V!18
issn 2175-974x | ano 2019 year
semestre 01 semester



# cultura hacedor, co-creatividad y practicas didacticas colaborativas

# maker culture, co-creativity and collaborative teaching practices

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How to quote this text: Barros, D. R., 2019. Maker culture, co-creativity and collaborative teaching practices. *V!rus*, Sao Carlos, 18. [e-journal] [online] Available at: <http://www.nomads.usp.br/virus/virus18/?sec=4&item=1&lang=en>. [Accessed: 08 July 2019].

ARTICLE SUBMITTED ON AUGUST 28, 2018

**Abstract:**

Design Thinking recognizes different contributions on collective creativity applied to project processes. It assumes that creativity can be considered as co-creativity or as a shared intervention, supported by actions of a participatory nature and collective collaboration that interacts with the initial creation, mutates based on interventions of others, and offers alternatives for the recreation of processes and results. With a clear trend from mono-disciplinary practices towards interdisciplinarity, we present a teaching practice carried out at the Industrial Informatics Workshop 2 with product orientation, in the course for Industrial Design FAUD UNMdP, Argentina. It was based on previous experiences reformulated from the perspective of a Maker Culture. There has been a focus on the design and redesign of an everyday object/machinery based on low complexity mechanisms. It was solved by 3D mechanical parametric modeling, rapid prototyping using different digital manufacturing technologies (3D printing, milling and laser cutting) and different communication modes. It is important, from a virtual perspective of post-digital environments interconnected to the Web, to present the methodology used as a possibility to contribute to teaching practices tending towards the exploration, formulation and practice of collaborative creation ecosystems that improve collaborative learning techniques.

**Keywords:** Maker culture, Co-creativity, Teaching practices, Design Thinking, Digital manufacturing

## 1 Interactions between maker culture, design thinking and co-creativity

Post-digital environments, which are virtual and interconnected environments, as rated by Cramer (2014) and Pardo Kuklinsky (2010), are propitious for the development of a particular phenomenon expressed as Maker Culture.

This activity is recognizedas originating in DIY(Do it Yourself Technology) and has been changing towards DIWO (Do It With Others). Based on interdisciplinary approaches it basically links design, computing and robotics. It stimulates collective work, generation of community knowledge and discourages individualism. Macmillan (2012) states that these practices give visibility to a controversial redefinition of innovative relationships between society, culture and technology. It emphasizes empowerment, access to open knowledge, free applications, unprecedented modalities of validation among peers, renewed possibilities of recreation of products without large investments, easy to share "what, how and why something is created and co-created". In short, these are virtual and real spaces of collaborative work. According to Arango Sarmiento (2016) they are altering relationships of the global-local antithetical pair which are being increasingly replaced by the massive-crowd individualized pair.

A strong sub-culture within this trend is oriented towards digital manufacturing. For Head (2017), these practices are supported by *ad hoc* networks of FabLabs or small-scale digital manufacturing laboratories and ThinkingLabs or laboratories for exploration, creativity and innovation. In this sense Martini and Chiarella (2017) indicate that these areas are conducive to carrying out tasks of exploration, design and manufacture of physical products on a personal and local scale to solve specific problems.

From such a pragmatic perspective, the material culture of "Homo Faber" manifests itself as a phenomenon that generates profound changes linked to the passage from the virtual world to the physical world. It values dialogical postures, cooperation, participation and shared creation, along with the development of skills necessary to generate and inhabit new sustainable environments.

In a complementary manner, Gutierrez Rubi and Freire (2013) point out that it stimulates the expansion of financing spaces from micro-sponsorships in search of project funds (crowdfunding) giving rise to new types of investors. It also creates new micro-production spaces, with free access to resources and indispensable applications for the development of equipment and 3D printers, applications for manufacturing open source remote processes, hardware and free software platforms, and technological and scientific documentation, among other resources.

The conceptual and methodological approaches of Design Thinking are convenient to articulate these new practices. Brown (2016, 2009) qualifies them as unstable states centered in man; positioned in cultural contexts of problems and uses; interrelated with experiences between objects, processes, emotions and functions, linking analytic processes with feelings and intuition; and based on the ability to be intuitive and rational.

It is interesting to focus on the possibility of investigating design teaching practices, which are creative and include reality-based, participatory co-creative and collaborative individual and group design practices. All tending to identify, face and resolve situations of diverse complexity; state and verify hypotheses; and experiment and generate rapid prototypes in project processes.

## 2 Creativity, co-creativity and collaborative practices

In the first place, it is recognized that, in a traditional way, creativity is individual in nature. It manifests itself in directions that can be in interaction with each other. Esquivas Serrano (2004) states that its object is to produce something unprecedented and original with the aim of altering reality, or with manifestations independent of reality, or to lead to unexpected solutions. For Taylor and Gantz (1969), creativity manifests itself in many forms. Expressive creativity, typical of the first years of life with congenital features, to develop new skills. Productive creativity, of a practical nature, to promote skills that will differentiate each individual. Inventive creativity, with a wide range of interests, to generate varied and original ideas arising from the flexibility of thought, experience and acquired knowledge. Innovative creativity, with a high level of abstraction, to modify, improve or generate new processes and results. The emerging creativity, of greater complexity, to promote principles, foundations and totally original ideas.

However, the concept of creativity can be considered from a broader perspective than that limited to the individual generation of novel quality ideas. De Bono (1994) argues that creative thinking is based on the logic of processes of self-organizing systems and effectiveness of techniques and developments that distance them from contingent situations linked to talent, personality or eventuality, and reaffirms it as a skill that can be cultivated and developed in a broader context. Csikszentmilhayi (2006) specifies that the creative process is recurrent, expressed at different moments and orders as a contaminated combination insofar as it links pairs from different cultural contexts and domains, social contexts and scopes, ultimately of persons and subjects.

Restricted to Design, the concept of creativity is close to a phenomenon of hybridization. It can be taken that creativity pulls towards co-creativity as a collective and contextualized construction. It would seem that it is the scope of action of communities of practice that are based on cultural diversity, different ways of living and understanding reality; to understand and interpret practices of social and technological innovation; to produce and generate value increasing knowledge according to unpublished variants of collaborative learning created with others.

For Sanders and Simons (2009) co-creativity derives from shared operations based on initial instances of individual creation, then it is linked to the presence of others who record and evaluate what is done, in addition to offering alternatives to the recreation of processes and results. They estimate that, in design processes in pre or post-design phases, the migration of creativity towards co-creativity has three requirements. It is essential that there is acceptance of everyone's ability to be creative, as a diversity of perspectives, positions and criteria; the capacity for dialogue and interaction among those involved, as a shared construction; the possibility of collaborative work, in as much as it includes common knowledge, materials and ideas with the purpose of sharing them to generate further common knowledge. In other words, the contribution of creativity in particular contexts as well as co-creativity in relation to previous basic ideas is legitimate.

Following the same line of thought, Sternberg (2005) considers that there are different levels of creativity and co-creativity according to levels of interaction and considers different statements referring to the paradigms of "what is or should be", "what is or has to be", "as things are now is how they will always be ‘and’ to do the same as others is the safest thing in life". He formulates a model that contains divergent and convergent strategies, insofar as accepting a paradigm or rejecting it with the intention of achieving its replacement. In order of increasing complexity, it recognizes qualitative typologies associated with different interventions on creativity and co-creativity. It starts with replication operations within and at the limits of the paradigm, as a certainty of the correct paradigm. It continues with redefinition operations, such as the need to reformulate the paradigm without exceeding its limits. It continues with operations of progressive increase and qualitative increase, such as forward advances and advances towards more than what others can achieve within the limits of the paradigm. In this state it defines a point of inflection as it overflows the limits of the original paradigm, causes its rupture and generates a new one. It disrupts with restart operations, with a new starting point oriented in another direction; with redirection operations, such as a profound change in the course of the paradigm; with reconstruction operations, like advances backwards and then in another direction; finally, with synthesis and integration operations, such as overcoming and formulating a new paradigm.

Freire (2012, 2013) argues that in the process of mutation of creativity towards co-creativity it is interesting to recognize, reformulate or rethink processes of transformation and innovation as initial challenges. The same, both individually and collectively, begin with the exploration of new ideas or opportunities that will trigger activities to discover and enunciate, continue with the development of models and prototypes to conceptualize and detail, and ends provisionally with the implementation and evaluation of the generated. Such a tour is in full consonance with Design Thinking. Both positions, on the one hand, reveal a type of integrative thought of an abductive nature, on the other they link deductive and reliable thinking characteristic of the abstract sciences together with an inductive and valid thought characteristic of the experimental sciences. For Christensen, Dyer and Gregersen (2011), these journeys use experimentation, verification, visualization and communication through rapid prototyping and manufacturing.

It seems inescapable that from such phenomena, says Anderson (2012), there is a cultural and economic hybridization oriented towards a new class of designers and producers in a fluid interaction between creativity and co-creativity. In a contingent manner for Cobo and Moravec (2011), these experiences originate in unpublished egalitarian environments, within the limits of formal education, or linked to informal practices, or they occur in intermediate meta-spaces. In any case, it is recognized that there are necessarily unique contributions, practices and shared hybrid competences between the intangible and physical modes of post-digitalization, which for Kelly (2016) are the result of unique cognitive ecosystems close to the concept of Collective Intelligence.

This raises some basic questions about how such events migrate towards formal learning in undergraduate careers, what influences and implications they trigger, their advantages and disadvantages in the training of students, how they are tackled using teaching practices, which are the degrees of reformulation and reflection on our own teaching practices. Originating in these questions, the state of the issue and its conceptual framework, a teaching practice was addressed in the Industrial Design degree course, with the intention of exceeding mono-disciplinary practices by tending towards inter-disciplinary practices. Interested to deploy this experience from processes related to creativity and co-creativity during the transit of the phases of a design process. It began with the exploration of new ideas or opportunities that triggered activities to discover and formulate; models and prototypes were developed to conceptualize and determine greater detail; these products and their production were implemented and evaluated based on prototyping as a viable materialization to explore, stimulate sensations and perceptions, build meaning, interact and generate feedback.

## 3 Case of collaborative didactic practices in industrial design

Based on previous reformulated experiences (Rodríguez Barros and Pellizzoni 2017, Rodríguez Barros, 2016), a teaching practice was developed in the Industrial IT Workshop 1-2 (tii 1-2) level 2 Product orientation, corresponding to the 3rd year of the career of Industrial Design the School of Architecture, Urban Planning and Design, National University of Mar del Plata, Argentina. It was carried out during the 1st semester of the

2017 school year, with a four-hour classroom period for twelve weeks, complemented by closed-group interactions on social networks. A work commission was formed by forty-eight students who worked individually and as a group, accompanied by a team composed of three graduate teachers and three advanced student assistants.

From the curricular framework, the objectives of the course focused on experimenting and developing methodologies andtechniques for 3D mechanical parametric modeling, rapid prototyping, representation and communication in a post-digital environment.

The practice focused on the design and redesign of objects close to students' everyday uses. We worked according to the teaching methods based on workshop activities, as an experimentation and manufacturing laboratory, as Schön (1998) points out. Conceptual and methodological slogans were used fluently and in interaction. The conceptual sustenance, in line with the methodology of Design Thinking (Brown, 2009 op.cit.), recognized interactive action sequences that formed a continuum of procedures with the necessary feedback, reflections and reviews. The restricted range was moved to spaces to Inspire (detect, discover and interpret problems), Ideate (formulate, create, validate ideas in the formal, functional and emotional, tending to generate viable, feasible and sustainable solutions) and Experiment (manage, build, visualize, show, test, evaluate and verify alternatives, and communicate). The operational sustenance, following the Design Process - Phases for the development of INTI products (2009), recognized precise moments of the project development on issues related to concepts and ideas regarding types, diagrams, representations of three-dimensional models, corporeity of prototypes, visualization of communication pieces.

In this way and in interaction with both criteria, the practice was focused on analyzing, discovering, and conjecturing; then on reflecting, projecting, and modeling; then on collating, prototyping, evaluating; and, finally, on arguing and communicating ideas and products.

Specifically, during this experience, design interventions were generated in interaction with preexisting concepts referring to basic mechanisms to be applied to objects redesigned by students. It was assumed that a mechanism is a grouping of mobile components that integrate machinery, that are interlinked with each other and facilitate the transmission of movements and forces. To be considered as such, they must be constituted, in a basic way, by various components such as links, nodes and joints or kinematic pairs.

Working in pairs, the students detected, based on close and daily joint experiences, and the consequent critical reformulation, a series of problems that served to specify and select the topics to be addressed. They had to focus on the design, 3D modeling and prototyping of simple machines with low complexity mechanisms.

They posed questions, jointly identified problems, posed possible solutions and alternatives, specified the user, contexts and mode of use.

They defined the objectives of the design and formulated a tentative hypothesis in the form of conjecture in order to optimize the effective, simple and satisfactory solution of the detected problem.

They recorded backgrounds on mechanisms, machinery and assimilable objects. They analyzed morphology, organizational structures, ergonomics, dimensions, functionality and materiality. Such antecedents were referents for the subsequent design and eventual partial redesign, following the perspective of redefinition and progressive incremental steps (Sternberg, 2005).

They solved the design of said object, putting emphasis on morphology, dimensions, functions, linkage between parts and assembly, and manufacturing possibilities. They interacted with manual sketches and parametric 3D mechanical models. Rendered the 3D model with advanced applications to assign realism. They generated animation videos to verify the operation of the machinery and the consequent mechanism.

Advised by experts, they explored available digital manufacturing options. They made fast prototypes, depending on the case, opting for laser cutting, subtractive technologies (2D-3D CNC milling, chipboard, foams, acrylics or MDF boards), and/or additives (3D printing).

They generated complementary 2D documents according to standardized regulations. With such documents and with the 3D model, in addition to short descriptive texts, they generated presentation catalogs, user manuals and digital and printed posters (Figures 1, 2, 3, 4, 5, 6, 7, 8).

They completed the process communicating their experience with a digital synthesis giving an account of the process and the resultant machinery and the components of the mechanisms involved, technical specifications and assembly plans.

Face-to-face, group exchanges and presentations, partial and final evaluations, self-evaluation and peer evaluation as a test were carried out.


**Fig. 1:** *Lazy Pet*. Dispenser pet food. Catalog (Cover, Index, Components, 3D Rendering Model, Parts, Renders). Lucía Belderrain & Alejandra Kloss Mardones, students tii 1-2. 2017.


**Fig. 2:** *Lazy Pet*. Dispenser pet food. Catalog (Cover, Index, Components, 3D Rendering Model, Parts, Renders). Lucía Belderrain & Alejandra Kloss Mardones, students tii 1-2. 2017.

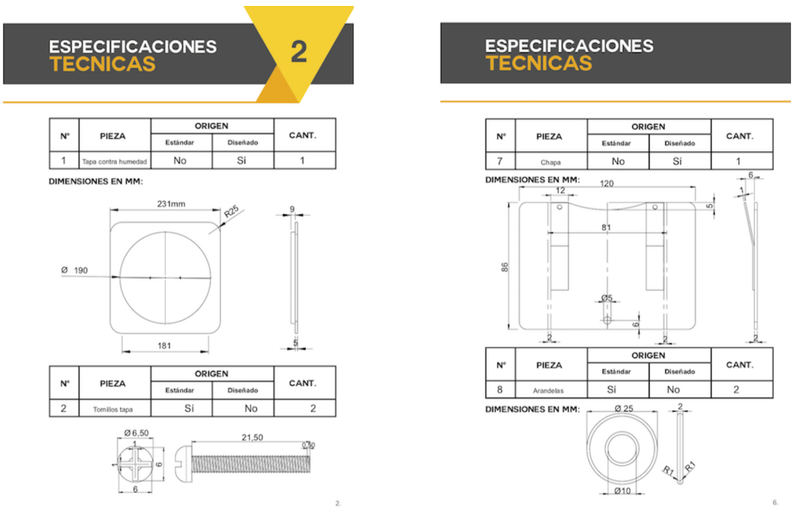


**Fig. 3:** *Lazy Pet*. Dispenser pet food. Catalog (Components, Model, Parts, Assembly, Operation). Lucía Belderrain & Alejandra Kloss Mardones, students tii 1-2. 2017.

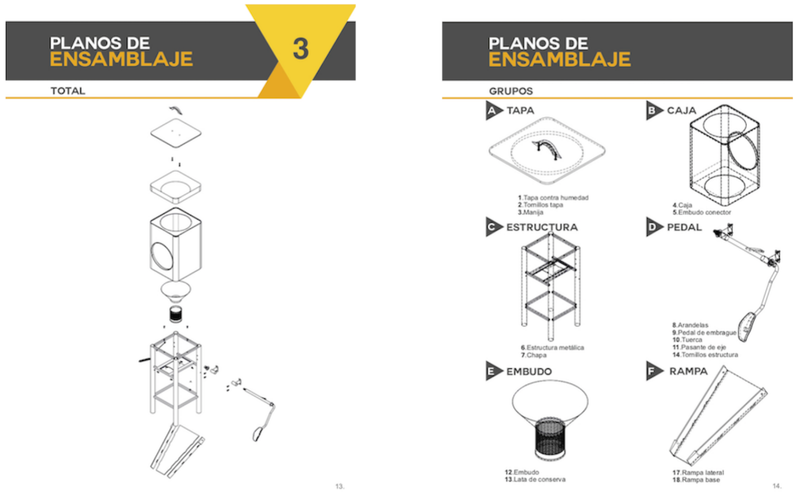


**Fig. 4:** *Lazy Pet*. Dispenser pet food. Catalog (Components, Model, Parts, Assembly, Operation). Lucía Belderrain & Alejandra Kloss Mardones, students tii 1-2. 2017.

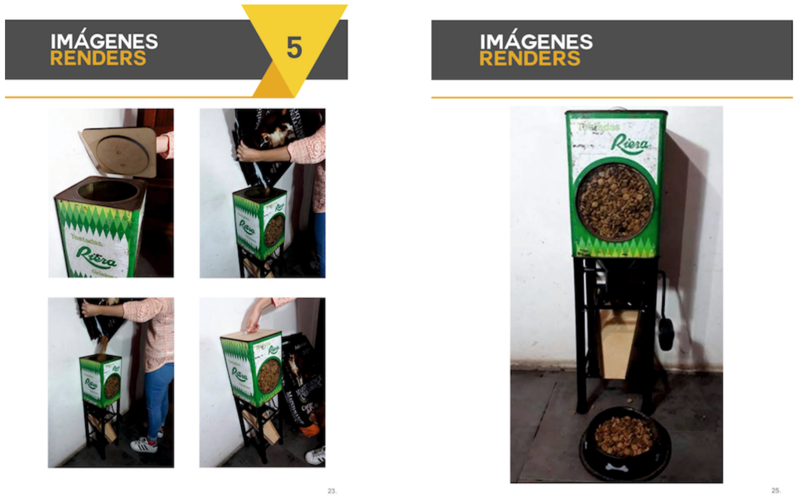


**Fig. 5:** *Lazy Pet*. Dispenser pet food. Catalog (Prototype Back Cover). Lucía Belderrain & Alejandra Kloss Mardones, students tii 1-2. 2017.


**Fig. 6:** *Lazy Pet*. Dispenser pet food. Catalog (Prototype Back Cover). Lucía Belderrain & Alejandra Kloss Mardones, students tii 1-2. 2017.


**Fig. 7:** *Lazy Pet*. Dispenser pet food. Catalog (Cover, 3D Rendering Model). Lucía Belderrain & Alejandra Kloss Mardones, students tii 1-2. 2017.


**Fig. 8:** *Lazy Pet*. Dispenser pet food. Catalog (Cover, 3D Rendering Model). Lucía Belderrain & Alejandra Kloss Mardones, students tii 1-2. 2017.

## 4 Results of the teaching practice

In the first place, a series of indicators were needed to analyze and evaluate the experience based on traditional creativity indicators. In this regard Guilford (1991), referring to the subject, believes that creativity is an indirect consequence of skills and competences related to fluence, flexibility, originality and elaboration, and is the result of divergent thinking and production.

For his followers Bessey and Mumford (2012) together with Logan and Logan (1980), creative thinking can be analyzed and evaluated according to indicators that contemplate actions and competencies that are faced every time a problem is recognized and requires resolution based on sensitive knowledge and mental flexibility, association and coding of new events, and links with previous and relevant experiences. Influenced by the sociocultural context, it infers the existence of learned coding by creating unique and interrelated responses with cognitive aspects projecting personality, emotion and originality. Consequently, it recognizes indicators of creativity of a flexible, singular, imaginative, integrating nature; recurrence to indirect and personalized teaching methods; stimulation of self-direction and self-assessment.

Secondly, by integrating the participatory concepts that stimulate co-creativity in post-digital environments and from studies carried out by the teaching group (Rodríguez Barros, Molina and Molina 2015), such indicators have been expanded and reformulated.

Following this line of thought Gardner (2017) began considering that creative thinkers resort to their own mental operations and those of others, making flexible and effective use of such cognitive behaviors projecting towards broad and challenging horizons, with clear goals and objectives, it is both vehement and constant as well as passionate and thoughtful. In post-digital environments, such modalities can become empowered towards new ecosystems of creation and collaboration and recognize meta-cognitive skills related to the construction of knowledge.

In this way, on the one hand, the capacity for innovation, the high quali-quantitative frequency of ideas, the unpredictability or uniqueness of these ideas, the degree of development, the deepening and finishing of productions, the ability to restructure and reconstruct, the conjunction between analysis and synthesis, empathy and sensitivity to problems was recognized. On the other hand, the stimulation of collaborative habits of creation and validation of knowledge, access to open knowledge, self-learning, self-evaluation and peer approval; the modalities of collective and individual participation were also recognized.

In summary, it was seen that this experience overcame instrumental limitations fixed by curricula and stimulated exploration. Problems and solutions to problems with innovative answers and relatively innovative feasible products were detected. The alternative of making rapid prototypes with 3D printing technologies made it possible to collate, verify and refine results in a feasible and accessible manner and with minimal investments.

There were considerable stimuli and advances towards instances of learning and self-learning, use of technologies and transfer to specific applications. Also, management capacity tending to efficient conceptualization processes of methods to determine uses, applications and interactions between 3D modelers, renderers, and those engaged in image processing, animations and digital manufacture. These advances were interpreted and addressed by students from observable sequences and consequences, in direct contact with products, results and feasibility of transfer to specific assimilable situations.

Proactive competences of a hybrid nature (e-skills*)* were observed regarding the capacity for observation, querying, association, connection, experimentation, integration, adaptation, re-adaptation, consensus and empathy. Likewise, regarding identification, formulation and appropriation of shared non-traditional modes of action in common environments with shared languages, both from disciplinary and interdisciplinary points of view.

## 5 Provisional conclusions and discussions

Based on typical Maker Culture scenarios, two aspects of positive influence of the experience are considered.

From the perspective of the students, in addition to generating operational and instrumental knowledge with graphic computing applications oriented towards logics and work methodologies, the commitment to take on active roles was highlighted, with awareness of the need for change and constant striving to be up to date. In the same way, they were faced with the inescapable fact that they had to interact in environments of exploration, experimentation, reflection and criticism about the practice itself and the processes involved in virtual and physical post-digital environments. Likewise, they had to understand that it was necessary to redefine the model for the production of knowledge, objects and environments, where students are active producers and consumers of technologies, content, objects and information generated by those same technological and interconnected infrastructures.

From the teaching perspective it is considered that in post-digital environments the traditional teaching role has varied and it is indispensable to deepen a state of fluidity and effective and constant renovation. Such a change operates both towards the figure of the guidance teacher in order to collaborate in the construction of meaningful knowledge and students in their learning processes, and towards the figure of the tutor teacher while accompanying the students in a personalized way, and recognizing individual students' problems, motivations and interests.

As a provisional conclusion, the experience generated meaning from the assessment of co-creativity and collaborative learning as transformative capacity. On the one hand, exploring and formulating practices towards new ecosystems that underline learning, reciprocal participation and creation with and together with others; produce empathy among peers and form communities of practice; learn to agree as to meanings and generate value from local and external knowledge. Also, to devise, generate, manage and produce ingenious systems; value interconnected participatory and cooperative work environments to take advantage of opportunities, confront risks and overcome failures, as well as obtain satisfactory results. On the other, to dismantle, rethink rigid rules and transform them into original and practical rules; and visualize and share trends.

Finally, and as part of the discussion, a proposal to reflect on a series of basic issues is posed.

Increasing the depth of learning with personalized guidance, both based on projects or problems close to the interests of students, as well as considering the needs of the environment without excluding experimentation of a free nature.

Emphasizing the development and stimulation of cross-section competences, both focused on own practices in particular areas of interest of different areas but extensive to interdisciplinary approaches, and also oriented towards the possibilities of creation and co-creation that these activate.

Appropriately considering the relevance of hybridization between Science, Technology, Design, Engineering and Mathematics during teaching processes, with a relevant place given to post-digital knowledge in programming and robotics, as well as encouraging coexistence, empathy and knowledge in any interaction with others.


## 6 Acknowledgements

The experience took place during transfer activities of research projects 15/B310 and 15/B337 SCTyC UNMdP EMIDA CIPADI FAUD UNMdP under the direction of Architect Rodríguez Barros, PhD.

The teaching team of the Industrial Computer Workshop 1-2, directed by Architect Rodríguez Barros, PhD, was integrated by Industrial Designer Pablo Pellizzoni, Graphic Designer Claudia Ros, Architect Paola Nigro, and auxiliary advanced students Lucas Turkalj, Guido Rumitti and Maximiliano Carosella. With the help of Industrial Designer Enrique Frayssinet as external consultant on 3D printing.


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