

Method of Perception of Materials by Users (PERMATUS) for Development of Sacred Images in Aparecida, Sao Paulo, Brazil

Talita Kathleen Correia de Sousa¹, Bianca Siqueira Martins Domingues², José
Wilson de Jesus Silva², Adilson da Silva Melo³, Jorge Luiz Rosa⁴, Rosinei
Batista Ribeiro^{2,5}

¹Department of Materials and Technology, Sao Paulo State University, Brazil
talitakathleen@gmail.com

²Department of Design, University Center Teresa D'Ávila, Brazil
biancasiqueira.m@gmail.com, jwjsilva@gmail.com, rosinei.ribeiro@pq.cnpq.br

³Institute of Production and Management Engineering, Federal University of Itajuba, Brazil
prof.adilsonmello@gmail.com

⁴Department of Materials Engineering, University of Sao Paulo, Brazil
jlrosa@demar.eel.usp.br

⁵Department of Production, Sao Paulo State Technology Faculty, Brazil
rosinei.ribeiro@pq.cnpq.br

Abstract—This article aims to apply a method of evaluating products in relation to the perception of their materials by users, based on studies performed with sacred images. The religious culture is one of the main characteristics of the city of Aparecida, located in the Paraíba Valley, in the state of São Paulo, Brazil, attracting tourists from various regions of Brazil, moving and expanding the source of income of the residents. The study is based on the user's method of perception of materials - PERMATUS that aims to assist designers in the selection of materials considering the subjective attributes as a way of incorporating identity in product development, valuing the artifact. Users' perception tests were performed with seven types of images in different materials, such as: metallic, polymeric, ceramic and composite with different diatomaceous earth loads in gypsum. The research was conducted at the tourist support center in the city of Aparecida. The results show that the materials influence and affect the sensations by the diversity in the individuals expression in front of the products, finishing, textures with significant impact in the choices and decision making.

Keywords— *Material Selection, Product Design, Texture, Sacred Images, PERMATUS Method.*

I. INTRODUCTION

The materials were of great importance for the development of human history in which for thousands of years man used basic materials such as wood, stone, bone,

horn and skin that were essential for his survival and progress.

"We live in a world of materials. It is the materials that give substance to everything we see and touch." The choice of materials it is an important step for the whole project, since they have a direct connection and influence the shape of objects, as can be seen from historical architectural monuments to simple products developed for our daily life. [1] "Material is the interface between artifacts and man"[3], the designer transforms his ideas, sketches, his designs into tangible objects through materials. In the development of a product the choice of materials is of great importance, because it is necessary to know the main characteristics in the material so that it meets the concepts present in the product.

Despite all the planning adopted for the development of a product (technical aspects, aesthetic attributes, among others) there is still an unexplored step, the relationship and interaction between the user and the product in question.

This article aims to apply the study of the method of evaluation of products in relation to the perception of their materials by users. According to the method Perception of Materials by Users (PERMATUS) was based on several methods, tools and techniques known and applied by professionals and researchers, both in projects for industry and in academic research. The Method aims to assist designers in the selection of materials, considering the subjective attributes of users as

an essential part to develop a project, valuing and making the final product significant. The PERMATUS has two phases with six steps and stresses the importance of applying several types of tests to obtain the users sensorial and emotional information and convert them into objective information. [4]

The study of the perception of materials is a component of a research that has been developed since 2013 as project through Conselho Nacional de Pesquisa e Desenvolvimento Tecnológico – MCTI-CNPq. The project has interdisciplinary characteristics in the areas of design, materials engineering and social technologies with technological extension of the academic master degree in Development, Technologies and Society at the Federal University of Itajubá (UNIFEI). The research aims to develop a new material using the residue before filtration of beer, Diatomaceous Earth, aiming at improving the quality of the material and the sustainability of the product. This residue is added in small percentages (5%, 10% and 15%) and mixed with gypsum – the main material used in the manufacture of this product – for application in sacred images. One of the prototypes of sacred image with gypsum and diatomaceous earth (with 5% of DE) was one of the objects used in the test on the PERMATUS method with the users in the city of Aparecida.

The religious catholic culture is one of the main characteristics of Brazil, mainly in the city of Aparecida, state of São Paulo. At the study site, the city's economy is made up of the service sector, with several sacred image factories. The micro-enterprise partner to develop this project is administered only by the own relatives and the manufacture of these objects is realized in an empirical way, without having any methodology for production, and also are not found methods that effectively evaluate the application of the materials in sacred images and that allow to know their influences in the choice or rejection of the product by the user, at the time of purchase or use. This type of information can contribute to a better understanding of the relationship between product, material and the emotional of the user in relation to the products.

"the subjective evaluations resulting from the research can be reversed in objective information" such as the definition of the characteristics of the product, the technical specification of the materials, definition of textures and finishes, among others. [4]

II. DESIGN AND SELECTION MATERIALS

The materials are the basis for all technological advances. [2]. The most important aspect of materials is to be facilitative, to make project ideas workable. Materials such as stone, iron and bronze played

an important role in the history of civilization and were essential for its development.

We live in a world of materials. They are the materials that give substance to everything we see and touch. Our species - Homo sapiens - is different from others, perhaps more significantly by the ability to project - produce "things" from materials - and by the ability to see more of an object than just its appearance. Objects can have meaning, awaken associations, or be signs of more abstract ideas. Projected objects, both symbolic and utilitarian, precede any recorded language - and give us the earliest evidence of a cultural society and symbolic reasoning. [1] The industrial revolution caused an accelerated multiplication of materials and forms of production, and was responsible for profound economic, social and cultural transformations. [4]

In material selection, the interactive material contact, each sense organ is able to provide different sensations. The tactile modality is an important system in the user-product interaction as a function of factors such as comfort, satisfaction and preferences, the properties of each material induce a unique and particular perception for each user. Therefore, strategic use of materials is one of the most influential means that designers can use to communicate and create emotional connections between products and their users. [4]

III. METHODOLOGY

3.1 Place of Study



Fig.1: Location of the city of Aparecida, State of São Paulo, Brazil

The economy of some cities stands out for the provision of services. In view of this, the project in question was developed based on the religious economic highlight of the municipality of Aparecida, located in the Vale do Paraíba, state of São Paulo, due to religious and historical tourist, which gathers more than 12 million tourists per year and in 2017 broke the record, receiving 13 million tourists. [18]

With the demand of religious tourism it is necessary to hire new employees in seasons. According to Jornal

Globo (2013), with the visit of Pope Francisco the city hired 1,500 temporary jobs for the production of sacred image of “Nossa Senhora de Aparecida”, being an influential factor in the city's turning of capital.

The study of the perception of materials by the users was carried out at the Tourist Support Center, one of the main centers of religious commerce in Aparecida, since it maintains an intense flow of people since it is located next to the new Basilica of “Nossa Senhora de Aparecida”.

3.2 PERMATUS Method

The User Perception of Materials method (PERMATUS) aims to study how users perceive meanings of the materials present in the products of their daily life [3]. The method is composed of six steps as illustrated in figure 2.

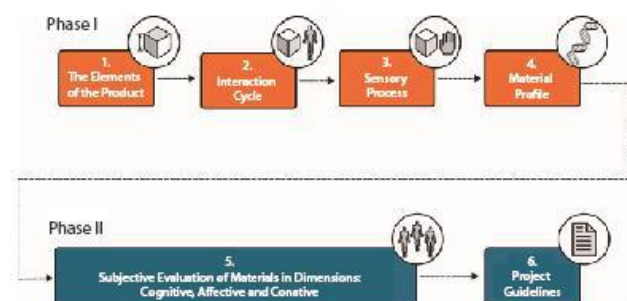


Fig. 2: Summary architecture of the method of perception of materials by users (PERMATUS)

The method is composed of six stages subdivided into two phases. Phase I consists of 4 steps, deals with questions related to the product to be studied (1) the elements of the product, (2) the possible interactions between the user product, (3) the sensory modalities involved in the stimulus (4) the profile of the materials that will be selected [4]. This phase can be considered as the structuring of the fundamental information for the consecutive stages of the evaluation and specification. In this way, it is important that it be carried out in the initial phase of material selection.

Performing steps 1 through 4 is the responsibility of the project team.

The first stage “Product Elements”, allows to know the product in detail, defining its elements, its main characteristics and most relevant aesthetic and ergonomic functions. This step it is like a dissection of the product into user-understandable components.

The second stage, “Cycle of Interactions”, analyzes the relationship between product and user, the particular product establishes cycles of interactions with its users, from the first contact, which begins before the purchase and extends through the stages of discovery, transportation, unpacking, use, storage and disposal of the

product.

The third stage “Sensory Process”, has as its tool the five sensations often applied, in this step all the sensations that occur throughout the cycle of interactions between user and product are analyzed.

The fourth stage of the “Material Profile” divides the material into three groups: Family, Class and Member, based on the nature of the atoms of the material and the connection between them, their variations and also in the details of composition. The product is attributed aspects related to aesthetics, practice and symbology. The aesthetic attributes establish direct relationships with the aesthetics of the product, perceived through the senses, the use, handling and experience of the user in relation to the product, configure the factors that establish the practical attributes, and social aspects that are directly related to the status provided by it, is attributed to the symbolic attributes of the material.



Fig. 3: Material Profile based in PERMATUS Method

Phase II consists of two stages, Subjective Evaluation and Objective Specification.

The fifth stage “Subjective Evaluation” is formed by the evaluation of users in the cognitive, affective and conative areas. In the cognitive sphere the users evaluate the product in practical circumstances of use, in the affective the users evaluate the emotions and pleasures motivated by the product, which defines the preferences of the users, composes the conative sphere, it is evaluated how much the other attributes influence in the definitions and choice of the product.

Finally, the sixth step, “Objective Specification”, defines the guidelines to be followed by the project, analyzing all the factors gathered through the previous five steps, it depends on the professional to transform the assessments of subjective character in objective evaluations, at the end of this evaluation are established the profiles of the materials that will be used throughout the development of the product.

3.3 Test with users

The model of perception of the materials by the users (PERMATUS) was applied in a practical circumstance. The test was applied with voluntary participants, using the six steps and had as objective a comparative evaluation of sacred images. The main function of the object chosen for study - sacred image - is of a religious symbolic character.

Table 1 -Test Characteristics

TESTS	FEATURE	POPULATION	TEST LOCATION
1	Apply the Permatius tool to evaluate 7 sacred images of different materials and finishes, based on the users' interaction with the products.	Individual tests with both sexes without any prerequisite required for participation in the test. It was realized with 10 users	Tourist support center in Aparecida, São Paulo, Brazil.

Seven sacred images of four families in different materials were chosen. Figure 4 illustrates which image models were stipulated for application of the test acquisition.



Fig.4: Sacred images in several materials

(1) Biscuit (cold porcelain); (2) Low carbon steel; (3) Polymer; (4) Polymer PLA (polylactic acid) produced by 3D printing; (5) Resin; (6) Gypsum; (7) Gypsum with addition of 5% of Diatomaceous Earth.

For the accomplishment of the tests two people were required for the application. The functions were divided into: the researcher instructed, interviewed and recorded important data during the test, and the assistant researcher was responsible for video recording the entire interview process and also supported the organization of the environment in which the tests were to be conducted.

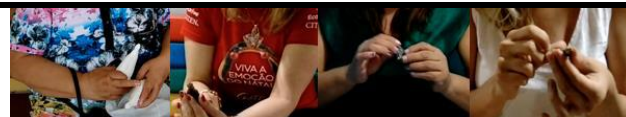


Fig. 5: Users interacting with the objectives

The sampling procedure adopted was accidental non-probabilistic, obtaining a total of 10 individuals, being 2 males and 8 females. The visual evaluation was first carried out only by means of photos of the seven models of sacred images constructed in four families of materials as already mentioned. The interviewee should choose the favorite sacred image and the one he would not choose considering only the visual aspect of the material. After the choices, without being informed about which material possessed each image, users could have contact with the seven objects already presented in photos and should say what material is employed in it. Upon completion, users should indicate which sacred image they would choose and would not choose after knowing what material was used in each object. The profile of the interviewed users was quite broad since there was no prerequisite for participation in the research.

IV. RESULTS AND DISCUSSION

4.1 Application of the PERMATUS Method

First the product was explored with respect to the elements that compose it, its relevant characteristics, main and secondary functions. Being an object of religious character the main function is symbolic, since for many people the image of "Nossa Senhora de Aparecida", symbolizes the own guarding by their homes. Each element of the image, besides having its aesthetic and functional function for the product, also has a symbology. The size of the image varies and also the materials that can include polymers, woods, plaster, resins, among others. Dimensions and materials are important factors as the manufacturing process influences the price of these images.

4.1.1 Phase 1 - Cycle of interactions

First contact: usually occurs in trades where the consumer can see images in various sizes and materials. These images are usually sold at local fairs, stores in some cases can be purchased online. At the physical points of sale, the sacred images do not have any packaging, they are displayed packed in transparent or unshielded with polyvinyl chloride (PVC) film wrappers.

Transport: These images are usually not heavy, for transportation the sacred image is wrapped in newspaper and a bag is provided, some may still be wrapped in PVC film.

Unpacking: consists of removing the sacred image from the bag, removing the newspaper and removing the case if you have one. This type of product does not accompany recommendations manual.

Use and rest: consists of accommodating the image in some room of the house or other environment and perform the cleaning periodically.

Disposal: This product does not have an exact life expectancy, however, its mechanical resistance is low, making it susceptible to fails. At the time of disposal, people generally do not know how to discard it, so much of it ends up playing in rivers, burying or putting in places known as "cruises", few people put in garbage cans because of the symbolic value.

4.1.2 Phase 2 - Sensory Process

Visual sensations: Refers to the quality of the visual elements of the image, the finishing, painting and so on.

Haptic sensations: Feel the weight of the image, the texture of its visual elements and the quality of the material used by its texture.

Olfactory sensations: The materials used may have aroma, but it is almost imperceptible.

Thermal Sensations: Feel the temperature of the material used as the gypsum for example.

Functional sensations: The product should be handled with care since the material is fragile and sensitive to falling, so it should be accommodated in one place and rarely removed.

4.1.3 Phase I – Material Profile

As already mentioned, seven types of sacred images were used, totaling four types of family of materials (Ceramic, metallic, polymers and composites) throughout the study, however to demonstrate the applicability of the method, we will continue using the example of the sacred image produced in gypsum.

4.1.4 Phase II - Subjective Evaluation of Material

Cognitive: presents the image as context of use based on the materials that compose it and how the user reacts to this interaction.

Affective: directly linked to the emotional relationship of the user with the image. Especially in the religious sphere.

Conative: the way in which a certain image differs from other influences directly in the choice of the user, although dominated by a religious feeling, portrays a purely aesthetic element in order to elevate to a certain spiritual plane.

4.1.5 Phase II - Project Guidelines

After the application of all phases and stages of the

method by the researchers, a questionnaire was designed for the volunteers of the research, to obtain sociotechnical information of the same for the test of application of the PERMATUS method in sacred images executed in the city of Aparecida, State of São Paulo, Brazil.

4.1.6 User Profile

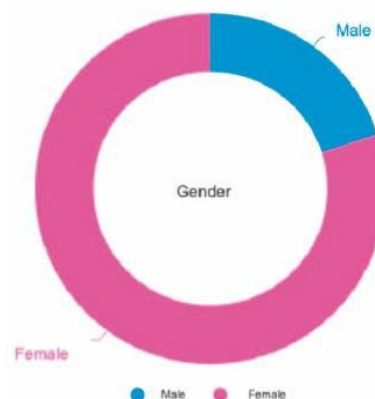


Fig.6: Gender of the research participants

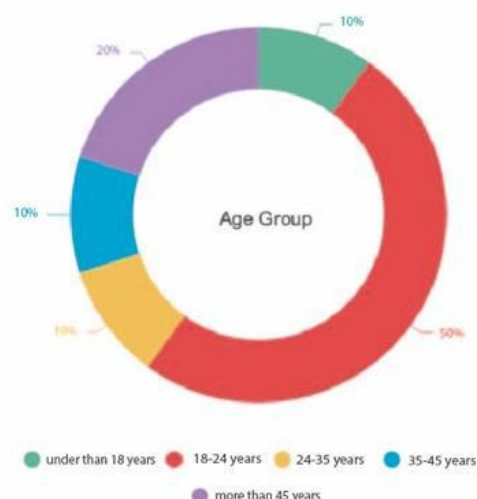


Fig.7: Percentage of age participants

Of the total number of participating users, 20% were men and 80% were women, predominating the female gender. The age range of the participants varies from under 18 years to over 45 years of age as shown in figure 6. Users aged 18 to 24 represent 50% of the total research, followed by over 45 years (20%), 24 to 35 years (10%), 35 to 45 years (10%) and under than 18 years (10%). In addition, information on the marital status of the users was collected. Being composed as follows: 70% of them are single, 30% married, 0% Widowed, divorced or with stable union.

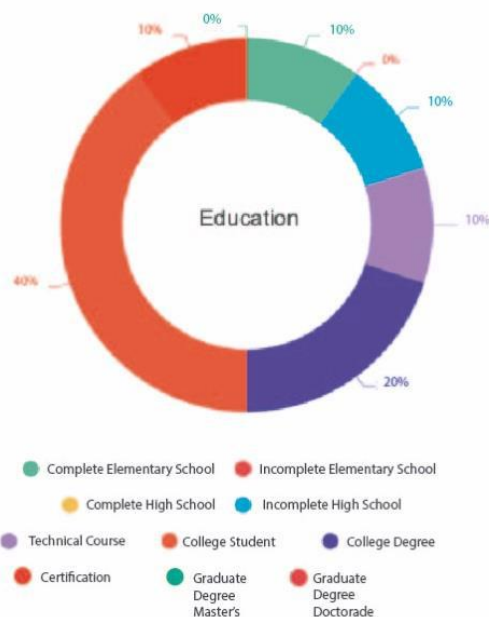


Fig.8: Academic Profile of the users

The academic profile of the users is quite varied and represents in its totality college students (40%), followed by graduates (20%), Certification (10%), Technical Course (10%) and complete elementary school (10%).

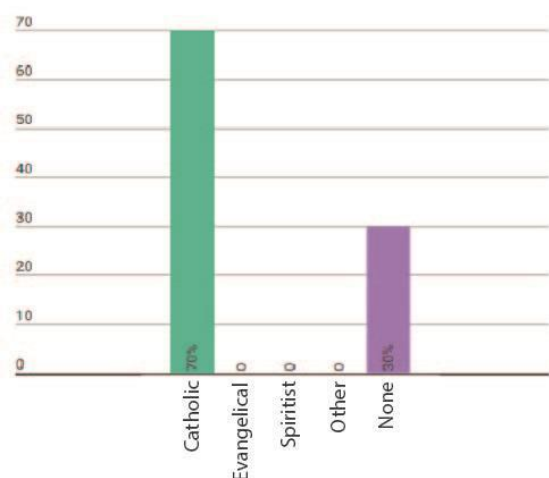


Fig.9: Religions of the users

The religion of the users was considered an essential factor to consolidate the profile of the consumer of sacred images. The Catholic religion predominates (70%), followed by users who have no religion (30%). The predominance of Catholicism in the sampling is due to the research place, Aparecida is the city characterized as the largest religious pilgrimage center in Latin America, receiving annually more than 13 million visitors, which make the city one of the main tourist centers of Brazil.

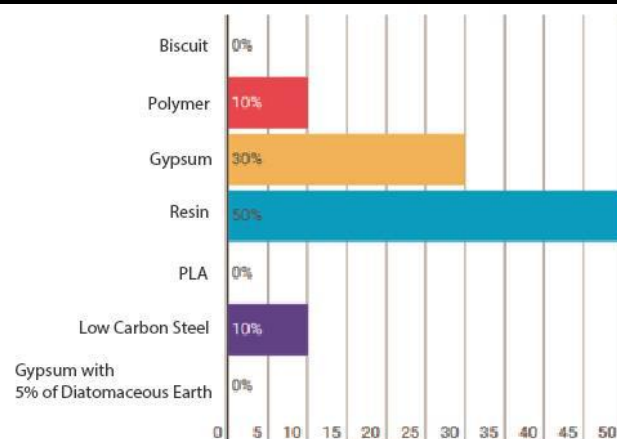


Fig.10: Percentage of choice of sacred images through photo viewing

The preferred religious image among the interviewees was mostly Resin (50%), followed by gypsum (30%), polymer (10%) and low carbon steel (10%).

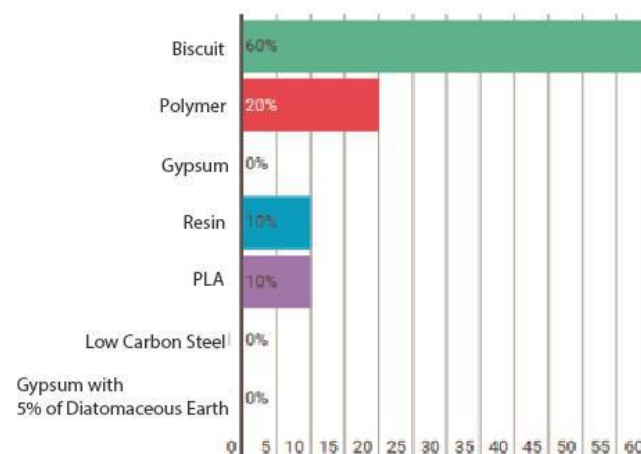


Fig.11: Which sacred image would not buy by choosing by viewing photos

The sacred image that they would not choose to acquire was mostly biscuit (60%), Plastic (20%), Resin (10%) and PLA (Polylactic Acid) - 3D printing (10%).

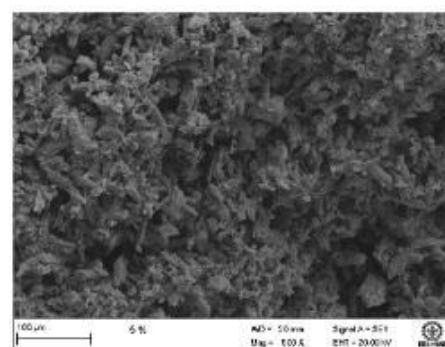


Fig.12: Scanning electron microscopy (SEM), gypsum with 5% of Diatomaceous Earth

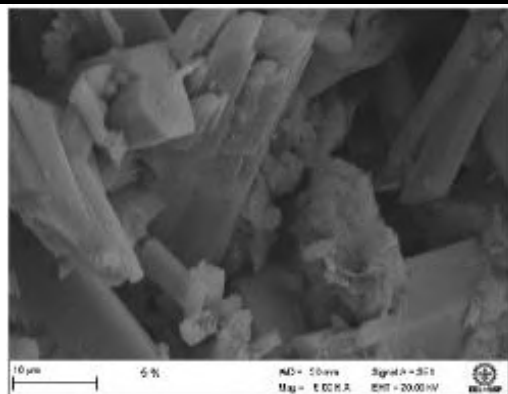


Fig.13: Scanning electron microscopy (SEM), gypsum with 5% of Diatomaceous Earth, possible formation of fungi

It was observed that the finishing of surface of the product is of extreme importance for the choice. In the user test the prototype of the material in development, gypsum with 5% of Diatomaceous Earth, was used, as the object had no surface finish and was not chosen by any user. It was observed that the research volunteers looked at familiarity with the sacred image of gypsum, but surface pores due to the material were a relevant factor for non-choice of the product.

The scanning electron microscopy session was performed at the Lorena Engineering School at University of São Paulo, using a Leo type VP1450 microscope. It was observed that the morphology of the material visually represents the formation of crystals coming from calcium in the shape of needles in disordered senses, samples loaded with diatomaceous earth at the concentration of 5% promote a change in the one-dimensional morphology of the crystals in the angular shape and the possible formation of fungi according to Figure 13. Because the ceramic material is very porous, gypsum with a 5% addition of diatomaceous earth has this surface feature, more pores forming on the surface than the material only pure gypsum.



Fig.14: How users identified the material of each object

The Word Cloud of Figure 14 demonstrates what the main words cited by users after interaction with products are. The research volunteers mainly cited the senses as a basis for identifying the materials. The main word cited was Tact (10 times), followed by Vision (9 times), Hearing (6 times) and Smelling (3 times).

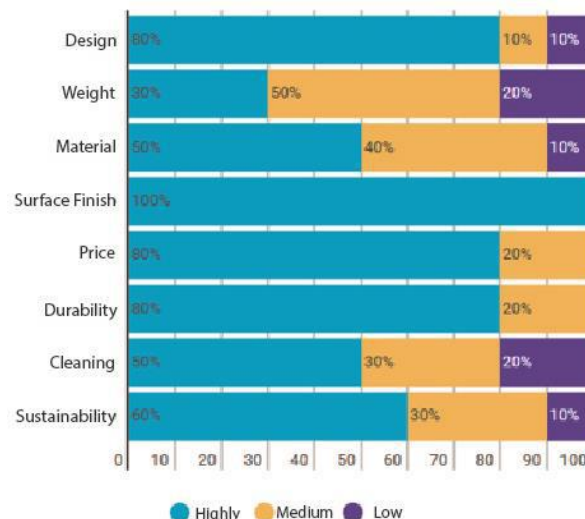


Fig.15: Importance of attributes

It was suggested [4] that the number of attributes should be reduced to make the test practical, because a smaller number of variables can lead to a more consistent and in-depth analysis of the data, focusing on the main problems to be evaluated. Thus, 8 attributes were determined in which the user would evaluate in a very, medium and not important way. The attributes that were considered very important in sacred images are: finishing (100% quoted as very important) price (80% very important), durability (80% very important) and design (80% very important).

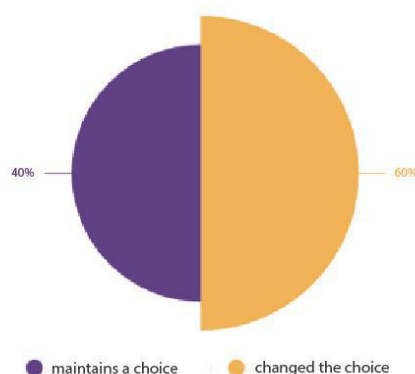


Fig.16: Choice after the interaction with the object

Figure 16 shows that most of the respondents (60%) changed the choice of which product to buy after interacting with the product. One of the factors that influenced the exchange of the chosen product was the discovery of which material was applied to the object,

several participants were surprised by the sacred image produced in PLA in the 3D printer, demonstrating that the user cares and prestige innovation in materials even in symbolic objects such as sacred images.

V. CONCLUSION

The PERMATUS tool has proven to be efficient and inexpensive, and can be applied in many areas from design to production engineering. The study of the perception of materials by the user was extremely important for the evaluation of the user's first interaction with the product in development (Gypsum and Diatomaceous Earth). Positive results were presented on the prototype, users did not realize that there was a difference between the object made of gypsum and the composite under study. Moreover, due to the application of the method it was possible to have a base of the profile of the tourists of the city of Aparecida, improving the research. The results of the experimental study demonstrated that the material is extremely important and influences the user's choice in the product acquisition.

The model presented an important medium for knowledge about materials, products and users. The study provided knowledge about the perception of users in several aspects, related to interaction, emotional reaction, identification through the senses, preferences, among others. The presented results proved that the subjective information and measures obtained from the users have the potential to be reverted in objective specifications.

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