make modifications before manufacturing. This company has been operating for the past 20 years' unique seating for their clients [2].

3.2.3 Bloc C

In this section, participants cannot modify their objects. Their choice is made from 10 pre-defined models. The procedure is a simulation of purchasing in a store.

3.4 MEETING SESSIONS

Three meeting sessions are needed for all the sections, except section C which is limited to two sessions.

3.4.1 Session 1:

This session's aim is to permit the participants to customize their object. Each section (A, B, C) has its own procedure.

3.4.1 Session 2:

The second meeting takes place one week after the first one. The participants are given the manufactured item they chose or helped design a week earlier. Coming in contact and interacting with the object, observing the participants' reactions is crucial for the purposes of this study.

3.4.2 Session 3:

The last session takes place one week after the second one. Having used their objects, participants share their comments and respond to a short questionnaire. The questionnaire's purpose is to detect indications of attachment between the participant and his or her object.

4. RESULTS:

This section explains the results for each method.

4.1 Section A

The method proposed to participants in this section, seems to have worked flawlessly. No surprises were observed when the participants received their object. Even with limited choices, they made selections corresponding to their tastes and preferences.

After using the customized object, participants found them better adapted to them than a similar non-customized object. This would explain why participants always left their object close to them so they could use it as much as possible.

Participants also expressed an interest in redoing the experiment with other objects. They wanted to keep their object, suggesting that a degree of attachment seems to have taken place between participants and their object.

4.2 Section B

Participants in this section enjoyed a large degree of freedom to customize their object. This may be one reason why everyone was convinced having fully participated in the customization of their object. However, when participants received the manufactured result of their customization (session 2), two of them seemed surprised by the results. The screen visualization did not seem to precisely transmit all the needed information. Even though the customized objects did not perfectly match the expectations of all participants, they

still kept their object close by so they could use it whenever possible.

In two cases out of three, participants found their object better adapted to them than a similar, non-customized object. In the remaining case, the object would have needed some modification to increase its comfort.

Also in two cases, participants say they would be willing to re-experience this approach with other objects. They believed, however, that it could not be used for every item in our lives. Two participants believed they had developed an attachment to their object. The third thought the object would need some modification to improve its comfort.

4.3 Section C

Participants in this section did not have any possibility of customization. They simply chose among an array of pre-determined designs, relying on the products' perceived comfort and aesthetics in the same way they would have done in a store.

They all wanted to redo this experiment with other objects.

Two participants did not believe they had developed any attachment to their object. Even so, they all wanted to keep their objects because they felt they were useful in daily use.

5. CONCLUSIONS

The results of this study demonstrate that customization could be re-introduced into the design process using the approaches proposed in section A and B. The techniques used in section A seemed to be successful because participants were able to manipulate the objects' components. The 3D computer visualization used in section B did not seem adequate to create mental images of the objects with sufficient information, as opposed to the way a physical model would.

The procedure used in section C, intended as a control group, raises the question: does choosing a product from a large variety of predetermined options qualify as customization? Participants' reactions and behavior seem to indicate that choosing does not mean to customize. It is important to note however, that the subjects in this group chose from among a limited number of alternatives (10). With a larger pool from which to choose, the conclusions could possibly be different.

All participants were interested in redoing the experiment with other objects, even those in section C who were not involved in any degree of customization. This shows that everyone desires better adapted products, responding to their needs and wishes. Also, they were aware that customization is now possible thanks to rapid prototyping techniques. Products can be developed and manufactured directly by those machines. RP can be used to make physical models well as produce finished products.

As for attachment, no precise conclusions can be given. Most of the participants, wanted to keep their object because it was customized to their desires. The same object could not necessarily satisfy someone else because of individual differences. In general, participants thought they would keep their object for a longer period time than other similar objects they own. They do not, however, seem to have developed an attachment to their object. Maybe the nature of the object would have been important in fostering the development of attachment. This might explain the results for the bookmark. Participants, in general, did not attribute great importance to this kind of object. Its simplicity and low price may be responsible for this kind of attitude.

The results obtained from this study demonstrate that Rapid Prototyping influences the design process. It is possible to use Rapid Prototyping to obtain a physical model and, later, a final product, implicating directly the users of the product. With this approach, consumers could obtain unique and customized products in much the same way craftsmen used to customize products for their clients. This is all made possible by new and exciting techniques and technologies.

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