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Collaborative learning by way of human-centered design in design classes

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ABSTRACT

The design classes are part of the bachelor curriculum of Brazilian Design. These classes are usually preceded by others that present the fundamentals and methodologies for product development. This paper adopted the human-centered design (HCD) for its potential to serve some of the needs and complexities of current projects and contexts. In order to foster rhetoric and multidisciplinarity among design students, collaborative learning emerges as an opportunity to practice design in a multidisciplinary way, due to the need to develop collaboration skills, as well as the transcendence of cognitive bias arising from individual activities. This article used knowledge construction processes in particular: the externalization and elicitation of task-relevant knowledge and consensus-building. Thus, the aim of this study is to propose an approach between design steps (taking HCD as the basis) and collaborative learning, based on their dimensions, in order to understand and address some of the current complexities and requirements of human, social aspirations and, consequently, projects. This approach demonstrates that the collaborative learning opportunity provided by the use of HCD can be driven by an adherence to the collaborative knowledge construction view. Real opportunities for the co-construction of new meanings stand out among the results of this approach, so that the learner can understand the complexities inherent to the design and to human beings, and can recognize and apply them in new and different situations.

Keywords: design education, human-centered design (HCD), collaborative learning, collaborative knowledge construction, design classes.

Introduction

The theoretical and practical design classes in design education approach and promote the professional activities that students will be capable of exercising when they graduate. In the different curricular structures of undergraduate courses in Design in Brazil and the capabilities they offer, there are notable variations in the terminology employed in the design classes. Another variation occurs regarding when these classes are taught; in some courses this happens in the first year and in others in later, more advanced semesters in the curricular structure. A characteristic common to these courses, however, are the classes prerequisites for enabling the student to study design subjects, among which it is desirable to include the design methodology class, which introduces the fundamentals and methods needed for developing projects.

Among the classic references forming part of the bibliography of design methodology and design class those authors particularly worth mentioning are: Bonsiepe (1984), Munari (2008), Bonfim (1995), Roozemburg and Eekels (1995), Baxter (1998), Löbach (2000). Some of these references can be considered as belonging to the transition to the post-industrial period, containing as they do some user-related elements and concerns. Some of the themes that are currently considered essential, however, did not appear on the horizon of the problems that were associated with the classic methodologies (Bonsiepe, 2012). With regard to the conventional design methodologies, Moraes (2010, p. 17) comments that their conception:

> *[...] for many decades served the basic needs of the consumer and was in line with the technical-productive limitations that existed during the whole of the industrial development period of the modern age. But today this no longer corresponds to the reality of the complex and changing scenario in which we live [...] New creative tools, therefore, are necessary for filling these gaps that the methodological models so far used are incapable of doing alone.*

When considering the Brazilian Curricular Guidelines for a bachelor's degree in Design (Resolution CNE/CES5/2004, March 8, 2004) (Couto, 2008), it is worth mentioning some of the passages that were taken from them and that were adopted for contextualizing and forming the basis of this article. According to this document, the teaching design class of the undergraduate course in Design must cover, among other things, structural elements to make it possible to achieve inter-disciplinarity and evaluate both what is taught and what is learned. Article 4 sets out the competences and skills that the professional's education must enable, such as: a creative capacity for suggesting innovative solutions, using a mastery of techniques and of the creation process; a capacity to interact with specialists from other areas in such a way as to use different aspects of knowledge and work in an interdisciplinary team when preparing and carrying out research and projects; and a mastery of the different steps in design, such as: a definition of objectives, data collection and treatment techniques, the generation and evaluation of alternatives, shaping the solution and communicating the result.

As a design class teaching proposal, therefore, that can meet some of the current needs, demands and complexities, this article adopts a human-centered design (HCD) approach. As Krippendorff (2000) mentions, education in human-centered design needs to teach collaborative design techniques and ways of involving stakeholders, not only as subjects or informants, but above all as active participants. HCD opens up a vast arena for designers to make their own practices clearer, to throw light on their own methods and to perfect their own language.

Formal education is an important dimension by which design students learn a way of speaking and thinking that is proper to designers (Krippendorff, 2000).The designer's skilled use of rhetoric is essential so there is complete inter-disciplinarity and multi-disciplinarity, as well as teamwork and working in partnerships, which are characteristics common to and intrinsic in design teaching and practice. In his research into the teaching of design class, Alvares (2004) pointed out the main problems he observed, the following being three of them: (1) what is learned in a class is not spontaneously transferred to other subjects and what has been learned in a class is not used for facing up to the real-life situations in which this knowledge becomes necessary; (2) relationship problems between the professor and student in the traditional teaching/learning process, which makes open and creative interdisciplinary action difficult; and (3) the profile of the teachers involved in developing inter-disciplinarity depends considerably on the willingness, the attitude and the skill of the professor/researcher to leave their routine intellectual, professional and social orbit and work closely with colleagues from other classes.

As an alternative for helping with the teaching problems described here and for fostering rhetoric and multidisciplinarity between design students, a knowledge of collaborative learning is an opportunity to practice the design activity in a multidisciplinary way, because of the need to develop a collaboration competence. Collaborative learning does not come about as a result of simple group action, since the simple division of work may often take advantage of the characteristics of each one independently. In the collaborative learning view, the student arrives (or may arrive, depending on the phase in which the classes are taught) with previous baggage from other projects and this knowledge may have been acquired by the student strictly within the context of the experiences they had, making it impossible for them to replicate it in another situation/project, which characterizes situated learning, in the sense expressed by Novak (2002). It is, therefore, essential to externalize, elicit and reconstruct knowledge (both for adjusting mistaken concepts and increasing the complexity of the conceptual structure) for promoting learning.

The objective of this article is to propose an approach between knowledge of collaborative learning in the design class stages and the adoption of HCD for developing projects, because this is a contemporary approach to design that focuses on the user and the human being and that manages to comprise and contemplate a considerable part of the world's current complexities and human demands and aspirations.

Human-centered design in design class

The human-centered design (HCD) approach is presented in some references as an expansion of user-centered design, to the extent that both share a similar origin. The roots of HCD lie in areas like ergonomics, computer science and artificial intelligence. As a result, HCD is based on techniques that communicate, interact, emphasize and encourage the involvement of people and this leads to an understanding of desires, needs and experiences that normally transcend the perceptions of the latter (Giacomin, 2014).

As Giacomin (2014) and Keinonen (2010) commented, among the factors that punctuate the change from the "user" concept to the "human" concept is the inclusion of the term in the ISO 9241-210 international technical standards, which contain six principles as to what human-centered design comprises:

(a) The design is based on an explicit understanding of users, tasks and environments;
(b) Users are involved throughout the whole design and in its development;
(c) The design is conducted and refined by user-centered evaluation;
(d) The process is iterative;
(e) The design deals with the user's experience as a whole;
(f) The design team includes multidisciplinary competences and perspectives.

Among the definitions of HCD, Krippendorff (2000) says that this approach is concerned with the way that people see, interpret and live with artifacts. Brunel University's Human Centred Design Institute (HCDI) defines HCD as:

> *an approach that integrates multidisciplinary expertise towards enhancing human well-being and empowering people. It leads to systems, machines, products, services and processes which are physically, perceptually, cognitively and emotionally intuitive to use (HCDI, 2016).*

Chart 1. Description of the stages from d.school's Bootcamp Bootleg.

Empathize	Define	Ideate	Prototype	Test
In adopting HCD, the people for whom the project is being designed need to be understood. Most of the time the designer is not a user and empathy will help with an understanding of who these users are and what is important to them.	In this stage the information obtained in the Empathize stage is synthesized into needs and insights, so generating a specific challenge. This declaration of the problem that focuses on the specific user is defined as point of view.	This is the stage for generating ideas. Its objective is to explore solution possibilities. From the diversity of the ideas, it is possible to prototype some of them and test them with users.	Prototyping is transforming ideas into physical things and may be any resource, like a board covered with post-it notes, role-playing, a space, an object or a storyboard. The user's interaction with the prototype leads to deeper empathy and helps shape the solution.	Testing enables the solution to be refined and improved. This is a way of introducing a cheap solution into the user's context. Prototyping is carried out as if one knows the solution is right and testing as if one knows it is wrong.

Source: d.school (2016), Institute of Design at Stanford. Back-translation from Portuguese.

This approach shows that innovation, along with business and technology, must also be a factor related to human needs, behaviors and preferences. By way of observation HCD is going to capture unexpected insights and produce innovations that will reflect what consumers want (Brown, 2008).

According to Giacomin (2014, p. 614), "Today's human centred designer is a relatively transparent figure who does not impose preferences on a project, but who instead stimulates, conveys and translates the will of the people involved". In addition to the theoretical references, HCD and UCD encompass a diversity of methods/techniques that are used by professionals in developing their designs. The collection diversity of these techniques grows continuously and some methods originate in other areas of knowledge, like psychology and sociology, while others are defined on the basis of experiences that emerged from design practice (Giacomin, 2014). It is possible to observe an organization in the structure of these collections that is based on the structure in which they are used. Among these collections are the toolkit produced by IDEO (2016), the proposal of Brunel University's HCDI and the collection of the d.school, which is attached to the Institute of Design at Stanford (2016).

The d.school proposal declares that its approach is human-centered and it makes available a toolkit called the Bootcamp Bootleg, which presents methods that were implemented and tested on the university's own course.

D.school proposes five steps: Empathize; Define; Ideate; Prototype; and Test (Chart 1). According to the definitions, they do not need to be rigidly carried out in the HCD process.

The organization and definitions of the steps proposed by the d. school are adopted for the approach proposed in this article, between an up-dated design process structure that helps with current user needs and desires and collaborative learning. The phases organized in the d. school, therefore, are transposed in this article as stages that are experienced by students in the design class. The methods that belong to each phase are not emphasized in this approach, since their definition is linked to the specificities and objectives that are intended with each project.

Collaborative learning and knowledge construction

In the view of Vygotsky (1978, 2008), development is conceived of as a process by which those learning grow intellectually through interaction with those around them. Nussbaum *et al.* (2009, p. 147) say about Vygotsky's conception:

> *From this standpoint, the common posture of attributing thoughts and intentions solely to individual actors is a misconception in the understanding of shared knowledge and group cognition, because it neglects the interactions that arise in the group as the source of development itself, by reducing group phenomena to actions of the individual group members and ignoring their contributions to creation of group meaning.*

When students have the opportunity to work in small groups they can contribute to a common understanding and develop verbal and social skills. Peers work in a common context and, therefore, may develop an insight into other learners' needs, their focus and the best way to explain them (Lave and Wenger, 1991). Those involved in this process benefit from the opportunity to experiment new ways of thinking when taught. They also obtain gains when explaining their ideas to others, since they need to verbalize their understanding and this makes the difference between what is internalized and its interpretation explicit, thereby giving rise to a clearer perspective of the topic.

Nussbaum *et al*. (2009) stress, however, that collaboration in itself does not necessarily produce learning, and it is with regard to this point that an important reflection for the teachers of design class arises. Effective collaborative learning requires accurate teaching plans and the students must be taught how to manage their learning in groups. Effective collaboration gives rise to greater peer participation in group discussions, and students then begin to demonstrate a more sophisticated level of discourse, interrupt less when others are speaking and provide more intellectually valuable contributions to these discussions.

According to Vygotsky (2008), the construction of new meanings occurs in a "zone of proximal development", or the area of cognitive structure that is ready to accept new ideas or alter them. This may partly explain the effectiveness of learning in a group, since the students tend to be closely aligned in their "zones of proximal development" and meanings can be more usefully and easily negotiated between them.

In this environment, it is relevant to consider that the whole teaching and learning process has different hierar-

chies. This hierarchy can be represented in different ways, as by the presence of the instructor or teacher, by the group members' unequal levels of knowledge of the task, or with regard to the proximity of the learner to the topic being studied (Correia and Infante-Malachias, 2009).

In collaborative learning, students build up knowledge that is rich in meaning and arrive at consensus by working with, talking to and sharing with others. This view is based on social construction, in which it is understood that it is possible to learn indirectly by way of the experiences of others (Boyer *et al*., 2006). To be capable of learning from their peers, students need to be prepared in how to learn collaboratively and to receive feedback on their social skills (Bolhuis and Voeten, 2001).

When looking in a systemic way at collaborative learning it is important to understand the variations that exist in theoretical perspectives. Strijbos and Fischer (2007) recognize that research into the subject of collaborative learning, both face-to-face and computer-supported, has thrived over the last few years. "The studies range from outcome-oriented (individual and group learning) to process-oriented (impact of interaction on learning processes, motivation and organization of collaboration) to mixed studies)" (Strijbos and Fischer, 2007, p. 389). The variation in the theoretical perspectives on collaborative learning is reflected in the learning metaphors used. Lipponen *et al*. (2004) split them up between the acquisition, participation and knowledge creation metaphors. Considering the question of the relevance of generating knowledge and teaching collaboration for creating a design science and for the development of cognoscibility (Bonsiepe, 2011, p. 230), this work adopts the knowledge creation view (Lipponen *et al*., 2004; Strijbos and Fischer, 2007).

There are four distinguishable processes in collaborate knowledge construction that cover both the content dimension and the functional dimension of learning (Fischer *et al*., 2002, p. 214-215), as follows:

- *Externalization of task-relevant knowledge*: A necessary condition for the collaborative construction of knowledge in the discourse is that students bring prior knowledge to the learning situation so that different points of view and opinions can be clarified. Situated learning approaches stress the relevance of externalization, because they consider the exchange of different individual concepts to be the starting point for negotiating the meaning that is common to the discourse (Brown *et al*., 1989). Externalization is the first step towards adjusting conceptual mistakes and increasing the complexity of what is already known;
- *Eliciting task-relevant knowledge*: According to Fischer *et al*. (2002), an important aspect in collaborative knowledge construction is driving the learning partnership and expressing task-related knowledge. Elicitation, which is generally expressed in the form of questions, may possibly lead to externalization, often in the form of explanations. Dialogue offers support for the participants to go beyond their own personal schemes and limited understanding (Saiia *et al*., 2008);
- *Conflict-oriented consensus building*: Collaborative learning often means that students arrive at a common evaluation or an answer with regard to the facts being studied. This necessary consensus may be reached in different ways. Conflict provokes thought. It awakens observation and memory, instigating invention. "Conflict is a *sine qua non* of reflection and ingenuity" (Dewey, 1922, p. 300);
- *Integration-oriented consensus building*: Another way of reaching consensus is by way of the integration of different individual perspectives in a common interpretation of, or solution to a particular task. This form of consensus-building can be important in some situations. However, the attempt to incorporate all the individual exhibitions in a common perspective may also lead to a superficial style of cooperation that avoids conflict. There is a notable tendency on the part of students to reach an illusory consensus. Fischer *et al*. (2002) measured these processes by combined analyses of content and the functional level of the discourse.

The group tends to construct knowledge in a more efficient and effective way when it regulates its own learning, in a process called social regulation. The highest level of social regulation is reached when the group constructs shared meaning and regulates and shares their learning in an autonomous way (Volet *et al*., 2009). Four factors have an influence on the reach of social regulation: a questioning culture; openness to attempts; the students' prior knowledge; and shared positive emotions (Volet *et al*., 2009). These factors may suggest some incentivized postures in the learning environment that are evaluated during the process so that a level of collaboration is reached that is of profound help to the learning mechanism.

Sawyer and De Zutter (2009) also stress the function of collaborative learning in inciting the development of creativity, a competence that is considered fundamental in the knowledge society. For Kneser and Ploetzner (2001), however, collaboration cannot be achieved through the pure division of work between participants, since it involves the mutual engagement of the learners for solving a problem together. Collaborative work can also lead to conflict, like cognitive overload, excessive activities, freeriding and social loafing (Kreijns *et al*., 2003).

With regard to the question of evaluation, Jang (2015) emphasizes that a formative approach should be used both for appreciating the result of the collaboration and the process and its implications for the learning experience. Evaluation comprises looking at how learning happens and the supply of feedback on the knowledge, skills and work products with the purpose of improving the quality level of a performance or a result. It is also used to describe how to determine the quality level. The cumulative evaluation, which is carried out after the education process has taken place, is the most frequently used. But evaluation can also be formative, in other words, carried out whilst an education process is on-going (Jang, 2015).

In recent years the use of information and communication technology has been widely included in discussions about the potential of collaborative learning and the challenges the latter faces. Based on improvements in technological artifacts, expansion of the use of the Internet end an

increasingly greater facility on the part of users to interact with the equipment available, a new and rich context for learning in groups has been unveiled.

The contribution of collaborative learning in design classes

Complementarity and the interface between the approaches of HCD and the view of collaborative learning that were adopted in this article result from the following assumptions: HCD may mean a proactive approach to design class, because it is connected to the contemporary dynamism in which the designer is educated. On the other hand, the simple adoption of a design methodology or model, however innovative it is, does not guarantee that learning will result.

Generally speaking, applied social science professionals, as is the case with designers, need to develop practical and theoretical competences in their education, by associating reflection and action. The instruction strategy that is adopted may focus more or less on one of these sets of competences. When HCD is used to promote teaching it is probable that the practical competence of the designer will receive greater attention. But attention must be paid to deviations in the learning process, like the situated learning indicated by Novak (2002), in which the student learns to solve the problem in that specific situation, without necessarily understanding the contextual and specific distinctions of new events.

Another common aspect between active learning methodologies, like those provided by using HCD, is that students may come to the class with previous project experiences and use them during the learning process without reconstructing concepts or learning anything new. When talking about collaborative learning, it is also possible that cohesive groups share tasks between themselves in an isolated way, by working in a group and delivering a product, but without promoting the co-construction of new mean-

Chart 2. Summary of the approach between HCD and collaborative knowledge construction for promoting learning and the development of contemporary capabilities by designers.

HCD process	Collaborative knowledge construction (CKC) Externalizing/Eliciting/Building consensus	Role of the instructor/moderator
Empathize	(1) Survey of what the team knows about empathy; what it knows about the task (activating previous knowledge); the preparation and use of instruments for empathy (externalize, elicit and create consensus); (2) Go into the field, learn with empathy.	(1) To instigate or lead the survey of prior knowledge about content (HCD) and the design task; (2) To evaluate the learning during and after the empathy process.
Define	(1) Externalize and elicit data collected and perceptions on the topic/ task to define the problem by way of consensus.	(1) To check and evaluate the challenges to the empathy process brought by the students. (2) After defining the problem, to observe and discuss how much the challenges and data collected led to implications for and repercussions on this decision.
Ideate	(1) The students generate concepts and ideas individually and/or in group. (2) The concepts and new ideas undergo the CKC process and are presented to one or more groups. (3) Collaborative evaluation indicates three strengths and improvements in the solutions to be developed.	(1) To act as the group collaborates (more or less present). To promote ideation in the molds of HCD. (2) To choose the teaching strategies required so CKC happens. (3) To evaluate the level of collaboration of the participants. To include peer evaluation.
Prototype	(1) The CKC process may occur by way of low resolution prototyping and the first presentations of the prototype. (2) Depending on the type of prototype, it can be evaluated by the user or stakeholder, and in this case the data too would be considered in the CKC. (3) Definitions of the adjustments of the prototypes are the result of conflict or integration consensus. (4) Once externalized, conceptual mistakes can be adjusted with the help of process data that come from the various stakeholders.	(1) Preparation and application of the individual, self-reporting instrument so students evaluate the learning process until they arrive at the prototype. Individual knowledge evaluation is complementary to collaborative evaluation and must be guided by the learning objectives that were defined *a priori*; (2) To offer feedback on the process (student learning) and on the product proposed in the design activity.
Test	(1) Students take part in a CKC process to externalize, elicit and arrive at a consensus about the test strategies and who will take part. (2) After the tests and with the results obtained in the application of the methods employed, the CKC process is repeated to propose improvements and so achieve the best product version possible. (3) In the case of tests, different techniques can be used to promote CKC. Some of them are provided by HCD itself, allowing students to discuss the product and the process with concrete evidence, like feedback from stakeholders, and any modifications to the prototype that may be necessary.	(1) To offer paths and strategies for producing evidence of student knowledge and facilitating the creation of consensus. (2) To evaluate not only the resulting product, but also the group's learning journey. (3) To evaluate individual learning, by comparing conceptual reconstruction based on the knowledge the students had prior to starting the course.

Source: Prepared by the authors on the basis of the research.

ings and without learning collaboratively. Each one does "their own part". Even if the resulting product is considered to be of quality, if there was no learning or no increase in the capabilities of the participants during the teaching process, it was an unnecessary waste of time and resources.

That is why it is important that the teachers of these classes align collaborative learning with the design methodology adopted so the learning process is managed in such a way as to develop the competences that are necessary to the designer, like collaboration. It is also essential that an evaluation is undertaken throughout the process and that any conceptual and practical mistakes of the students with regard to the project process are made evident, thus enabling the transfer of learning to new situations and in different contexts (Jang, 2015).

In this environment, the teacher's role is that of facilitating learning, moderating the development process of the groups and guaranteeing that HCD is assimilated by the students during the process.

Based on these findings Chart 2 is proposed, with the intention of clarifying the possible teaching actions that exist in the alignment between the approaches of HCD and collaborative learning by way of collaborative knowledge construction (CKC).

Final considerations

Design classes are significant opportunities for active and collaborative learning in design courses. Even though the universe of perspectives with regard to design is ample and denotes different discourses, the understanding of this research is that contemporary design approaches that focus on users, or on human beings, manage to comprise and contemplate a considerable proportion of the current complexities of the world and human demands and aspirations. Among these approaches, HCD was chosen here because it is aligned with the present-day demands which those graduating from Design courses face.

The collaborative learning opportunity provided by the use of HCD can be driven by adherence to the view of collaborative knowledge construction. When students externalize, elicit and generate consensus with regard to the subjects studied, real opportunities for co-constructing new meanings are generated. This means that wrong knowledge may be improved upon and simple conceptual structures can be developed in such a way that the student understands the complexities that are inherent in the design and in human beings and can replicate them and apply them in new and different situations. At the same time this facilitates the work of instruction by clarifying whether the learning objectives are, in fact, being achieved and implies new challenges, giving rise to the mastery of tools not only from design areas, but also from the teaching and learning areas.

The approach presented in this article brings with it the possibility for the professor to apply the various design stages based on the HCD approach, by adopting collaborative learning. It is understood, however, that in the academic routine there are different types of limitation and that the professor is unable to develop all stages in the class in a collaborative manner. In this case, even if the process is not fully carried out in the way presented, it is valid and possible to adopt it at one or more of the stages, thereby mixing them with other stages, like those provided for in the classic methodology, for example.

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