# A Guide for Learning Design Practice

R. Sanz-Segura(✉), A. Fernández-Vázquez, E. Manchado-Pérez, and I. López-Forniés

Departamento de Ingeniería de Diseño y Fabricación, Escuela de Ingeniería y Arquitectura de la Universidad de Zaragoza, c/María de Luna 3, 50018 Saragossa, Spain
rsanz@unizar.es

**Abstract.** The learning and acquisition of industrial design skills and, in particular, methods and design process, are implemented in the scope of Bachelor's Degree in Industrial Design and Product Development Engineering at the University of Zaragoza, Spain. This publication presents contents related to the methodological control of the design process, included in the subject "Design workshop II: methods and design process", conducted during the first semester of the 2nd year of the degree. From this experience, this contribution shows the tools used in the subject to ensure that students are given the necessary knowledge to be able to apply a methodology and propose a clear and structured design process. The experience is based on the use of detailed scripts that structure practice sessions, showing and exemplifying their application through the projects developed during the course. This material can serve as a guide for its use and implementation in future teaching activities and academic projects in the field of engineering, in which a methodological basis and control of the design process is required, linking these aspects with the development of different analyses focused on the provision of essential information for the project. The result of these teaching practices is to facilitate a meaningful learning for the student, the interdisciplinary integration of knowledge for its application to the design process, the improvement of academic goals as well as an efficient coordination among teachers that improves communication among all the members of the university community involved in the degree.

**Keywords:** Design process · Design methods · Design methodology · Teaching · Learning design

## 1 Introduction

Industrial design engineering is a technical activity with a twofold objective: to improve people's lives through the development of new products, and to enhance the economic growth of companies that launch these products to the market by increasing user satisfaction. To reach this goal, various tasks are carried out, some of them specific to the discipline and others shared with another fields such as the study of the characteristics of users, their needs and expectations, the proposal of new technological developments because of their potential use at the service of people, the analysis of the market; or the prospective approach of future scenarios, among others.


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The results could be: (a) the generation of ideas for new products or services that improve existing ones or provide skills that increase the quality of people's life, generating in either case new market opportunities; (b) the development of ideas from the evaluation and prototyping stage to serial production; or (c) the execution of communication elements based on corporate identity, such as packaging.

With regard to industrial design, another important issue is the control and monitoring of project activity to ensure, as far as possible, the achievement of the described objectives and the generation of documentation to strengthen existing knowledge in the field of the project. The learning and acquisition of these skills and, in particular, methods and design process, is implemented in the scope of Bachelor's Design and Product Development Engineering at the University of Zaragoza, through a series of modules where the studied concepts are put into practice, following a vertical structure in which the different learning goals are gradually integrated [1]. Thus, it is possible to build up from the knowledge of some basic elements of the project activity, continue working on the development of the communicative capacity of the products and then, in order to deepen the methodological control skill over the whole process, integrate the most diverse technical and humanistic knowledge and, finally, develop cross-cutting skills that facilitate teamwork in the context of the business world.

This publication presents contents related to the methodological control of the design process, included in the subject "Design workshop II: methods and design process" [2]. The subject is conducted during the first semester of the 2nd year of the degree, as part of the 2nd module of subjects. Its overall goal is to provide students with the tools and knowledge necessary to perform analysis, obtain conclusions and propose improvements of one product, so that it can be materialized through a final representation.

The result of these teaching practices is to facilitate a meaningful learning for the student, the interdisciplinary integration of knowledge for its application to the design process [3], the improvement of academic goals as well as an efficient coordination among teachers that improves communication within all the members of the university community involved in the degree.

## 2 Methodology for Learning Design Practice

The general aim of the degree is to provide the student with the skills to address the management of knowledge and design capacity necessary for the planning and development of the entire conception, manufacturing process and life management of a product [4]. In this sense, the subject has a project-based learning approach [5, 6], as the implementation and development of these skills are pretended to be acquired by the student through experimentation in the context of a real product design experience [7, 8].

Learning design practice is based on a theoretical understanding of content, explained in lectures to the entire group, which are supplemented by case studies while applied simultaneously in projects. Projects development is supervised and reviewed during a series of practical sessions or design workshops within smaller groups in which the theoretical contents are put into practice. This practical and experimental learning allows the setting of the contents, and allows the implementation of various tools and techniques of analysis previously shown during the theoretical lectures.

A product design project is important and complex enough as to entrust its success just to intuition, luck or chance [9]. Therefore, in the development of the design activity, it is necessary to apply a methodology, for the available work methods must be known in advance. It is also necessary to work following a pre-established and controlled approach throughout the process, especially considering the difficulty of effective teamwork learning. Method and control are necessary for ensuring that students acquire the essential knowledge about the environment in which the project is going to be developed and applied, and control the technique and deadlines for its execution.

A method is defined when a set of actions, processes and tools are theoretically considered [10]. This approach is subsequently tested and validated empirically. In the academic field presented, the actions to be carried out are:

– Market study and segmentation, product positioning maps.
– Structural and functional-formal analysis of the product.
– Semiotics and communication structure analysis of the product.
– Study of users both from ergonomics and use sequence of the product.
– Project briefing.
– Applied creativity to innovative product conceptualization.
– Definition of manufacturing processes, and value/costs analysis.
– Documentation of the Project, including 2D and 3D rendering, and models and prototyping production.
– Packaging development.
– Presentation of results.

## 3 Design Process

The design process starts from the analysis of the internal characteristics of a product, analyzing the solutions adopted for its realization, questioning them, proposing possible improvements, and providing the necessary technical and formal evolution to achieve the materialization of the new product, also through an exterior shape. It is therefore a process of construction from inside to outside.

Sometimes, decisions are taken in the very early stages of the design process, and are maintained throughout the project without having been the result of a profound reflexion of the various existing possibilities. This is a very serious but unfortunately too frequent mistake. Those first determinations condition the whole developing of the project, as inadequate decisions taken too soon are very difficult, or too expensive, for being changed in later stages.

For this reason, the subject emphasizes the importance of these first phases, helping and encouraging students to reserve a significant amount of time for the analysis and evaluation of the alternatives and, if necessary, for modifying, but never totally rejecting, the various options considered.

The second consideration is that the process serves to manage with at least a minimum guarantees relevant aspects such as the symbolic load of the shape. As well as for the development of the function is necessary the methodological control, it is required the adequate handling of the expressive tools associated with the precise development of the aesthetics of the product, so as to avoid interpretations or subjective approaches that can lead to confusion or, at worst of the cases, mistakes in the interpretation of the product.

Experience has shown that for fixing knowledge definitively, it must be exposed repeatedly, and with an approach that combines theory and practice. In this way it is evident to the student, without any doubt, the practical potential of the taught subject, while generating the necessary practice in the tools associated with said theoretical base. The order and the rigor in the exposition of the subject has been demonstrated fundamental to reach the formative objectives sought.

Different methodologies have been developed for the process of product design and development [11–13], but all of them involve or essentially propose three basic actions: planning, development and realization. This sequence is repeated on a different scale, both globally within the project, and in detail within each of the tasks necessary for the resolution of the intermediate phases and the final details.

This methodology is very similar to the Deming circle [14], which establishes the steps of planning, doing, checking and acting, and varies only the verification phase, which in the case of the design processes developed within the subject is done automatically at the end of each phase through meetings with presentations to project managers.

Sometimes phases overlap, so that when one has not yet finished, the next one begins, thus continuity exists between the different phases or parts of the project, always depending on the type of project. And sometimes they are developed jointly, as in the case of the first two (previous phase and information phase). But these circumstances do not alter the basic scheme of the process, which is structured in the manner described in the following section.

Firstly, students perform a generic approach of a design process, to structure it in stages, apply a methodology and select the design strategy. Additionally, students define product design specifications in order to develop relatively complex products up to a satisfactory technical grade, which includes the way and needs to develop the project.

As already stated, this is a typical methodological process. Broadly speaking, it refers to a sequence of work commonly accepted and extended among professionals, based on analysis, a controlled creativity, and the control of phases and project decisions. Thus, the methodology is proposed in different ways by the different professionals, in a search of the greatest possible effectiveness and each professional adapts the method based on their own experience. As a summary, the following scheme is proposed corresponding to the product design process followed by students (Fig. 1).

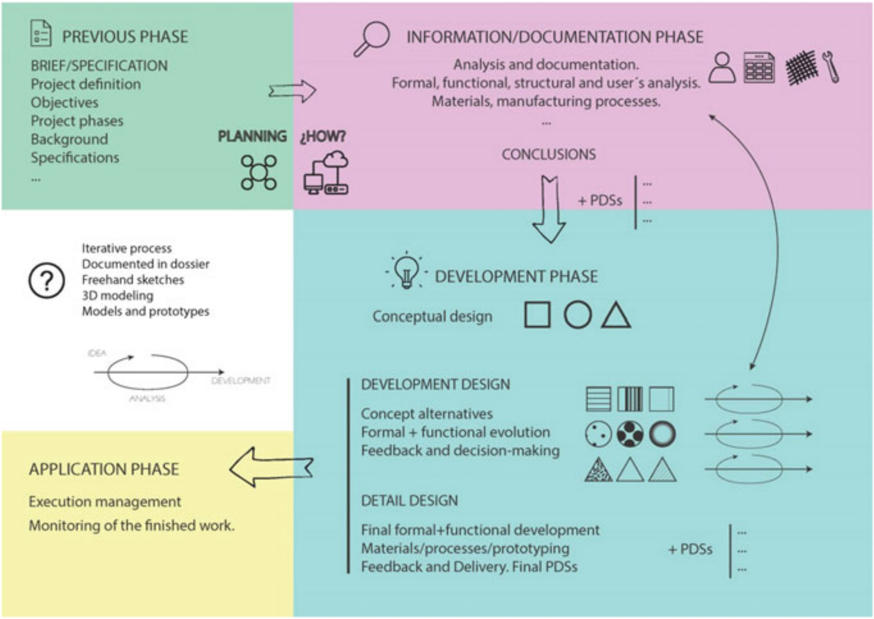



**Fig. 1.** Design process. Adapted from "Métodos y proceso de diseño. Taller de diseño" [2]

## 4 Guide for Design Workshops Schedule

Based on this previous academic experience, Table 1 shows one of the tools used in the subject during practical sessions to ensure that, during its development, students are given the necessary knowledge to be able to apply a methodology and propose a clear and structured design process. This is intended to provide students with a base that enable them to integrate and relate, in a vertical manner, the rest of the subjects that will be taught throughout the degree.

The experience is based on the use of detailed scripts that structure practice sessions, showing and exemplifying their application through the projects developed during the course. This material can serve as a guide for its use and implementation in future teaching activities and academic projects in the field of engineering, in which a methodological basis and control of the design process is required, linking these aspects with the development of different analyses focused on the provision of essential information for the project.

Design workshops are presented in 2-hour practical sessions. The schedule of the workshops is divided into four sections: board explanation; teamwork; discussion; and next session "to do". The duration of each activity is not mandatory, and can vary depending on the needs or circumstances of each group of students, but all of the activities must be developed, as the training objectives of each session must be accomplished.

The use of detailed scripts with the necessary steps to translate the theory into practice has had one of its best results in *methods and tools description* section "design

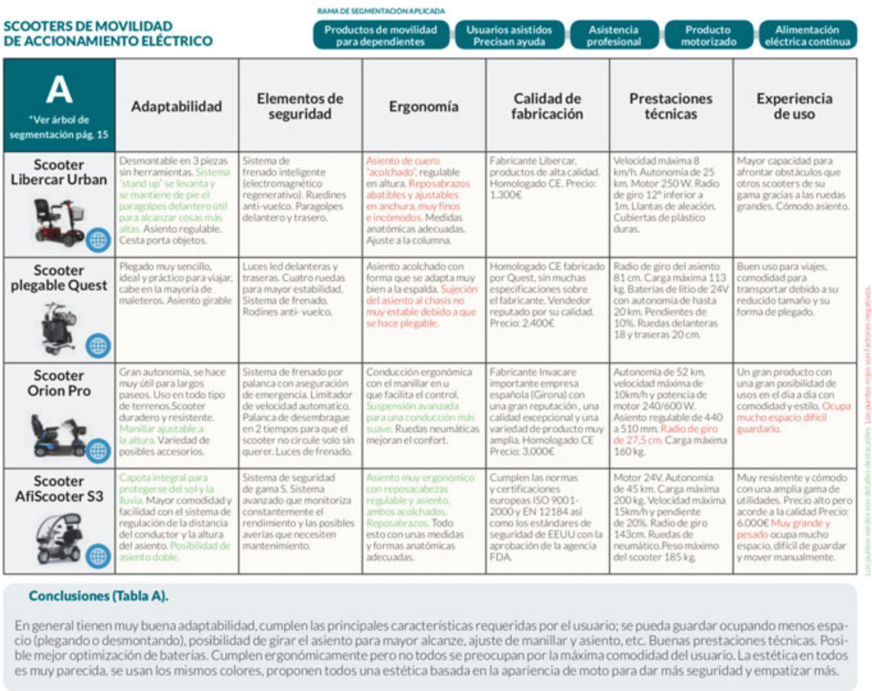
**Table 1.** Design workshop description

| Tasks | Objectives | Work description | Recommendations | Timing |
|---|---|---|---|---|
| Board explanation | Description of session objetives<br>Relate theory to practice<br>Revision of calendar and global objectives | Theory introductory speech<br>Methods and tools description<br>Design requirements | Key points<br>Timing<br>Process-based approach<br>Assessment<br>Engagement | 30′ |
| Teamwork | Student teamwork planning<br>Teamwork coordination<br>Tasks definition<br>Decision-making | Definition and sources searching<br>Research<br>Methods implementation<br>Analysis<br>Conclusions<br>Teacher review | Collaboration<br>Critical thinking<br>Communication<br>Team coordination<br>Divergent/convergent thinking<br>Iterative process | 70′ |
| Discussion | Sharing information<br>Feedback collecting<br>Problem solving | Support the students to achieve their goals | Collaboration<br>Critical thinking | 15′ |
| Next session “to-do” list | Summary and conclusions | List and review tools, methods and documentation to be delivered<br>Workshop conclusions | Board work summary<br>Screenshot | 5′ |

factors” corresponding to one of the main *theory introductory speechs*: “Analysis and techniques applied to the design process. Market and product”. Students, frequently and recurrently year after year, find difficulties in understanding the difference between design factors and design specifications. Once the student collects the information of the product to be developed and coming from different sources (*definition and sources searching/research*), he has the ability to create homogeneous sets of consumers within a specific market (segmentation). Under a series of common criteria and design factors, as many as necessary, analyze products of the same category (or segment) with each other in order to obtain relevant conclusions (*methods implementation*).

The design factors are specific aspects of each product and allow us to analyze similar products based on the same criteria (or design factors) to eliminate uncertainty and, on the other hand, to start the design with the necessary information and a series of conclusions that allow generating concepts of design that can be further developed.

An example of this type of analysis based on common design factors is shown in Fig. 2, corresponding to the *teamwork* done by a group of students. It does not compare objects that are different but those that have a common base (they belong to the same market segment and are analyzed according to common factors); this is the precondition for perceiving differences. The analyzes and design tools used give meaning to the different variables and allow to discriminate the most important ones. Thus, it is able to identify the points of improvement, weaknesses or strengths of the analyzed products.



SCOOTERS DE MOVILIDAD DE ACCIONAMIENTO ELÉCTRICO

RAMA DE SEGMENTACIÓN APLICADA: Productos de movilidad para dependientes · Usuarios asistidos Precisan ayuda · Asistencia profesional · Producto motorizado · Alimentación eléctrica continua

| A *Ver árbol de segmentación pág. 15 | Adaptabilidad | Elementos de seguridad | Ergonomía | Calidad de fabricación | Prestaciones técnicas | Experiencia de uso |
|---|---|---|---|---|---|---|
| Scooter Libercar Urban | Desmontable en 3 piezas sin herramientas. Sistema "stand up" se levanta y se mantiene de pie el paragolpes delantero útil para alcanzar cosas más altas. Asiento regulable. Cesta porta objetos. | Sistema de frenado inteligente (electromagnético regenerativo). Ruedines anti-vuelco. Paragolpes delantero y trasero. | Asiento de cuero "acolchado", regulable en altura. Reposabrazos abatibles y ajustables en anchura, muy finos e incómodos. Medidas anatómicas adecuadas. Ajuste a la columna. | Fabricante Libercar, productos de alta calidad. Homologado CE. Precio: 1.300€ | Velocidad máxima 8 km/h. Autonomía de 25 km. Motor 250 W. Radio de giro 12° inferior a 1m. Llantas de aleación. Cubiertas de plástico duras. | Mayor capacidad para afrontar obstáculos que otros scooters de su gama gracias a las ruedas grandes. Cómodo asiento. |
| Scooter plegable Quest | Plegado muy sencillo, ideal y práctico para viajar, cabe en la mayoría de maleteros. Asiento girable | Luces led delanteras y traseras. Cuatro ruedas para mayor estabilidad. Sistema de frenado. Rodines anti- vuelco. | Asiento acolchado con forma que se adapta muy bien a la espalda. Sujeción del asiento al chasis no muy estable debido a que se hace plegable. | Homologado CE fabricado por Quest, sin muchas especificaciones sobre el fabricante. Vendedor reputado por su calidad. Precio: 2.400€ | Radio de giro del asiento 81 cm. Carga máxima 113 kg. Baterías de litio de 24V con autonomía de hasta 20 km. Pendientes de 10%. Ruedas delanteras 18 y traseras 20 cm. | Buen uso para viajes, comodidad para transportar debido a su reducido tamaño y su forma de plegado. |
| Scooter Orion Pro | Gran autonomía, se hace muy útil para largos paseos. Uso en todo tipo de terrenos.Scooter duradero y resistente. Manillar ajustable a la altura. Variedad de posibles accesorios. | Sistema de frenado por palanca con aseguración de emergencia. Limitador de velocidad automatico. Palanca de desembrague en 2 tiempos para que el scooter no circule solo sin querer. Luces de frenado. | Conducción ergonómica con el manillar en u que facilita el control. Suspensión avanzada para una conducción más suave. Ruedas neumáticas mejoran el confort. | Fabricante Invacare importante empresa española (Girona) con una gran reputación , una calidad excepcional y una variedad de producto muy amplia. Homologado CE Precio: 3.000€ | Autonomía de 52 km, velocidad máxima de 10km/h y potencia de motor 240/600 W. Asiento regulable de 440 a 510 mm. Radio de giro de 27,5 cm. Carga máxima 160 kg. | Un gran producto con una gran posibilidad de usos en el día a día con comodidad y estilo. Ocupa mucho espacio difícil guardarlo. |
| Scooter AfiScooter S3 | Capota integral para protegerse del sol y la lluvia. Mayor comodidad y facilidad con el sistema de regulación de la distancia del conductor y la altura del asiento. Posibilidad de asiento doble. | Sistema de seguridad de gama S. Sistema avanzado que monitoriza constantemente el rendimiento y las posibles averías que necesiten mantenimiento. | Asiento muy ergonómico con reposacabezas regulable y asiento, ambos acolchados. Reposabrazos. Todo esto con unas medidas y formas anatómicas adecuadas. | Cumplen las normas y certificaciones europeas ISO 9001-2000 y EN 12184 así como los estándares de seguridad de EEUU con la aprobación de la agencia FDA. | Motor 24V. Autonomía de 45 km. Carga máxima 200 kg. Velocidad máxima 15km/h y pendiente de 20%. Radio de giro 143cm. Ruedas de neumático.Peso máximo del scooter 185 kg. | Muy resistente y cómodo con una amplia gama de utilidades. Precio alto pero acorde a la calidad Precio: 6.000€ Muy grande y pesado ocupa mucho espacio, difícil de guardar y mover manualmente. |

Los puntos verdes son detalles destacados. Los puntos rojos son factores negativos.

Conclusiones (Tabla A).

En general tienen muy buena adaptabilidad, cumplen las principales características requeridas por el usuario; se pueda guardar ocupando menos espacio (plegando o desmontando), posibilidad de girar el asiento para mayor alcanze, ajuste de manillar y asiento, etc. Buenas prestaciones técnicas. Posible mejor optimización de baterías. Cumplen ergonómicamente pero no todos se preocupan por la máxima comodidad del usuario. La estética en todos es muy parecida, se usan los mismos colores, proponen todos una estética basada en la apariencia de moto para dar más seguridad y empatizar más.

**Fig. 2.** Analysis of design factors. Screen capture of teamwork developed by second-year students (2017–2018) corresponding to the project "design to improve the mobility of dependent users"

## 5 Primary Results of the Experience Developed

The experience with the scripts of practices, which have been used for the first time in the subject during the year 2017–18, has materialized in a significant improvement of the achievements of the work developed by the students in the first phases of the projects.

The combination of the information provided in the theoretical classes with the reinforcement of the knowledge that was realized in the practical sessions has allowed, in addition, that the work that was developed during the practical classes served as a base for complementary work which the students had to develop outside the classroom. The final sharing of the results achieved has allowed, in each of the sessions, to detect errors from the most initial phases of the project, avoiding that these were maintained throughout the entire project.

Finally, a better coordination has been achieved in the development of practical sessions that not only facilitated the work of teachers, clarifying the tasks to be developed in each session, but also providing the students with a sense of homogeneity and rigor in the subject that has avoided both misunderstandings and differences in the pace of development of the work among different class groups.

This improvement has been measured by comparing the appraisal of the evaluation surveys fulfilled by the students at the end of the courses 2016–2017 and 2017–2018. The analysis has focused in the valuation of questions regarding coordination. The response rate in the academic year 2017–18 was 65.91% (58 responses from a total of 88 students), considerably higher than the response rate in the academic year 2016–17, whose participation was 33.75% (27 responses from a total of 80 students). As it is shown in Fig. 3, the theoretical and practical classes have been better coordinated, and it has improved the evaluation of the way the subjects have been explained by teachers, avoiding repetitions between them. But the real improvement can be seen in the rising up to a 20% increase of the evaluation of the coordination between teachers.

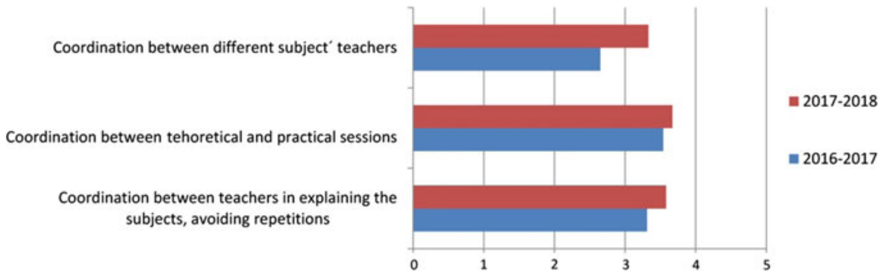



**Fig. 3.** Comparison of the evaluation of students, between consecutive years, of coordination problems within the subject

In any case, the experience developed has only been a first test that should be continued and improved in future years. Some aspects that may be susceptible to improvement have been detected, such as the degree of participation and involvement of students in the activities, which should be analyzed in future experiences. These will allow, in addition, to evaluate in a more quantifiable way the improvement that this methodologies entails in the acquisition of knowledge by the students.

## 6 Conclusions

It is important to state that the academic project should not be confused with the professional assignment. The academic project aims firstly to show a way of working and provide its experimentation to achieve a learning through the project, more than to achieve project results themselves.

Methodology must be differentiated from process. Knowing the process establishes the method or methods to follow (sometimes, vice versa). All methodologies have a common base; the flexibility in applying one method or another is the key to success in different environments, which is another goal to reach in a learning experience. No method is infallible in absolute terms. The same method can be correct in some situations and incorrect in others. The projects are different. The methods experienced in other projects can be reused provided they are evaluated positively in terms of this new situation.

There are different methods of projecting according to the designer and type of project. Any method can be enriched with new methods. A new method can always be developed before a new project. It can be improved by modifications or reviews of existing old methods.

In a creative environment, creativity is applicable to the process and to the methodologies themselves. Creating new methods is a necessary task itself to develop stimulation techniques of creativity workshops, since sometimes saturation or lack of references can block the student's generation of ideas. To be able to do this work requires creative ability, have technical knowledge and also strive to know well how are the people who will use the product, where they will use it, what their needs are and what will be the best way to manufacture the product, among others aspects. So the multidisciplinary identity of the design process is something that the students must bear in mind at every moment while experimenting with specific tools.

Though the process exposed in this paper the design student:

- Will be able to know, to experience, and to understand different methods of industrial design approaches, their potential evolution and their application possibilities depending on the kind of project to be carried on.
- Will learn to particularize the design process, making it applicable to any project design, and adapting it to any particular case.
- Will understand the need and relevance of structuring design processes in phases to keep a control of the project environment, an adequate scheduling and a proper management of the overall frame of work.
- Will gain confidence on their training to find solution to different problems of increasing complexity, based on the development of conceptual proposals within a design process.
- Will able to reach a technically viable product proposal from a conceptual proposition.

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