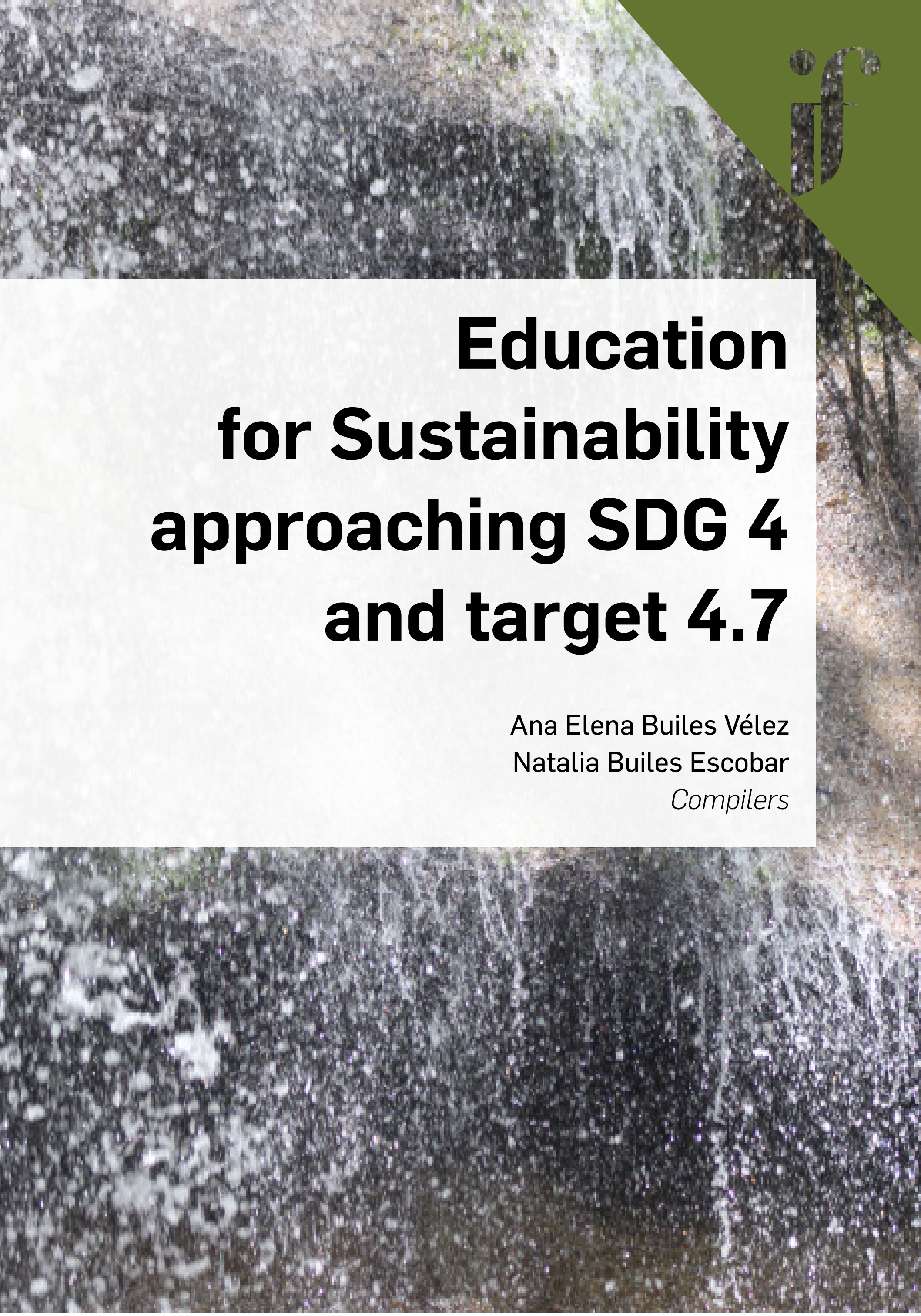

Education for Sustainability approaching SDG 4 and target 4.7

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Products Validation in the Design Project and Scopes in an Online Educational Environment[1]

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Abstract

This article gathers the results of a research on the project's pedagogy, which, starting from the analysis of the contemporary theories about it, presents their common horizons to contrast them with results got in previous research. Therefore, through a critical approach it was proposed to explain terms used to refer to the design project and validate modifications to a project method proposed in the education of designers. That was necessary to adapt it to the online workshops produced by COVID-19 confinement in 2020. Those modifications focused on its

1 Research Project: Lineamientos para una pedagogía del y para el proyecto en contextos de enseñanza las disciplinas proyectuales. Rdo: 583C-05/20-35

most critical activity, in-process product validation, which is essential to evaluate products' environmental and social sustainability and the training in responsible design practice.

Keywords: Design, pedagogy, project, validation, online connection.

Introduction

This paper shows the results of the research study Lineamentos para una pedagogía del y para el proyecto en contextos de enseñanza las disciplinas proyectuales. It was developed by areas in Proyecto e Innovación and Crítica y Proyecto (Project and Innovation, in Criticism and Project) of the Estudios en Diseño (Studies in Design) (GED, for its acronym in Spanish) and Estudios en Arquitectura, Urbanismo y Paisaje (Studies in Architecture, Urbanism and Landscape) (GAUP, for its acronym in Spanish), groups of the Pontificia Bolivarian University (UPB). The phenomenon, the projectual activity, tooked place in workshops of the professional cycle of the Industrial Design (IDES) undergraduate program at UPB. The aim was to validate the modifications to a method[2] linked to the training processes of designers. This method includes six moments of project actions that develop around two parallel axes: projectual axis and research axis[3] (Mesa-Betancur y Correa-Ortiz, 2018. p.502). These actions gather activities and tasks to be carried out throughout the project, unfolding design and research methods and resources to provide project decision for every stage[4].

2 Methodology is defined as a strategy for the array of methods.

3 The initial inquiry as part of the research for the project (Mesa-Betancur y Correa-Ortiz, 2018. p.501) is the most common. However, during the process, there are activities that relate the research to different project moments (Mesa-Betancur, 2019. p.2), including the expected performance validation of the products.

4 At Portsmouth, United Kingdom, in a conference on design methods in 1967, Geoffrey Broadbent (Broadbent et al., 1971. p. 22) stated that some attendants, especially Markus, viewed the design process as a course of events leading from the project idea to its

In 2020 because of the pandemic and the confinement, it was needed to virtualize the project workshops. Thus, IDES School launched the academic project Virtualización experimental (Experimental Virtualization), which included ongoing research. The assignment was to explore the validation of the design project products in an online educational environment and apply them to one of the program's subjects[5]. It was an opportunity to contribute to the research whose objectives aim to describe the project pedagogy guidelines that include the project praxis and study based on a theoretical analysis of the project. To expose the shared perspectives, compare them with previous research results. And to validate the suggested project method (Mesa-Betancur, 2019) and explain the terms and concepts used for the design project description using a critical approach. As preliminary results, we present the methodological, theoretical, and conceptual frameworks used, the disambiguation of terms, the methodological validation, and the findings regarding their extent in an online educational environment for the designers.

Methodological framework

During the research a documentary review was carried out to identify sources. Then, the selected sources were classified, followed by a categorization for their analysis and a critical verification. The Educational Action-Research by John Elliot (2009) was used to validate the method

realization. It is performed either information, analysis, or summary «intervals» as a part of a "Decision Sequence" that links the "Operation research" to the project.

5 In the UPB IDES undergraduate curriculum, the main subjects are educational spaces where collaborative team projects are developed, located in different environments of professional practice in order to contextualize the skills of the designers in formation. Four components are synergistically structured around the project design: theoretical, thematic framework; observatory, research for the project; feasibility, project, and its products management; experimental workshop, design and formalization. This structure allows methodological development by articulating research, design, and management scenarios (Mesa-Betancur y Correa-Ortiz, 2018. p.502).

modifications in order to analyze the students' design process. In the follow-up the students used the adjusted project method in their design process. One researcher served as an experimental workshop teacher and the other as a feasibility teacher. The first one kept a field diary to report the course events, considering the strategies used, the development of the practice, and the actions and effects of the involved actors. The second monitored the adjusted validation processes. The students used the Estrategia de explicitación (explicit strategy) (Mesa-Betancur and Mejía-Quijano, 2011. p. 178-179) to record the mismatches perceived in their process. Finally the information gathered in the classroom was collected, classified, and systematized, and semi-structured interviews were conducted with the students who were part of the experience. The comparison of this information allowed us to draw the conclusions mentioned above.

Theoretical framework

It was reviewed twelve design methodologies (Broadbent et al., 1971), eight projectual theories (De Sola-Morales et al., 1971.), two Project Theories (Piñón, 2006, Argan, 1969), five design methods (Gero y Kannengiesser, 2014; Cross, 2002; Pahl y Beitz, 1984; Jones, 1982 and Archer, 1982), one design method (Llovet, 1981) and documents on projectual research, modeling and testing (Tappan, 2012; Balderrama and Flores, 2018; Sathikh, 2019; Rodríguez-Parada, Romero and Domínguez, 2016 and Villafuerte and Sossa, 2019). Research-project links were traced and evidenced, especially the validation of products during the formalization phase, and the terms with which they referred to projectual issues.

As Peer Sathikh (2014. p.1) states, from the former work in the 60s and 70s about "Projectual Research" focused on its methods and processes a variety of terminologies were (and still are) produced to referred to these[6]. The conducted review, both in the architecture and industrial design areas, proved that the authors refer to the assessment of the finished products (built or produced) or in its design process, with terms such as evaluate, assess, validate, verify and feedback of feedforward. Although, the meaning in which they are used depends on the author.

The relation between project and research was first highlighted in Progetto e Destino by Giulio Carlo Argan (1965, pp. 21, 27, 70). It states the need to verify step-by-step the "project-process" and the succession of its intentional acts so the "project operation" is critical, rectification and address for future action (p. 56). For Argan, it is crucial to verify the intentionality of the actions and the time in which they occur. Other authors suggest this relation differently.

In 1966, in architecture, Manfredo Tafuri, Gabrielle Scimeni, Luciano Semeran and Guido Canella (De Sola Morales et al., 1971) also refer to the action of verifying. The latter has to do with evaluating aspects of a constructed building as a product of a project, among others, its validity and formal objectivity, its economic-social impact, the veracity of the data deployed in the process or its historical validity. Therefore, Anthony Ward, Raymond G. Studer, M. L. Jane Abercrombie, Geoffrey Broadbent and Amos Rapoport in 1967 (Broadbent et al., 1971) alluded to projectual actions as a feedforward, verification, or evaluation to refer to the assessment of the project products (constructed buildings) and as a reference for future processes. Rapoport clarifies that the selected method should consider the success achieved when the produced designs are assessed (p. 319). Helio Piñón (2006) does not explicitly mention these activities during the projectual process. He only states that his students are not only "devoid" of tools for creativity but also lack "judgment capacity to assess their proposals" (p. 64).

6 During the review, the studies and documents centered on the architectural project and its methodology after the 70s were limited.

In design, Gerhard Pahl and Wolfgang Beitz (1984) as well as Nigel Cross (2002. pp 14, 39, 57 y 155) point out the need to verify the technical and economic aspects of the product at the detail design phase. Cross includes in this verification (before the final version) for manufacturing tests with prototypes and evaluation of results against design criteria, the checking of requirements through weightings set by the members of the work team. Bruce Archer (1982) also talks about designing validation tests for the last phase; however, in 1967 (Broadbent et al., 1971. p. 208), he stated the need to assess and evaluate the product in process through simulations of its behavior to report project decisions. Christopher Jones[7] (Broadbent et al., 1971. p.392 and Jones, 1982. p. 130) points out that it is necessary to validate and test the product during the process and simultaneously verify the validity and truthfulness of the data used for the decision-making[8]. Recently, Silvia Villafuerte and Liliana Sosa focused the validating, assessing, and verifying actions for IDES projects.

Back in the Architecture field, despite the importance of the critical assessment over one's interpretations in specific projectual moments mentioned by Alberto Samoná (De Sola Morales et al., 1971. p. 177-178), the evaluation is performed against the experience of the built. Thomas A Markus (Broadbent et al., 1971. pp. 235, 241, 250-252, 254) is the most specific regarding predicting results during the projectual process. He points out the importance of evaluations through assessment and tests whose results are "decision factors" (p. 235); without discarding data derived from the assessment of buildings in use, he states the models produced during the process must have enough details to test them. On a radical side, Sydney A Gregory (p. 227) stresses the need to find a single evaluation method for alternatives during the process, enabling

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7 The document is a guideline for validation and verification more than a design framework.

8 This last aspects (verifying) is crucial for Jones (1982), who, compared to Cross (2002), states the importance of empirical evidence over consensual weightings. Jones' and Cross' theories came with many thoughts of the late 20th Century on the IDES project.

establishing their suitability to the function, costs and manufacturing process in terms of effectiveness and efficiency.

As another no less important aspect, Ward states that tension between subjectivity and objectivity has existed among the design methodologies concerning the role of Rapoport's "subjective assessments standards" or the subjective interpretation of the "objective" phenomena (p.16); in short, the designer decides (most authors agree). For instance, for Broadbent, the designer's judgment (p. 412) is crucial because there is no aim mean to establish the qualitative. It has been observed that this old tension could be resolved through the objectivity-objectification dialectical by including as many tools as possible. All this to achieve the objectification of a process in whose subjectivity has a prominent role. However, we agree with Markus when he points out that the "evaluation techniques" applied to the project lack development and more research and experience will be needed to make them play a strategic role during design. But we disagree when he states that at present, they are merely tactical tools "a testing device to ensure that catastrophic failures will not occur" (p.254), which is already a major outreach.

In summary, most authors agree that, since the classical project and until the twentieth century, the element of judgment on the quality of the project was the level of perfection or beauty achieved by the product. However, in contemporary times, the value of the project is determined by the rigor of the process (Mesa-Betancur, 2017. p.51, 53; 2018. p.67, 94).

Conceptual framework

To understand the adjusted method, the following terms are introduced: *design problems, dimension, requirement, product, model and prototype;*

and the terms validation and verification and simulation and simulacrum are clarified.

In the first place, a *problem*[9] or design approach is understood as establishing needs or opportunities in a contextual situation that can be addressed by design. It involves inquiring, defining, and describing a phenomenon as a tension related to an assignment or an initiative. The design problem synthesizes information that situates the project and determines actors whose "needs" contribute to clarify its intentionality and design requirements (Mesa et al, 2019. p.6). (Mesa et al., 2019. p.6).

Such requirements[10] connect the purpose of a product with its observable or measurable performance, quantitatively or qualitatively, as a mediator in a practice; they understand its relevant features and characteristics (Mesa-Betancur, 2019. p.1) and guide the decision-making during its formalization. Between the desirable and the necessary, between the workable and the achievable, and between the aspirations and requirements, they vary. They can be seen as performance requirements of every aspect of the object and classified as restrictions when they cannot be changed. When they represent goals to be achieved can be seen as aims and as variables when they may change during the process (p.7). As a formality, the requisitions must be clearly and precisely written, setting a project action that rests with a characteristic of the object, its purpose, and a validation method.

Dimension is a point of view from which an object, to which particular characteristics are recognized, exhibits a unique feature (Prieto, 1988.

9 For the design problem term, previous research results were contrasted with: Mesa-Betancur et al. 2019; Mesa-Betancur y Correa-Ortiz 2018; IDEO, 2015; Gero & Kannengiesser, 2014; Pahl y Beitz, 2013; Ullman, 2010; Cross, 2009 y 1996; Maslow y Lewis, 1987.

10 The requirement term is based on: Mesa-Betancur et al. 2019; Mesa-Betancur y Correa-Ortiz 2018; IDEO, 2015; Gero & Kannengiesser, 2014; Pahl y Beitz, 2013; Ullman, 2010; Cross, 2009 y 1996; Maslow y Lewis, 1987.

p. 30). The UPB IDES program defines five project dimensions, points of view from which an object to be designed must be considered. In first place the interpretative dimension, *aesthetic-communicative*, which includes the way how perception influences (becomes effective) over the impact of the object and assess the communicative support regarding the feature of the form. The instrumental dimension, *functional-operational,* incorporates how the function impacts the product operation and assess the formal solution that makes them possible. The material one, *techno-productive*, includes how the technique influences the production and assesses the feasibility of a proposal based on the chosen processes, available technology, and qualities and limits of the materials. The management dimension, *economic-administrative*, incorporates how the economic factor impacts the project and product management and assesses the coherence, relevance, efficiency, and effectiveness of resource management and the selection of the distribution and procurement channels for products. Last, the ideological dimension, *historical-political*, covers how the historical moment affects social action and assesses the project regarding ethical, aesthetic, and political and in a democratic and the rule of law context (pp. 30-31). In every dimension, requirements for the formalization of the products are established. The *product* is the result, not only on the physical aspect, of a work, process-operation both material as mental or intellectual. Thus, it can be tangible or intangible. In the design area, the tangible results are called “goods” and the intangible ones “experiences” or “services.”

In the design field the products are materialized for their assessment as *models* or *prototypes*. A model is an experimental scheme of a more complex real object made to ease its comprehension and study its behavior. It can be physical (typically in scale) or virtual, total, or partial, and it works as a reference for the prototype. In the industrial context, the former is the first product of a process in actual conditions that act as a “model” for manufacturing the following products that would be its copies. It’s used so its developers can test it and remark on potential flaws or shortfalls. Once tested, analyzed, and adjusted then, mass production begins. On the educational scope, what can be called "prototypical" models (related to the prototype) or 1:1 test models are built. They replicate as many design characteristics as possible, so its performance can be validated regarding its requisitions. However, not all aspects could be validated and, sometimes, just a few of them.

The term *verification* carries further elucidation and validation, related to the projectual *assessment*, *simulation* and *simulacrum* as a test scenarios.

Verification[11] is a level in which we evaluate or corroborate the veracity of the projectual process, the methodological coherence and the concrete data and evidence that support or are the reason for the decisions taken during the process. In the educational area, the verification instance and evidence of verification is the project report.

Validation[12], meanwhile, is a projectual activity where first it is confirmed that a product corresponds to a problem stated as a projectual

11 For Jones (1982, p.57), to verify is to ensure that the sources are reliable and adequate; that the data register and the tool usage has been correct; that the projections have been accurate, in short, that they are truthful and applicable. According to Yadira Corral (2009), validity refers to the degree of reliability of the information for the decision to be made (p. 230). For Studer, verification is carried out on the built products and consist of knowing that a problem has been solved in practice (Broadbent et al., 1971. p. 123), it involves verifying the resulting system, its behavior and relation to the environment. He states that the design framework has been ignored in the design* activity. Howbeit, Cross (2002.P.14) sees verify in an immediate sense to validation, namely means assessing design proposals through weighted lists where goals are compared against requisitions (p.46). Pahl and Beitz recommend verifying the technical and economic aspects during the detail design stage (p.39).

12 Gero and Kannengiesser indicate that to evaluate (next to validation) is to evaluate the design solution based on the established rules by comparing the behavior of the solution against expected behavior (p.11).
Similarly, Villafuerte and Sosa (2019) point out that according to CIPAM (2006) (by its Spanish acronym), "prospective validation" provides documented and reliable evidence that a tested product will behave within the established specifications (p.19). This should be done at different phases of the process and with different approaches, giving particular attention to sustainability. According to them, the benchmark that can be validated should provide data that confirms the validity of the proposal and reduce its risk of failure (Villafuerte y Sosa, 2019. p. 195, 197). Lucía Rodríguez, Luis Romero and

situation. And its characteristics are relevant for its use and suitable for its material and symbolic function. It matches the expected benefits of people who do a practice in certain context. Second, it ensures that the products in their materiality can withstand given working conditions with no unexpected wear or functional mismatches, meaning the life cycle. Likewise, it assures that their production is achievable under the named conditions and that their distribution and procurement are suitable to the target audience. Last, it is confirmed that the product complies with the established rules and the design criteria regarding social and environmental sustainability.

In the academic field the most common validations are those based on the representation using drawings and analog or digital models[13]. Validations are based on the data comparison; physical trials using "prototypical" models; and the socialization of final or partial results as an academic level of validation for the project scope and the development of students' competencies. To conduct them, protocols are established, where the variables considered or the expected quantitative or qualitative values, the suitable processes, the resources, and a time frame are determined. The gathered information is systematized and analyzed, and the summary data point out the relevant modifications to the products (Mesa-Betancur y Correa-Ortiz, 2018. p. 503).

Manuel Domínguez (2016.p.1-2) and Omar Balderrama and José Flores (2015.p.26) agree to it. Nevertheless, for Jones (1982), good design is the optimal solution to valid needs in particular circumstances (p.159). Aspects or characteristics of a product must be validated during at different design phases while combining methods (p.130). Trial situations with the actual users should also be chosen to distinguish valid and invalid solutions (p. 131); to be clear about their performance in a task, and to adjust them based on the result (pp. 196-198). Cross (2002), on its behalf, states that validation is performed during the final design phase (p.43). For him, it consists of checking requisitions and comparing alternatives (p.47); he gives particular attention to the cost-benefit value and perceived value (p.160). He states that Archer (1982) identifies a final development phase where prototypes are made, and product validation tests are designed before manufacturing (Cross, 2002. p. 35).

13 Sathikh comments similarly (2020. p. 7).

In summary, the project is verified as a process and the design products are validated as one of its results.

Continuing, validations that require testing are performed through *simulations* or *simulacrums*. In order to distinguish both scenarios, these terms were compared with those from other disciplines by adapting them to the projectual process because of their similarity. First, simulations are tests that are carried out in a controlled environment (physical or virtual) of the designer's work context. They are also known as "desktop exercises". Designers and other actors may substitute for those in the real context. They are also based on the conjectures on failure risks, performance potential, affective or sensorial responses, perceptions, and impacts, among others that are included in the validation protocols.

Simulations are used to strengthen decision-making processes at specific moments, which make them strategic and tactical tools for project and products management. The simulation dynamic is based on a protocol that establishes the events that may occur chronologically in an actual context, and this sequence is replicated in a chosen mean for the simulation. The exercise control and the analysis of the resulting data strengthen the decision-making. Simulations can be classified as partial when parts or specific characteristics of an object-product are tested and total when it is tested in all its dimensions.

This type of exercise is an efficient pedagogical strategy for the development of projectual skills and capacities and expertise that supplement the formation process by allowing a better understanding of a projectual situation, knowledge, and experience that contribute to its professional practice.

On the other hand *simulacrums*[14] are practical exercises that represent a situation as close to reality as possible (INDECI, 2014. p.1). Therefore, it is a way to test a design object in context. During its planning, it is important to ensure that there is correspondence with the daily life of the actors and that the exercise takes place in the intended context. A simulacrum is relevant when it is necessary to test a goal performance in context or the perception and impact on people because of its presence or during their engagement.

It is developed by activating a placed activity, from which the object is the mediator, as if it was happening in real-time and where its participants play their usual role. Hence, the protocol making requires strict control of time, and it is appropriate to have carried out previous simulations to optimize the activities and their monitoring. They are classified according to their scope or complexity. According to their scope they can be specific when they test parts or general when they test the product. In terms of complexity they can be simple if they are performed in a single scenario and aim to assess basic interactions. Complex if interaction variables test as many options as possible. And multi-scenario simulacrums if they are made in different locations (p.10). For this reason, its complexity determines the resource mobilization and logistics, the number of people to control it, and the record of its development and process assessment.

Similarly to simulation, simulacrums have a high pedagogical value, given that they allow for to strengthening and testing of useful skills (besides knowledge, capacities, and expertise) in the decision-making process regarding the modifications to the designed products (Martínez Rueda, 2016. p.9).

To summarize, *simulations* are conducted under a controlled environment while simulacrums are carried out in the named situation in

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14 This term is supported in INDECI (2014).

the project approach (INDECI, 2014. p.2). Regarding its costs, the former can be conducted with few resources from drawings, study models, or digital modeling, whereas the latter requires more resource investment; for example, prototypes or 1:1 test models are needed. Now, *simulations* are easy to plan and execute compared to simulacrums. They only entail information management and are easy to control (they depend on the skill to manage the means). However, its scope is limited and demands analyzing and reading properly for decision-making. *Simulacrums* involve carrying out protocols in context. They are complex to control and require attention to detail before, during and after the test. Still, its scope is vast, and the results are more reliable and clearer.

As a resemblance, they are correlative to the formalization process. They allow us to see the product's potential and to inform the projectual decisions. They strengthen teamwork and cooperation between the involved actors (Martínez Rueda, 2016. p.10). Contribute to the consolidation of projectual and critical competencies for responsible professional practice.

Results and analysis

Once the frameworks for the validation of the changed method have been clarified, we describe the execution of the projectual[15] activities in different moments, the way they were developed in an online educational environment and their scope. Although we mentioned six projectual actions, neither the total of the involved activities nor all their tasks were reported, only those related to product validation.

15 The validation activities were only applied to industrial design projects. In the review carried out at the School of Architecture, there was no evidence of them being used, it seems as Beatriz Colomina (2010) states that architects act as if their buildings are images and do not care how people occupy them (p. 120).

In the first moment, concerning the contextualization of the assignment or the initiative that drives the project, the projectual action one also known as initial inquiry was developed. A reading of the context in which the order was placed and a state of the art of related products available for procurement were carried out. At the end, conclusions for the product proposal were drawn by relating a situation with its impact. Based on these conclusions, the approach (design problem) was developed.

Starting the projectual action two “conceptualization,” the first activity, building a product proposal (descriptive text) responded to the described situation in response to the assignment or initiative.

This description incorporated the object characteristics in terms of the interactions, perception, and impact on people when using it and the reason they would have for doing so.

With this in mind, we built a reference framework based on the state-of-the-art objects, but not only, that presented characteristics that could be assimilated into the proposal. As a synthesis, a project name was given as a linguistic reduction (Mesa-Betancur y Correa-Ortiz, 2018. p. 503, Llovet, 1981. p.31-33), which focused on the process of idea-creation intentionality.

The product approach and proposal were the first validation activity. The arising situation was reviewed to make sure that the delimited was presented as described and the proposal to validate its relevance. Protocols were changed for the online environment. Structured interviews[16] and surveys with open-ended questions were used for data collection. The fieldwork was carried out through video calls and online applications[17]. In order to systematize data, answers were transcripted

[16] Soonthorndhada (1989) was used as a reference to develop interviews.

[17] In this case Google Forms was used.

and codified and analyzed through a comparative matrix[18]; last, the findings were plotted. They were not much different from those gathered in the classroom. Although, participant observation usually used was not conducted because of the confinement. Instead, students resorted to observing their own domestic environments (not necessarily consistent with de projectual situation) and contrasting them with the other findings got to identify differences and similarities. It allowed us to aware the importance of this task to apply it in a future situation. As a synthesis, a requisition matrix was developed, and it included its dimension, type, variable considered, and the value or expected condition in its validation.

At the beginning of the projectual action number three, the formal synthesis of the design product, three activities tooked place: the development of a "formal hypothesis" (Mesa-Betancur y Correa-Ortiz, 2018. p.505; Mesa, 2018. p.92; 2017. p.52; Argan, 1969. p.38), the production of options and alternatives, and its assessment (Jones, 1982. p.34). During these, the initial conditions of usage and operation of the proposed object were focused, and dimensional control tests and postural simulations were conducted; they are both validation activities. The designs were compared with the standardized data, dimensional standards based on the percentiles[19] and close at hand products that, because of their characteristics, worked as references.

In the former design methods were used to analytically compare the proposed dimensions against the chosen standard ranges for potential users. Starting from exploratory scale drawings, experimentations with study models[20], and articulated mannequins. During these simulations it was compared the views of the object considered enough, based on

18 Baranger (2009. p. 13-15) was used as a reference for the data matrix tool
19 In this case, Panero and Zelnik's (1996) text was used as reference.
20 The value of study models in these early validations is stressed by Sathikh (2014. p.6).

an intended sequence of usage, against the ergonomic standards of reference (see image 1)[21].

For the latter existing furniture (or part of them, such as cushions or structures) and another close at hand elements (like boxes, boards, cardboards, among others) were used to "build" in an intuitive-experimental way a volume simulated that would have close characteristics to the proposed object (dimensions, angles, etc.). And on which to conduct posture trials with people who had similar characteristics to the users considered. The tests were recorded in photographs and videos for analysis, the observation was supported by structured interviews with the participants. The students performed the experience in their homes (see image 2). These validations proved to useful not only for their results but also motivationally. They realized the products' dimension and usage potential they objectified their designs and appropriated its project. During this time, validations were also performed. They assessed the aesthetic perception, the correspondence with the existing rules and the distribution channel, and the procurement proposed. In the first one, the product's legibility was validated using structured interviews and surveys with closed and open-ended questions accompanied by design drawings[22]. For the second validation, a first approach to the correspondence with the existing rules and the product was revised[23], in progress. Last, the characteristics for the proposed channel were assessed in a consumer journey map[24] and a comparative matrix with products of similar channels identified in the state of the art. (see image 3).

21 All images were taken from: Rodríguez, Franco and Rodríguez (2020) Bitácora Digital de proyecto del Núcleo Proyecto y Domesticidad.

22 Unlike production designs, design drawings are those proper to projectual development. They can be as formal as needed, but their purpose is to build the product, assess it, and make decisions for its modification. (Dittmar, Rogers y Ginis, 1980).

23 The ICONTEC standards 1440,1987, 2306, 2514, 2867, 50141, 5431 (ICONTEC. 1978, 1990, 1987, 1989, 1991, 2002, 2006) were compared.

24 The analysis was based on Angrave (2020. P. 13-19).

Image 1

Image 2

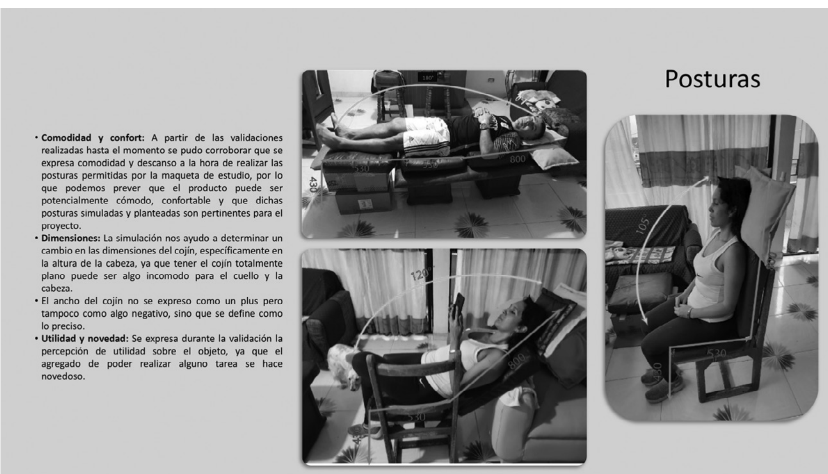
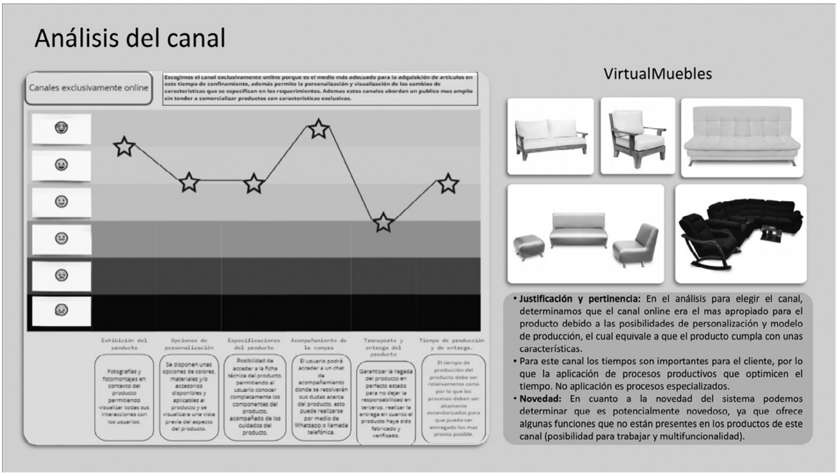


Image 3



The simulations and analyses performed were suitable and allowed to inform the modifications.

In the preliminary draft stage corresponding to projectual action four (the object synthesis of the design product) we got a more informed product with adequate characteristics to carry out tests focused on its operation, materiality, and production. The first complete progress of the Project Report (Informe de Proyecto) (Mesa-Betancur and Correa-Ortiz, 2018. p. 506) was presented as a verification level.

At the beginning of action five, at the contextualization of the object-product of design, we clustered the changed requisitions during the process based on the required test for their ultimate validation. Also, we designed testing protocols according to whether they required simulations or simulacrums.

Since only simulations could be performed, since simulacrums required a prototype or "prototypical" model that was not within the possibilities, we proceeded to the construction of detailed digital and physical models in the scales recommended for standardized tests[25]. We used Fab Studio, partnership UPB-Rhino3D Colombia, and the accessible remotely software for the first models. For the other models, students developed 1:5[26] test models (each student built one) with materials accessible[27] to their location, like the product.[28]

The validation tasks were organized in a matrix for test protocols[29], the aspects to be validated of each requisition, trials' step-by-step, the resources, the variables to validate, and the expected or guessed value. The physical models allowed stability and performance tests, and the digital ones allowed different CAE (computer aided engineering) analysis. Resistance, structural behavior, and manufacturing possibilities were the last ones that focused on techno- productive aspects. Nesting analyses were also conducted, where necessary, for the production variables. FEA[30] (Finite elements analysis) models were used for the structural trials (see image 4), and DFM[31] (Design for Manufacturability) and DFA[32] (Design for Assembly) analysis matrixes were used for productive feasibility (see image 5). Each validated aspect, the involved people, the tools used, and the evidence and the findings were recorded in another matrix and finally synthesized in analytical graphics. These allowed us to

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25 Omar Balderrama and Jose Flores (2015.p.26) state that designers value ergonomics and usability, appearance and acceptance of their models; they check the functionality of mechanisms, volume-area relations, limits of endurance, or they simulate materials.

26 Sathikh (2014. p.7) points out the use of models for this type of test.

27 Sathikh (2014. p.7) states that for physical testing if its scope is to be improved, the model must be built with the same materials as the final product.

28 This situation was because some of the team members were geographically dispersed, and the University's model and prototypes laboratory was closed due to the pandemic.

29 Rodríguez, Romero and Domínguez (2016) state that matrices for validation allow us to disaggregate factors (information) and turned into (data) technical, physical or visual characteristics.

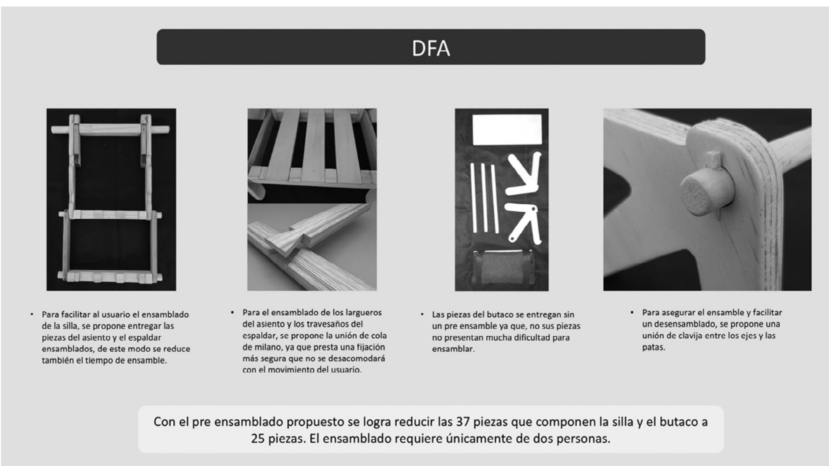
30 For this analysis, we used Solid Works software licensed by UPB and accessible remotely.

31 The analysis was based on Anderson (2004. p. 29-32).

32 The analysis was based on Boothroyd (1980).

Image 4

Image 5



make definitive decisions about the shape, materials, and manufacturing from optimization strategies.

These tests did not represent a problem; they were enough to make modifications and start the detailed execution of manufacturing and assembly drawings and technical specifications. The elaboration of more precise drawings allowed the development of a scale test model within manufacturing limitations, and to adjust protocols for more accurate tests.

Shortly before starting projectual action six, the socialization of the products and results of the project was recorded in a timeline of the construction of a 1:3 physical model (see image 6) to bring closer the production line. The partial 1:1 pieces model some teams could build was also reported. With this material, commensurate charges tests, preventive, and corrective maintenance analysis FMEA[33] (Failure mode effects analysis) were performed, in anticipation of some of the product's life cycle phases to change its detail design. After that, an environmental sustainability validation was carried out by an eco-audit[34]. Since the carbon footprint measurement is only significant if it's used with other reference models, the available in the core were compared. Significant variables were focused on, such as the impact of the raw materials selection and local processes, and transportation. Rather than provide certainties, this test allowed students to identify controllable variables, support environmental sustainability and recognize its importance for professional practice (see image 7).

The chosen channel, costs, and estimated price, cost-benefit ratio were assessed. The validation of the procurement and distribution channel was performed through comparison of the product against others on offer and consumption surveys. Through approximation of

[33] The analysis was based on Sangüesa, Mateo and Ilzarbe (2006. P.148-149).
[34] The licensed software by the UPB and accessible remotely was used.

Image 6

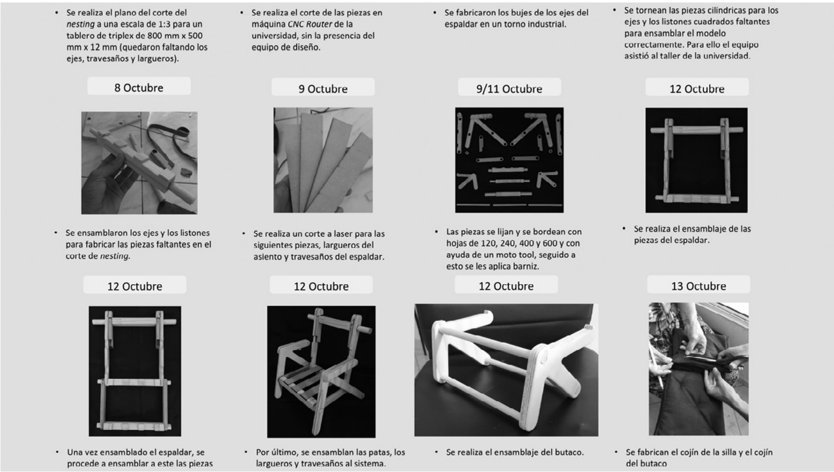
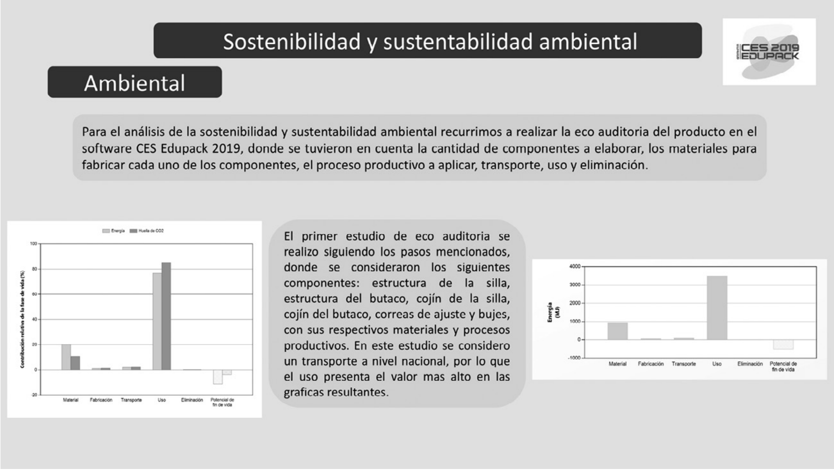


Image 7



costs by materials valuation, processes, and commercial parts. And through, escalated projections of prices based on costs and reference products offered in channels. The findings are no different in scope from those got in the classroom.

Simultaneously, analytical matrices were developed to assess characteristics that provide novelty and product variants. The first considered variables such as appearance, use or function, material, dimensions, weight, duration, productive process, sustainability, and price variables. The second one included variation to replicate the product in other contexts of use, socioeconomic or sociodemographic. We identified characteristics to adjust to some of them (see image 8).

The argumentation of social sustainability gathered validations findings from all dimensions. The analysis and test findings were compared against the existing rules, responsible resource management, certified raw materials, productive capacity, local manufacturing process, and fair-trade practices. Likewise, product coherence with the people's life habits and their perception (user-friendliness, harmony with its context,

Image 8

Replicabilidad

Contextos de uso	Se considera que el producto por sus funciones y características no puede replicarse en un contexto diferente al domestico, sin embargo, se pueden ajustar ciertos materiales para ser usado en otros espacios de la casa, como los exteriores sean en balcones o terrazas, ya que en las encuestas se considero como otro espacio donde se ubicaría este objeto a parte del interior de un hogar. Tambien puede replicarse para el mobiliario de hotelería en exteriores, haciendo cambios y ajustes en los materiales para que pueda implementarse de manera optima
Contexto socio-económico	Se considera factible en el producto realizar variaciones para estratos socioeconómicos mas bajos y altos por su facilidad de producción, variabilidad de materiales y posibles alternativas en algunos componentes. Para estratos mas altos se puede variar la madera e implementar algunos tipos como roble, en la cojinería se puede implementar espumas de mejor calidad para brindar mayor comodidad y confort. Para estratos mas bajos se puede mantener el mismo tipo de madera, es decir, pino o en su defecto usar madera mas barata como el triplex sin dejar a un lado la calidad y se podría reemplazar las correas de cuero por un herraje de 3 posiciones para reducir costos.
Contexto Socio-geográfico	El producto es optimo para replicarse en otros contextos socioeconómicos similares a los de Medellín como en ciudades pertenecientes a países latinoamericanos y norteamericanos, por lo que a nivel nacional en las principales ciudades como Bogotá, Cali y Barranquilla podría funcionar de manera optima. A nivel internacional puede replicarse en países con contextos sociales y configuraciones del espacio similares al nuestro, como Ecuador, Argentina y Perú, siempre y cuando no se requieran optimizaciones del espacio muy estrictas como en los países asiáticos donde se implementa mobiliario integrado a la pared y las características no permiten dichas condiciones. Ecuador: Argentina: Perú:

affective association) was validated using contrast matrix[35], structured interviews and surveys together with photorealistic representations or photomontages in actual situations. Given the qualitative nature of this data, the core components accompanied its interpretation and decision-making according to their scope.

As expected, the product validation in a context with real actors was not possible and validating some functional-operational and aesthetic-communicative requisitions was complex. The usability, functionality, and even the potential usefulness of the product could only be guessed. The findings supposed the object's potential behavior, reducing the got scope during classroom education. Despite the usefulness, that was to perform simulations of the sequences of use, assembly, and operation (from digital models and animations compared with the reference mechanism or objects) and perception tests from photomontages.

Finally during the projectual action six, socialization of the products and findings of the project, an online presentation was held and the final verification, the informe de proyecto (project inform) was presented. It included as optimization prospects the findings of the ultimate validations that could not be deployed as immediate modifications but should be considered in the future. This action was simultaneously academic validations of the students' skills.

Conclusions

Adjusting the core activities to the conditions of virtual mediation implied, methodologically, optimizing methods and tools that had shown effectiveness to cooperatively develop project activities using virtual

35 An example of these matrices can be seen in Rodríguez-Parada, Romero and Domínguez (2016. p. 3).

images of objects. To achieve this an educational environment was set up using the platforms and applications that allow collaborative work. As shown, this allowed and, finally, specified products validation through simulations and data comparison. The requisitions that allowed to be validated through this method and proving reliability were the techno-productive, economic-administrative, and even historical-political dimensions. The functional-operational and aesthetic-communicative ones that required simulacrum showed little reliability. Although the simulations mitigated (not replaced) this failure, the results were inconclusive. Despite some requisitions being not more critical than others, the uncertainty about some aspects can cause, as Markus says, "catastrophic failures." The experience proved that validating products using one representation form or another, with a certain level of detail, does not impact its validity but its reliability and scope. The more characteristics present, the more reliable findings. Therefore, making a proper interpretation will mean considering both the tools and means used, such as accuracy and the extent of the tests.

The obstacles to develop a prototypical model: the impossibility of performing collaborative on-site work as well as the restricted resources, raised a question about the educational integrality. When it was considered that one member of each team should build and validate it, overcoming resources, it was questioned that when team members are in different locations, cannot meet or there are restrictions to do so. The question is if it is legitimate, from a formative point of view, that performing separate tasks compromises a disparate scope of competence for each other?

To summarize, although the educational experiences of the designers through an online environment opened new perspectives for the projectual processes. It also showed the impossibility to perform under the circumstances described, critical validation activities that affected the level of competence achieved by students in the classroom education and declared by the UPB IDES program.

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