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HCI Four Waves within Different Interaction Design Examples

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Abstract. The several approaches available on literature regarding the origins of the universe conduct us to remove certainty concerning what we know about the world: the things (artifacts), theories, and behaviors among other effects. Making an analogy with it and some constructs of Human Computer Interaction, we face that the waves or paradigms have been concentrated on different focus, however, ontologically in intersection and complementarity with each other. To illustrate these connections, several creative design case studies, developed in different eras are described. The results and discussion about the waves characteristics, the theoretical concepts and those practical cases, will probably, take us to think better on a less bumpy road that leads to more positive user experiences.

Keywords: Waves in Human Computer Interaction, Creative Design, Culture, Interaction Design

1 Introduction

According to literature, there are four waves (paradigms) that Human Computer Interaction (HCI) has jumped, which correspond roughly historically to how HCI has developed in terms of the academic discipline that have most prevailed as inputs to its pluri-disciplinary character. The first wave was focused on technical patterns; the second wave was concentrated with the cognitive paradigm; the third, on the ethnographic paradigm. Research in the third wave challenged the values related to technology in the second wave (e.g., efficiency) and embraced experience and meaning making (e.g., [28]). Then, a fourth, namely the trans disciplinary design paradigm or fourth wave was added [20]. Other contributions about this wave were presented by Blevis [5] who argued that: the trans disciplinary (see for example, [27], [30] paradigm may be defined as a focus on insisting on a values-orientation for interactivity design as a higher order concern than collections of methods or domains of expertise. They added that the trans disciplinary design is distinguished from the other paradigms by its primary cardinality of focus is on politics and values and ethics. The four waves were considered the 4th ‘Gratifying’ Wave by Cabrero [9]. Lately, Ashley et al [36] argued that the four waves must push harder, beyond measured criticism for actual change in institutions.

This paper is organized as follows: Author presents a snapshot on HCI waves, then, examples of serious and silly creative artifacts design, followed by the design cases

analyzed according to each wave characteristics. Finally, a discussion and contributions are presented before the conclusions.

2 A Snapshot on HCI: The Waves

After the initial HCI wave of technical rationality, Grudin began to focus on the cultural barriers that separate HCI and IS [17]: HCI discovered the limitations of laboratory studies and surveys to understand discretionary use of methods and the focus of Information Systems (IS) in research has grounded on the economic, organizational, and marketing theory and practice [18].

The first wave was based on cognitive science and human factors. Bannon [1] argued that it was model- driven and focused on the human being as a subject to be studied through strict guidelines, formal methods, and systematic testing.

In the second wave, according to Bannon [1] the emphasis is "from human factors to human actors." In the second wave, the focus was on groups working with several applications. Theory focused on work settings and interaction within well-established communities of practice [32]. Other important aspects and concepts for reflection were situated action [37] and distributed cognition [31]; [22].

The third wave of HCI explores the several interdisciplinary inquiries within the HCI field. This includes the extensive compilation of aims at understanding the design, methods and applications of forms of interaction with new technologies and the varieties of human knowledge and experiences. This wave claimed to expand from the working and computer-based context into a broader environment of the mobile and the home, the everyday lives and into culture [6]. This, then, meant to break the boundaries between work and leisure, arts, and the home: in other words, between rationality and emotion.

A contemplation of a fourth wave in HCI emerge from, for example, problematizing methods, tools, and techniques [12]; also, by propositioning to solidly moving from User-Centered Design (UCD) philosophies of professional designer into a more Participatory Design (PD) involvement of laypeople [35] in the construction of sustainable and gratifying futures. What seems clear is that there must be a liaison and a human attuning in the adoption of human values towards a gratifying UX [19], as well as a carefully drafted agenda toward an HCI research and practice based on human needs and social responsibility [29]. Bødker's [6] challenge to 'identify' a fourth wave HCI, on a new vision that places 'politics and values and ethics' at the forefront without abandoning the strengths of previous waves. Ashley agrees, while they go deeply on the discussion stating that a fourth wave must push harder, beyond measured criticism for actual (e.g., institutional) change [36].

After these views about different authors and their considerations about each wave's characteristics, we focus on a deeper engagement with the existing literature from

Grudin and Bodker. Bødker [6] has initiated the three waves of HCI captured and presented the challenges faced by HCI in the past three decades.

Harrison, Tatar [20] postulated an almost similar idea in categorizing the development of HCI into 3 stages. Bødker [6] referred to it as three waves of HCI while Harrison (2007) referred to it as three paradigms of HCI development based on the phenomenological matrix they created. These prove that Bødker [6] was not alone in this effort and both studies apprehend an almost similar timeframe of the HCI development.

Referring to the history of HCI publications, Bødker [6] assumed the challenges in HCI research which the HCI community has broadened intellectually from its root in engineering research to cognitive science, sociological studies, emotional design as well as social participatory research.

According to Bødker [7], the three waves timeframe is: first wave - from the early years of HCI to 1992, second wave – 1992 to 2006 and third wave – 2006 and beyond. The transition of first wave to second wave was discussed by Bannon [2] in his paper From Human Factors to Human Actor. The first wave was pitched towards cognitive science and human factors. It was model driven and focused on the human being as a subject of rigid research with formal guidelines and systematic testing, and most of the studies were conducted in a closed scientific lab setting. Bannon [2] observed there was a significant change in the second wave as there was a transition from human factor to human actor in the HCI research. User studies were carried out from the enclosed scientific labs to the real-life environment as anthropology ethnographic research approaches were adopted. Concept of context became important. This signified the beginning of user entered design (UCD). Theories and research approaches from non-computer science disciplines were applied. Proactive methods, such as a variety of participatory design, prototyping and contextual inquiries, started to emerge in this wave [7, 16]. In the third wave, the success of consumer technology was observed, integration of multiple devices such as desktop, laptop, iPad and mobile. Multiple user experience-based situations become evident when the devices are used in different environments. Ubiquitous computing increased whereby computing is made to appear anytime and everywhere [7]. Research in the third wave challenged the value related to the second wave and embraced experience and meaning making [12]. User created content, common artifact and shared artifact caused the boundary between user and designer to become ambiguous in the realm of social network service (SNS). Scopes of proactive methods such as participatory design as well as the argument of the ability of such methods from existing practices to the need of emergent use were broadened.

The fourth wave is governed by two fields: positive psychology (well-being beyond humans defined as needy) and cognitive neuroscience (human irrationality), which leads to calls to consider an even more “human-centered perspective” [3] such as human values [8] and ethical aspects [33], embodiment [23]; [20], and well-being [10].

In summary, the first wave approach is based on the formulations of engineering; where the second was focused on the human mind's mental and cognitive aspect, information processing and general communication between man and machine. In contrast, the third highlights the relationship in the impact of society, culture, value and social changes. The fourth focuses on the transdisciplinary design paradigm, which means, on politics and values and ethics.

3 Creative Design

The analysis of the different approaches of HCI waves can help us to have more understanding of human behavior and its interaction with artifacts. Design has a central position in HCI. It is the medium to fix a problem. Thus, the HCI waves concerns are reflected in the different design perspectives. If we look around us, we see things. Those things have been designed following one or more of four wave characteristics on HCI. They were designed as models-driven and focused on the human being, developed by groups working with a collection of applications. They use contexts and application types broadened, and intermixed, relative to the second wave's focus on work. They challenged the values related to technology in the second wave and they embraced experience and meaning making. From the fourth wave we notice, for example, a more participatory design involvement. The design is refined as matters of rigor, openness and tolerance.

Design, making and intervening in the world have captured the attention of communication scholars in recent years. From explaining algorithmic bias on social media to the creation of online storytelling platforms, contemporary questions of communication require an understanding of the affordances, biases and constraints of communication devices, interfaces and systems - as well as an understanding about the work of designers that create these technologies.

Furthermore, there is also growing interest in using design as an inventive method in order to inquire about the world and build theory through the making of media, things and prototypes. Design is the reflection on the transformative power of doing, making and knowing as strength for positive change in the world. It connects us to the surrounding world and the society of which we are part; good things can happen, and new realities are possible, we just have to work for them. People design with a purpose since pretty much everything we do now has a purpose. However, sometimes things are created by hazard (some of the great discoveries happened by hazard) or even as a result of a creativity process. Other times design was inspired by nature.

This section presents three types of output designs: those that were invented with or without a purpose (engines of our ingenuity), those that were born useless and those that reflected the value delivered by design thinking, which is almost always seen having improvements in the creativity and usefulness of the produced solutions. It

reflects the type of creativity in engineering and technology, and in what way, it communicates to innovation in art and science.

3.1 Engines of our Ingenuity

Engines of our ingenuity” was a radio program, where stories of how our culture is formed by human creativity. Lienhard [11] looked at history, art, technology and the epic failures and successes that human curiosity had led us to. He registered his reflections about the nature of technology, culture and human inventiveness in a book with the same name as the radio program. Lienhard observes that the interactions between society and technology result in machines that reflect social needs while also acting as the instruments of social change; he also stated that “the history of technology is a history of us – we are the machines we create” [11]. If we look back to some of those engines, we stay astonished with them, either because of their aesthetic appearance or the absence of remote technology integration, for example, cars, bicycles, airplanes and so on. However, we learned, and those artifacts contributed to the technology development, and to the research on several areas. All together subsidized to the things we have now, and to those that are in groundwork for tomorrow. The way artifacts were developed and improved along the years, permitted us to understand the nature of creativity in engineering, technology, art or in science domains.

3.2 Chindogu Philosophy

Chindogu [11] means a ‘weird tool’. The Japanese comedian Kenji Kawakami, who termed the idea in his book, in the mid-nineties, 101 Useless Japanese Inventions, invented the term: “The Art of Chindogu”. “Every Chindogu is an almost useless object, but not every almost useless object is a Chindogu. In order to transcend the realms of the merely almost useless, certain vital criteria must be met. These criteria, is a set of ten fundamental tenets, that define the art and philosophy of Chindogu, as outlined by the International Chindogu Society to bear in mind: A Chindogu cannot be for real use; A Chindogu must exist; Inherent in every Chindogu is the spirit of anarchy; Chindogu are tools for everyday life; Chindogu are not for sale; Humor must not be the sole reason for creating a Chindogu; Humor must not be the sole reason for creating a Chindogu; Chindogu is not propaganda; Chindogu are never taboo; Chindogu cannot be patented; Chindogu are without prejudice. As an illustration, the next figure presents some of the Chindogu products. These pictures are taken from a Chindogu website with authorization from the International Chindogu Society (Figure1).

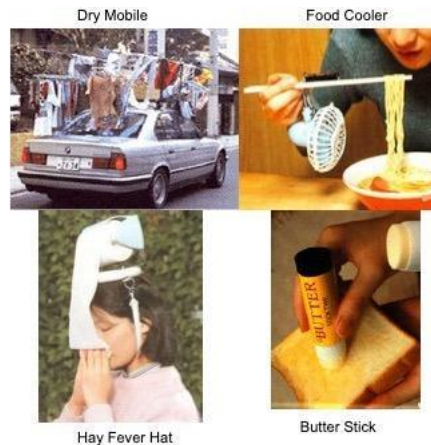


Figure 1 Chindogu Pictures [<https://www.chindogu.com>]

This philosophy was considered as a motivation source to put working together multidisciplinary professionals and researchers on a research workshop as it is described in section 4.

3.3 Culture Creativity and Interaction Design

Leonardo Network (Leonardo-Net) [25] was an international interdisciplinary research network, led by the UK, established to define a program of research in culture, creativity, and interaction design. Within this network several workshops took place.

Authors present two case studies from two workshops as examples of creativity in design. The first one was based on the Chindogu philosophy as a motivation source to put working together multidisciplinary professionals and researchers. The second one had a different purpose. The goal was to examine human-computer interaction (HCI) and the theory, design and application of interactive technologies, specifically, in relation to the arts. Conversely, it is permitted to define a research agenda at the interface between the two. The project included among other outputs, an arts/science interactive digital artwork, the execution of which was planned as part of the collaboration of the nodes. The involvement of artists and scientists brought to the design practice different perspectives. Designers with an arts perspective look at design differently from those with engineering perspective. The objectives were to involve the participants to think and to materialize the design thinking process with only drawings and words.

Human Beans (HB), two creative designers, who made fictional products by hacking

commercial culture, designed new services by working with real people. They were the facilitators. Their aim was to challenge assumptions. Some of their presented developed projects were: “Hearwear – hearing augmentation for the hearingable”; “What’s Cooking Grandma? – a media platform to reconnect with grandmothers” and “Neighbours TXT – a service platform to help neighbors to help each other.” [21].

4 Results

In the Chindogu Challenger, three artworks were constructed following the Chindogu tenets and the theory, design and application of interactive technologies, specifically, in relation to the arts including the definition of a research agenda at the interface between the two. In the second case study, the researcher chose two representative draws from one of the work rounds. Participants were obliged to choose from a given table, a technology, a context and a problem. Then, the goal was to use drawings and words to create ideas to explore in future HCI research. They were representative of the materialization of the design thinking process.

We provide an overview of some of the interaction design examples within the frame of the HCI waves and consider their impact on the design process.

1st wave – technical and theoretical aspects, focusing on the interaction between a specific user with a specific computer. First design example - Engines of our ingenuity - the interactions between society and technology result in machines that reflect social needs.

2nd wave – value choices rather than technical ones because of the endless technological possibilities. Second design example - Engines of our ingenuity.

3rd wave – elements of human life are included in the human-computer interaction such as culture, emotion, and experience. Third design example – Chindogu - Society to bear in mind.

4th wave – well-being beyond humans defined as needy and human senselessness, which leads to consideration of “human-centered perspective” such as human values and ethical aspects, embodiment, and well-being. Fourth design example – Leonardo network - The objectives were to involve the participants to think and to materialize the design thinking process with only drawings and words. The design of new services by working with real people. Also, an example of a university teaching method in HCI.

4.1 Case Study 1

The program was composed of about twenty multidisciplinary researchers. From these, sixteen participated in the Chindogu Scrapheap Challenge. One day was given (about five hours) to each team to build a solution to the challenge using either the materials and equipment provided or material that each team brought to the competition. The

event included mainly two stages: one to find ideas, mainly conceptual; and the other to implement ideas, essentially practical in nature. These were preceded by an opening session and concluded with a final session, in which each group presented the work developed. Mind, body and spirit – how does diversity impact?

4.1.1 Findings

Team 1 - The group discussed some ideas about electric chairs, addictive things, automatic cleaners, electricity and mobile phones, and the material they needed for the artwork was defined: kitchen foil, a piece of carpet, transformer, etc. Participants described the use of the device (“What we have here is a stack of CDs cases. The critical thing is the plastic access of the dialectic for those who remember from the school physics. On one side, we have a foil going inside and outside...”). It addressed the ideas of connection to a person and that kind of problems could arise in the wild: it was stylish but useless (Figure 2).

Teams used a set of methods, which consisted of a large body of knowledge and techniques (design thinking). This was the start of the design process – an innovative one, then, the thoughts were put into action by the design doing process.



Figure 2 - A Static Mobile Phone Charger [19]

Team 2 - The project “Remote Wild Animal – Interaction Device – Using Petting, Enabling Technology” (P.etting E.nabling T.echnology), was made of: a back scratcher; a Lego robot; a mechanical tickling hand; a computer mouse; a rubber bands; sheets and plastics for a tent; a computer for voices and a toy dog. They addressed the problem – interacting with animals. Along with the HCI themes: interaction without connection, interaction not only in, but also with the wild. A demonstration of the scratching, tickling and calling of the animal with the robotic hand that cuddles him

was presented (Figure 3).



Figure 3 - Remote Wild Animal – Interaction Device [19]

Team 3 – Participants decided on using cats after the suggestion “interaction in the wild, that could be, cat computer interaction” and the analogy from the Chindogu tenets: “Can’t it be for real use – cat computer interaction?”. The notions of death, remembrance, dreams and “their realization in pillows” were then introduced. The chosen name was: “Nine Lives dot dot Question Mark” (Figure 4). Authors explained how they had arrived at the concept. (“we built an installation for capturing memories and dreams and the layers left behind to replay them...”). The artwork story was: (...) “Sinbad lays on his cushion and he dies. So, the owner takes the cat to the graveyard, lays him down in the graveyard, takes his collar, and places the collar on the cushion to remind the owner of the cat... Jess visits the cushion to remember his dear friend (...)”.

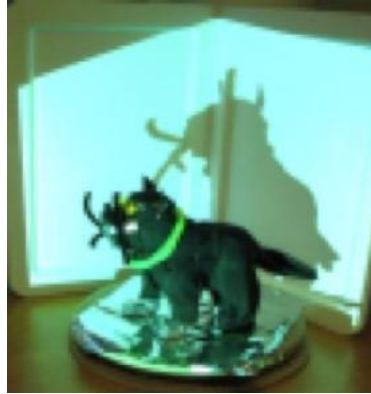


Figure 4 - Nine Lives dot dot Question Mark [19]

The Chindogu philosophy tenets were the standpoint and the research approach used was the design thinking process. The results mirrored in the presented figures are examples of the future research areas identified as the interface between Human Computer Interaction and the arts. It reveals the work of each team's creativity. The funny results, the non-obvious and innovative projects, exposed the concern about people, technology, arts and the contribution to people's quality of life improvement.

4.2 Case Study 2

This case study had twelve participants who worked together for six hours. Human Beans initiated the project. Then, participants split into two groups: one went to visit the exhibition "Front Page" at the British Library and the other group went to visit the exhibition "Michelangelo" at the British Museum. The goal of these visits was an inspiration hunt for the participants' work during the day. People met in the workshop after the visits. They presented what they found inspirational to work from their morning visit.

The second part of the presentation consisted of an interactive exploration of HB's fictional products and inspirational material including: cleanliness, wellbeing, crime, gaming, virtual worlds, experiments in interaction, food, new digital crafts, and death, among others. After that, they posed two questions to the audience: "What you have learned from this morning; from what you looked at what inspired you at most?" and "Think about a problem that you think you would like to solve or an issue that you would like to explore or a technology that you would like to exploit." Participants had ten minutes to create the project.

4.2.1 Findings

The project ideas were created in response to three factors set by HB: a good problem to be solved in future research; a good issue to explore in future research and a good technology or combination of technologies to be explored in future research. There were four rounds of work. After the project concluded, each team presented feedback to the audience. At this workshop, other challenges were proposed following the same context. The results were presented, and the main concerns focused on: Mental Wellbeing; Climate Change; Street Crime; Energy Consumption; Online World; Migrant Communities; Social Exclusion, among others.

In the first-round, team 1 chose a project based on: Problem: “lack of sleep; Technology: reality television; and Context: supermarket” (Figure 5).

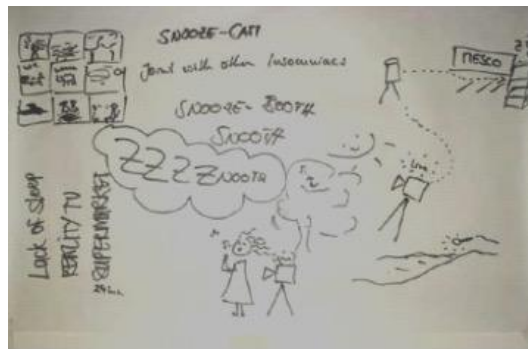


Figure 5 - Lack of Sleep, Reality TV, and Supermarket [19]

Team 2 did the project based on: Problem: “physical fitness; Technology: “any related to simulations”; Context: “a seven-year-old dog that had been mistreated by owner”. Team 3 had: Problem: “binge drinking”; Technology: “camera phones”; Context: “a 68-year-old that used to work in science”. Team 4 used: Problem: “world peace”; Technology: “Sony PSP”; Context: “a nurse who worked shifts and was planning a family”. In another round, following the same procedures, we underline the “Social Exclusion” theme (Figure 6).



Figure 6 - Social Exclusion [19]

The source to inspire the participants was the “look around” in London city. The participants were researchers from different fields, art, engineering, computer sciences, musicians, psychologists, filmmakers, and ethnographers, among others. According to the presented work description and the obtained results we may conclude that every day we may apply knowledge from a variety of sources to resolve problems, to manage relationships, and to contribute to a better-quality of communities’ life. Participants did the whole work in teams. Human Beans were the facilitators and the people who settled the challenges.

The main participants’ preoccupation was with people’s daily life and with the problems we face around us: mental wellbeing, dementia, street crime, migrant communities, family life, online world, cultural community, remote surveillance, etc. These challenges happened about ten years ago. However, in literature we find that the quality-of-life improvement keeps being a concern for research and for the technology development plan. The themes discussed on the workshops, advocated by participants, reflect several tenets influences concerning the four HCI waves, especially, the transdisciplinary design which enables each designer to articulate her or his vision of what truly matters in design with the materials of digital technologies: social networking, the concern of using different devices, with accessibility and sustainability which are areas in constant development.

5 Discussion

The four waves of HCI follow a chronological order, but the emergence and acceptance of a newer one does not replace the existing ones. They coexist in the same communities. Different research paradigms can underlie the HCI wave. Table 1 presents the four waves differences according to diverse authors.

Table 1 - Four waves differences

1 st Wave	2 nd Wave	3 rd Wave	4 th Wave
<p>Stems directly from engineering roots of HCI</p> <p>The focus is on human factors and ergonomics.</p> <p>Human being as a subject to be studied</p> <p>Interaction is perceived as a form man machine coupling</p> <p>This wave is pragmatic and focused on practical results</p>	<p>Stems from cognitive science.</p> <p>The emphasis is on theory and the focus is on what happens in the human mind in terms of information processing</p> <p>Focus on groups working with several applications</p> <p>Interaction is perceived as metaphor of mind and computer.</p> <p>The concept of context is a focus</p>	<p>The topics culture and values are marginalized</p> <p>Interaction is seen as a form of creation of meaning in which both artifacts and its context employ mutual influence</p> <p>Several interdisciplinaries inquires with HCI field</p> <p>Interaction with new technologies</p> <p>Human Experiences</p> <p>Technology connected with human body and soul</p> <p>Rationality and emotion</p>	<p>Problematization of methods, tools and techniques</p> <p>User centered design to more Participatory design involving laypeople</p> <p>Adoption of Human values towards a gratifying UX</p> <p>Practice based on human needs and social responsibility</p> <p>Placing politics and values, integrity and ethics at the forefront</p> <p>More push for change</p> <p>HCI and IxD</p>

Each researcher or community uses the waves characteristics the way they consider more adequate for the work in hands or according to their own understanding and experience. In our view, the important thing is the sharing of knowledge, the exchange of experiences, the collaboration, the revision of methods, the creativity, and the solutions for the problems that need to be solved at a given time.

There is an overabundance of creative theories and models and no one is generally accepted [4, 34]. The main reason is probably due to the multidisciplinary nature of the subject. Creativity is becoming an intrinsic part of working life. It is a quality that is highly regarded, but not always well understood [14]. Creativity denotes a person's capacity to produce new or original ideas, insights, inventions, or artistic products, which are accepted by experts as being scientific, aesthetic, social or technical value [13]. Creative activity grows out of the relationship between an individual and the context of his or her work, as well as, out of the relations between an individual and the other human being. Much human creativity arose from activities that took place in the context in which interaction and the artifacts that embodied group knowledge were important providers to the process. Moreover, creative thinking is not so much an individual feature but rather a social phenomenon involving interactions among people within their specific group or cultural settings [26].

The three approaches of design presented, in this paper, are exemplified with artifacts that were designed to solve problems (e.g., engines of our ingenuity). Some of them were the results of the use of theories and practices from sciences, art or technology. The intention could have been the invention of something, with a purpose or created by hazard, to improve people's quality of life (cars, airplanes, boats, clocks, bicycles, etc.).

The Chindogu Japanese invention, which means valuable or priceless tools are genius, but people would look silly using them out in public. Following this philosophy or art, the useless inventions at first glance, seem a bit reasonable. Then, people realize they are just no better than the usual way of doing things. However, being silly and useless the gadgets are designed to solve everyday problems. They are solutions to a

particular everyday problem.

Using some design research techniques such as observations, interviews and activities analysis, the researcher investigated designers in specific environments in order to learn more about them through what they said, how they behaved and the objects they designed. The design thinking process involved multiple stages, and in some cases, brainstorming and discussions. During data gathering and data analysis it was demonstrated that there were some aspects of interaction design that were common to all case studies: design is an interdisciplinary process by its own nature which was verified by the different teams' background and design contains social interactions. Social interaction design integrated communication capabilities, and dynamic changing sequences of social actions between individuals and groups, who adjusted their actions and responses according to the actions of others' interaction. People attached meaning to situations, and interpreted what others were meaning. This overall attached meaning was reflected in the designed artworks [26].

In one of the cases studies it was demonstrated that the goal was not to build an artwork or artifact, but to practice design thinking. Design thinking is a way of applying methodologies to any of life's social situations. It is a creative process based around the building up of ideas and it encourages people to provide maximum input and participation. It is a process for a practical and creative resolution of problems or issues.

The researcher concluded that designers, in general, and design thinkers, in particular, shared a common set of values: these values were mainly creativity, collaboration and culture. The value delivered by design thinking is almost always seen to be improvements in the creativity and usefulness of the produced solutions.

Moreover, technology was always a medium or a tool during the development of all the artifacts. Neither better than using the words from [24]: "As technology strives to connect with the human body and soul, we must now think about the world as a small portion of the Universe, thus act with responsibility in developing life and the human race with a set of values, ethics, and integrity that are coherent with Gaia and all things in the world being interconnected".

Conversely, technology is both a practice and a creative idea, and not simply the concrete manifestation of a solution for human problems. This challenges the idea that technology is only created by exigencies – it also requires human objective and imagination to materialize and achieve it.

As a professor at the university (X) teaching HCI classes, we engage informatics' students to do practical projects by presenting interactive artifacts, which could make part of those that we have at our disposal in our daily life. However, for different reasons they do not. The students made the role of designers and they are free to use different characteristics of each HCI wave. They have a proposed challenger to accomplish. Normally, they are satisfied with their ability to innovate, to develop their creative skills, and to present powerful ideas. In the 'real' world sometimes these ideas win: design prizes, academic results, motifs for discussion, and topics for research.

Conversely, the rate at which these ideas achieve commercial success is low. Many of the ideas die within the university never becoming a product. Among those that become products, a good number never reach commercial success. This is a concern because, such as the engines referred to on the paper, even the chindogu's artifacts and creative designs from the described cases, almost all of the student projects stay saved in a room or on a computer file. If we try to guess the reasons why, it will take us to several complex roundabouts to discuss in this paper. This example serves to illustrate that HCI concerns are considered in different places and teams' work. In this case we are talking about design thinking process and design doing.

5.1 Contribution

The main contribution of this paper is to underline the several waves' features that have served as guidelines for HCI researchers and followed as methodological approaches, especially when they develop artifacts, independently of their backgrounds, behaviors, beliefs, values, interests, and considerations about technology experiences.

Then, we presented different perspectives and examples concerning interaction design, since the appearance of the things that are part of our daily life, such as the car, the mobile phone, the plane, the clock, (some engines created, in some cases, initially, by naivety). Next, we offered illustrations of artifacts, created to be useless even though one can find them in daily use. We also settled on artworks resulting from the creative work of research teams, coming from different areas of knowledge, professional experiences, cultures, age. The main objective was the use of design techniques aligned with technologies and with HCI methodologies, to contribute to improve people's quality of life, digital social inclusion and to identify new areas of investment in HCI. Complementarily, in other arenas, such as, at universities, it was presented a narrative and description about the learning by doing method that have been used on the studying/ learning process undertaken with informatics' students. They used their creativity and the available technology in the school's laboratories and made prototypes of artifacts that could become products of quotidian use in our daily lives. The design process and the development methods were followed similarly with those from the examples presented before as well as the waves' characteristics. However, in this case, some of the outputs are drivers to fail due to several constraints. Probably, because we do not have an agreement about, for example, the concepts that are the basis of something's generation. The transdisciplinary approach (the fourth wave) focuses on design frameworks, values and ethics, design for important themes such as sustainability, equity, adaptation, justice, and social responsibility which were found values on the designed outputs.

Finally, we intended to highlight that, probably other waves will come soon, containing other focus. Those focuses, whatever it may be, should be aligned with the

scope of research groups, academia and industry in order to have a nearby consensus when these people collaborate in the development of artifacts development and on the universal application of methods and techniques. Conversely, the social changes we are facing – the new normal – will irreversibly change the way we think and work in HCI and design. The recollection of waves characteristics and the presented creative designs take us to say that: We don't think that we are diving into the surf in search of a wave to ride back to the shore. So, the debate about HCI, in general, or about design, in particular, will lead us to discover or improve the way we work doing research. probably, the focus should be on the social value plan, starting to understand the others, each other, and ourselves.

New approaches have been used by different authors. For example, Xiangshi et al. [38] proposed a new approach or (wave) or future directions to HCI which goal is to synergize interaction between humans and technologies under the appellation—Human Engaged Computing (HEC) which specifically identifies, promotes, enhances, and synergizes innate human capacities and technological capabilities by maximizing synergism and minimizing antibiosis. They call for a coherent understanding which gives priority to human outcomes, with technologies serving humans as stewards in nature.

Frauenberger argues that our intimate entanglement with digital technologies is challenging the foundations of current HCI research and practice. It is also considered that the relationships to virtual realities, artificial intelligence, neuro-implants or pervasive, cyberphysical require to consider evolving the current research paradigm. The called Entanglement was developed from the following four perspectives: (a) the performative relationship between humans and technology; (b) the re-framing of knowledge generation processes around phenomena; (c) the tracing of accountabilities, responsibilities, and ethical encounters; and (d) the practices of design and mattering that move beyond user-centered design [15].

6 Conclusion

The goal of this paper was to review the literature about HCI waves characteristics and to understand if, over the years, the artifacts were designed under each paradigm either chronologically or according to the researchers' interest and needs. We concluded, based on the presented design examples, that designers chose the wave's characteristics independently of the historical chronology. They adapt it according to the best guidelines that fit the artifact process or fitting the broader perspective on how technology relates to us.

Design is about people. It is about our hopes and dreams, our lives and joy. How we perceive aesthetics and how it makes us satisfied with the artifact leads to creating

symmetrical conclusions and reproducing them in different forms, helping each other and advancing research to better humankind.

Some of the ideas offered by the designs seemed foolish in the whole presented cases. Although, the designers, at some point, believe that they did a solution to sort a kind of problem or what they express in an artifact had only a creativity to propose. Others may not accept either as such. However, if we consider great ideas of the past and how they were generated, and if we judge them by appearance, we will arrive at the conclusion that some of the ideas were engines of ingenuity. Nevertheless, those design ideas and discoveries permitted the development and evolution of our society and the artifacts contributed to improve some of our quality of daily life. The main goal of this paper was attained since we settled the waves characteristics and searched examples that have been focused on them during the design process development.

Probably, the contribution for a next wave or wavelet will come from the results of an interesting discussion among several researchers and professors concerning, for example, standard concepts' meaning, terminologies and their translations across languages. The top of discussion in research/academy communities is about: translation of the word affordances on the design of interfaces. The goal is to understand, in the different languages, if all over the world they are referring to it with the same meaning. Authors are also discussing their preoccupations concerning terminology about design and plan, since in some disciplines and or/ situations the term is used almost interchangeably. And an interesting debate is appearing around design thinking, design doing, and design driven transformation.

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