Human Computer Interaction Teaching Method to Encourage Creativity

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Abstract—**Scarce attention has been given to Human Computer Interaction teaching methods to promote creativity and innovation. Standard approaches to teaching interface design include the use of design aids such as usability guidelines, interaction design patterns and anti-patterns. These approaches do not, however, encourage creativity properly. Interaction design space is usually limitedly and unsystematically explored during student designs. In this paper, we propose a pedagogical framework for design exercises for use in the teaching of Human Computer Interaction and present some examples of its usage. The use of the pedagogical framework makes it possible to teachers create significant Human Computer Interaction experiences to students, fostering them to activate mental processes underlying creativity.**

Keywords-creativity; human computer interaction; collaborative learning

I. INTRODUCTION

New information technologies have revolutionized the way people work, study, socialize, access and transmit information, have fun, communicate and access services. This fact calls attention to the problems caused by software with poor user interfaces, making computer science researches and software developers very aware of Human Computer Interaction (HCI) as a driving force within software development practice and usability as an essential aspect of HCI.

A bad user interface for a Website or desktop application has a huge social cost. A badly designed user interface can detrimentally influence millions of people and consequently cause users to make expensive errors [1]. Although today there are lots of good solutions that can be reused by developers, many user interfaces are bad designed. That leads us to believe that one possible reason of the problems of HCI is an absence of appropriate and efficacious education. Undeniably, an effective way to improve HCI is by improving HCI education. Questions about education and understanding HCI must be addressed in the academic or research literature about this subject.

Indeed, computer science research has wide interest in effective teaching methods for the discipline. The field of HCI recognizes a more or less standard process of how to teach and practice interaction design, that is summarized the following phases: problem definition, user study, iterative prototyping, and evaluation [2]. This point of view is adopted in HCI as an engineering discipline. In reflecting on key objectives of engineering, primary concerns are with efficiency and reliability.

In an engineering approach of HCI, practitioners must be able to build interfaces quickly and consistently. Engineering as a discipline that seeks procedures to systematize and operationalize best practices, allowing others to create usable interfaces and lending analytical structures to guide analysis within diverse contexts [1]. Teaching engineering practices involve the engagement of HCI students in problem-solving by using procedures and analytical methods. Software engineering, computer science, and information systems students are taught structured methods to analyse, decompose, and to develop systems. Such structures can hinder creativity, which is generally a much less structured activity.

User-centered design approaches do not necessarily lead to good designs either [3]. User-centered design helps the designer focus on the user and the context of their work. Creative and innovative solutions require an extra effort, which the designer must then build upon to deliberately and consciously to devise them.

As a result from engineering emphasis, most HCI courses have a significant focus on teaching the students to evaluate interfaces usability. This sparked the advent of a new industry in usability evaluation services [3]. Despite much more research is still needed for methods that improve usability, we believe that another very important problem is a lack of methods for inventing better solutions and designs in IHC. If there are better solutions in the first place, there will be a lesser need to make tests and redesigns to software that has been delivered.

Creativity needs to be more valued in HCI. Researchers in HCI education must investigate more what is involved in inventing creative solutions, and therefore, how we might be able to teach this to the students. They should adapt and repurpose existing tools and methods, and orchestrate them in a way that would boost creativity, in order to scaffold students to gain the insights that can lead to creative solutions.

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The challenge for educators then is to move from these highly organized structures, to organized, but yet creative, structures that can facilitate creative invention [4]. To achieve this aim, teachers needs to understand the nature of creativity and inventiveness and therefore how it can be fostered in the light of HCI context, without disregarding the systemic HCI methods available for the search of well-crafted designs.

In this paper we propose a framework for design exercises for use in the teaching of HCI aiming at positioning teachers and students with regards to both adaptive and innovative creativity. The use of the pedagogical framework elaborated in this research makes possible to teachers create significant HCI experiences to students, allowing them to activate mental processes underlying to both innovative and adaptive creativity. Innovative creativity is related to the original, transformational, and expressive, while adaptive creativity linked to logical, adequate, and well-crafted solutions.

First, in section II, we present a framework for design exercises in HCI. In section III, we discuss the application of the framework in HCI teaching. In section IV, we describe a preliminary case study that was conducted during one semester of an HCI course. In section V, we present and discuss some preliminary results. Finally, in section VI we describe further investigations concerning the framework presented.

II. Framework for Design Exercises in HCI

Collaborative learning is the pedagogical method that provides the fundamentals for the proposed framework. Collaborative learning has been proved efficacious when the teacher helps the students to develop the collective ability to use dialogs for learning, fostering productive interactions during argumentation in instructional settings. Discourse must be facilitated aiming creative and innovative processes and products.

This work introduces a framework to nourish creative discussions during collaborative problem solving in HCI. We consider here that invention occurs at different levels of innovation. The framework contains seven collaborative and creative dimensions. The dimensions are: immersing, unpacking opportunities, exploring complementary paths, overcoming boundaries, expanding, discovering unpredictable places and developing. Each dimension contains dialogic processes. Dialogic processes are dialogs aligned with mental creative processes associated to both adaptive and innovative creativity. Dialogic processes afford ideas build upon other ideas while people collaborate. Here we say that the students widen the design space when a new idea emerges and that they deepen the design space when an idea is evolved. Following, we present the dialogic framework dimensions.

A. *Dimension 1. Immersing in the Design Space*

Students can widen the design space while discuss having in mind search information having an objective in mind and search information for inspiration, detect relevant and irrelevant information, recognize familiar information and cope with new information, reapply techniques and adapt techniques, experience having an open mind and experience having an objective, state goals and brainstorm, adapt hypothesis and make conjectures, are aware of generalities and specificities, and explore similarities and differences of problems.

According to Jonassen [5], when students scrutinize similar problems for their structures, they gain more robust conceptual knowledge about the problems, constructing stronger problem schema. This dimension concerns with the enhancement of the analogical thinking. Analogical reasoning involves the transfer of solutions from previously known problems to novel ones and the ability to abstract similarities and apply previous productive experiences to new situations. This dimension is also concerned with the search for information. To be successful at discovery and innovation students should be aware of previous and related work and should be aware of principles and techniques to be applied in the development of their work. The more diverse your knowledge, the more interesting the interconnections.

B. *Dimension 2. U*npacking Opportunities *of the Design Space*

Students can deepen the design space when discuss while collaboratively look for attributes and relationships among concepts and new ideas, and try to organize the information, recognize dependence and independence relations, necessary and sufficient conditions, causes and effects, similarities and differences, correspondences and oppositions, class inclusion and exclusion, associations and dissociations, hierarchy ascendant and descendant relations, order and disorder, abstract and concrete features, potential and non-potential uses/functions, examples and counter-examples, and make an interplay between concrete and abstract features.

Guilford advocates that elaboration and fluency are two fundamental components of the creative process [6]. This dimension embraces the divergent thinking abilities elaboration and fluency. The teacher can boost the students´ improvement of these abilities to explicit what is already there but hidden and also to deal with the who, what, why, and how elements of solution ideas.

C. *Dimension 3. Exploring Complementary Paths in the Design Space*

This dimension involves complementarities. Here, we elaborate dialogic processes based on Ponty´s [7] notion of “chiasm”. In Ponty´s notion of “chiasm,” two concepts emerge as complementary ways of referring to an idea. For example, both sides, figure and ground, depend upon each other and can reverse around each other. This divergence is considered to be a necessary and constitutive factor in allowing subjectivity to be possible at all. However, he suggests that rather than involving a simple dualism, the divergence between touching and being touched, or between the sentient and the sensible, mind and body, subject and object, self and other also allows for the possibility of

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overlapping and encroachment between these two terms. For all dialogic process we address its complementary to address more possibilities of exploration of an idea and to achieve better awareness of students. The teacher is also called to elaborate the students´ tasks based on complementary concepts.

D. Dimension 4. Overcoming Boundaries of the Design Space

Students can widen the design space while discuss and jointly situate ideas in a bigger, smaller or different context, performing contextual shifting, search for relationships with "neighbour" ideas outside a given context, deals with scope and limitations, and deals with constraints relaxation or imposition.

Generating alternative designs is an essential aspect of the interaction design process [2]. Considering alternatives and thinking about different perspectives can provide the designer with considerable insight into the problem space. Considering alternatives is important to "think out of the box". Students as future designers and software developers must be trained to consider alternatives.

E. Dimension 5. Expanding the Design Space

The students can widen the design space making together recombination and combination of similar or distinct concepts and ideas, building on other´s ideas, decomposing and composing ideas, re-thinking their previous ideas, and rebutting ideas. The students also try to make combinations of possible disparate or unconnected ideas. They derive new knowledge on the basis of a lack of similarity between two or more past constructs or elements from domains which are far apart.

This dimension entangles constructive interactions among students related to innovative construction of a complex system of ideas. The main premise in this dimension is that unexpected and new arrangements and other´s interpretation trigger new interpretations and ideas. Previous opinions and concepts are co-constructed and students´ understandings expanded. Students integrate answers from many places in diverse ways, in a process of transcending and exchanging different perspectives and constructing new ideas.

Here, it is evoked Dewey´s notion of transactional inquiry to elaborate the creativity concept in a dialogic way. Dewey defined inquiry as a set of operations by which an indeterminate situation is rendered determinate [8]. When participants engage in inquiry together, new meanings are created as a co-production. For Dewey, the term transaction emphasizes the transformational aspects of interaction [9]. A mutual exchange is a transaction whenever a response to another's act involves contemporaneous response to a thing as entering into other's behaviour, and this upon both sides.

F. Dimension 6. Discovering Unpredictable Places in the Design Space

Students can widen the design space, when they have the opportunity to explore a bad idea. They do not only reflect about positive impacts, relevant implications or good features, but also reflect upon why a failure occurred, about negative impacts, features and implications, why an idea did not have impact, and problems created. They do not just eliminate the wrong paths, but reflect and take advantage of it. Students turn ideas and concepts in new interpretations, also thinking about misconceptions.

This dimension capitalizes on often way in which bad ideas become beneficial detours to good ideas. The exploration of good ideas allows a local exploration of the design space, which leaves unexplored large areas of this space [10]. The exploration of bad ideas pulls the students to new unpredictable places, facilitating a movement to far away places, which thus allows students to overcome the limitation of exploration that good ideas entail.

G. Dimension 7. Developing the Design Space

Students can deepen and widen the design space evaluating, comparing, selecting concepts and ideas, considering different alternatives, pointing positive and negative outcomes based in criteria application, starting a search for a more adequate cognitive perspective, reasoning process aiming to resolve conflict and uncertainty, identifying best solutions, and removing inconsistencies.

This dimension encompasses the evaluation, critics, and bringing together of ideas. By means of evaluations of ideas students are able to carry out decision-making processes based on criteria application and improve ideas considering its bad features. One important aspect of this dimension is that when students evaluate and critique different perspectives and ideas they must be confronted with uncertainty and conceptual conflict. Both are states of disequilibrium that activate a process of conflict resolution and a quest for certainty [8]. Besides, interaction criticism is a design practice that enables design practitioners to engage with the aesthetics of interaction, helping practitioners cultivate more sensitive and insightful critical reactions to designs and exemplars [11].

III. Applying the Framework in HCI Teaching

According to Preece et al. [2] interaction design is about designing interactive products to support people in their everyday working lives and interactive experiences that enhance and extend the way people communicate, interact and work. Interface design comprises determining how content is organized and presented, choosing appropriate design metaphors and affordances, and providing effective interaction and techniques.

However, teaching students how to develop interactive experiences is not an easy task. There are a myriad of aspects involved that should be considered. It is not an easy task to create a meaningful experience for others. The

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students must first understand your audience, their needs, abilities, interests, and expectations, and then have the ability to conceptualize and refine effective solutions. The same apply to teaching students to be creative and allowing them to experience such skills.

Teaching attention is mainly focussed on usability principles and guidelines, but although principles and guidelines are extremely important, they are not the only aspect to be considered. Principles and guidelines do not suggest solutions, although they can be used to guide design. Principles and guidelines of usability provide clues to the designer about what to do but not about how to do.

Patterns are increasingly being used in software engineering education. Many pattern libraries have been published [12][13] and more are appearing every year. Alexander introduced the notion of patterns [14]. A pattern focuses on the relationship between problem, solution and context. The solution can be realized in different ways but has an invariant core, which captures all the possible solutions to the problem given. Solutions described in patterns are proved to work in practice, they are a proven solution for a common user interface or usability problem that occurs in a specific context of work. Patterns communicate insights into design problems capturing the essence of problems and designs in a compact form. They describe the problem in depth, the rationale for the solution, how to apply the solution and some of the trade-offs in applying the solution [15].

Some research shows that the use of interaction patterns is successful [16]. It was shown that designers who made more use of the available interaction patterns were able to produce better results than those not using the patterns. Anti-patterns are also used to convey the knowledge in HCI. An anti-pattern is a solution that seems like a good idea, but backfires badly when applied, and can cause an interface to fail. Anti-patterns are literature written in pattern form to encode practices that do not work or that are destructive.

Guidelines, patterns, and anti-patterns exist to capture experts' expertise and to communicate knowledge. Design guidelines and patterns can be used to help the interface design, being used to aid the production of usable design solutions. These design aids however, encourage and foster creativity or the generation of new metaphors or alternative designs in a limited way.

A trade-off exists between enforcing the use of standard design guidelines or patterns and encouraging the development of creative design solutions. This paper explores the possibilities for developing a combined approach to teaching creative interface design. This approach proposes the combined use of guidelines, patterns, and anti-patterns and the proposed framework with the aim to produce usable and creative design solutions. Following we provide some possible instructional uses of this integrated approach.

A. Examples of Tasks in View of the Framework

Example 1. This task is based on Dimension 1. In this task, the teacher establishes an HCI subject and patterns related to the chosen subject. Afterwards, the teacher uses the dialogic processes from the Dimension 1 to scaffold students' collaborative activities and dialogues to promote knowledge creation. This task focuses on Websites navigation and the discussion is centered on the fat menu pattern [12].

Considering the dialogic process "Search information having an objective in mind" and "Specification", the teacher asks students to search Websites to discuss different adaptations of the Fat menu pattern. Also, the teacher ask the students to discuss if the Websites found are strongly related to the problem described in the pattern. The problem is: the designer deals with many categories, possibly a hierarchy with three or more levels.

Having in mind the dialogic processes "Recognize familiar information" and "Generalization", the teacher asks the students to discuss trying to figure out what kind of Websites is best designed by fat menus based on the examples provided in the pattern description and the Websites found.

Paying attention to the dialogic process "Adapt techniques", the teacher asks the students to jointly choose a Website to adapt the Fat menu pattern, regarding that users must focus their attention on the available navigation options with no distractions. The teacher asks the students to discuss ways to use headers, dividers, white space, and how to take advantage of horizontal space. Also, the teacher asks the students to discuss the uniformity and regularity of the pattern adaptation, designing to fit well into colour scheme and other aspects on the page.

Regarding the dialogic processes "Make conjectures" and "Search information for inspiration", the teacher asks students to discuss the viability to include graphics elements in the fat menu pattern adaptation. The student can look at similar systems or look at very different systems.

Example 2. The teacher asks the students to make connections between the Fat menu pattern and other patterns, between Fat menu pattern and guidelines, and among elements and other patterns inside the pattern. Questions formulated by the teacher are used to lead the discussions. The questions are based on the dialogic processes from Dimension 2 "Recognizing associations", "Being aware of concrete and abstract features", "Recognizing order", "Recognizing class inclusion and exclusion", "Recognizing dissociations", "Exploring differences and similarities", and "Recognizing associations".

1. The Fat menu pattern can include others to complete him?
2. There must be order inside the Fat menu pattern?
3. How can be organized the categorizations inside Fat menu pattern?
4. How can be managed the vertical separation of categories in the Fat menu pattern?
5. How are the differences and similarities between Fat menu pattern and Menu page pattern [12]?

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6. Using the Fat menu pattern the user enters directly in the content. This feature can be associated to a guideline?
7. Using the Fat menu pattern the information is hidden until the user looks for it. This feature can be associated to a guideline?

Example 3. In this task, the teacher takes into account Dimensions 3 and 7. In view of Dimension 3, students are supposed to explore complementary paths and in light of Dimension 7 students are supposed to criticize and build on other's ideas.

The dialogic processes from Dimension 7 considered in this task were: "Point negative and positive outcomes", "Compare ideas", and "Select concepts and ideas".

The teacher chooses three Websites and asks the students to point in each Website positive and negative outcomes of the following Website complementary features and to justify their answers. The complementary features to be considered by the students are:

1. Visibility and constraint;
2. Delimiters and white spaces;
3. Figure and background;
4. Good and bad usage of a metaphor;
5. Simplicity and complexity of the information;
6. Breadth and depth in navigation.

Afterwards, the teacher asks the students to compare and select the best Website designs.

Example 4. This task pays attention to Dimensions 1, 2, 4 and 5. In this example, the teacher follows the steps:

1. Choose a Web or desktop interface;
2. Ask the students to discuss while collaboratively decompose the interface, detecting the patterns used in its design;
3. Change the application context;
4. Ask the students to discuss while collaboratively integrate, adapt, and elaborate the patterns to create a new design in the new application context.
5. The dialogic processes took into account were "Decompose ideas", "Combine ideas", and "Recombine ideas" from Dimension 5; "Perform contextual shifting" from Dimension 4; "Elaborate an idea" from Dimension 2, and "Adapt techniques" from Dimension 1.

Example 5: In this task is regarded Dimension 6. Here, the teacher utilizes anti-patterns to provide opportunities for students to explore a bad design in order to better understand good designs. Anti-patterns capture poor or sub-optimal software development practices. So, the students have the opportunity to analyse why an apparently good idea did not have a positive impact and also to investigate how they can provide an alternative for a poor design. First, the teacher presents a set of anti-patterns, each one possessing a bad characteristic, such as: external inconsistency, internal inconsistency, dialog box without cancel button, go overboard in selection during data entry, badly designed affordances, badly designed metaphors, and complex or extremely deep navigation. Second, the teacher asks the students to discuss about what is bad concerning the anti-pattern, why this feature is illogical, inadequate, and ill-crafted, if there is a good design possessing this feature, if so what is the difference, and if there is a situation where it could be considered well-crafted.

IV. Preliminary Case Study Description

A preliminary case study was conducted during one semester of an HCI course. One class containing forty-eight under graduate students from software engineering course was subdivided in 8 (eight) groups, each group containing 6 (six) students. The students were analyzed considering interaction and participation patterns in online discussion forums in Moodle Platform. There were assigned 7 (seven) collaborative tasks to the students. The tasks are described following.

Task 1. The students were asked to analyze 16 (sixteen) Websites, considering good and bad usages of affordances and metaphors. The students were also invited to evaluate and critique other students' ideas.

Task 2. The students were asked to analyze 7 (seven) Websites, considering usability guidelines. The students were also invited to evaluate and critique other students' ideas.

Task 3. First, each group must choose a good and bad Website. Second, the groups must justify your choices, taking into account good and bad usages of affordances, good and bad usages metaphors, and usability guidelines.

Task 4. The teacher presented usability guidelines and interaction patterns for mobile applications. The students were asked to create a mobile version for a given Website, obeying the usability guidelines and performing patterns adaptations and combinations.

Task 5. Make a collaborative paper interrelating the usability guidelines presented. Discuss in your group forum.

Task 6. Criticize the Website of the Institute of Informatics. Discuss in your group forum.

Task 7. Make a re-design of the Institute of Informatics' Website. Consider the interaction patterns presented and discuted in class.

Interaction and participation patterns were analyzed based on Newman, Webb and Cochrane's adapted model [17] described in 10 categories. This model was chosen because it covers key aspects of the proposed framework. The framework application aims profitable students' interactions that result in a deeper and wider design space. Following we describe Newman, Webb and Cochrane's adapted model.

Category 1. Relevance: Relevant states or diversions.

Category 2. Importance: Important points and issues or unimportant points and trivial issues.

Category 3. Novelty, new info, ideas, and solutions: New problem related information or repeating what has been said.

Category 4. Bringing outside knowledge or experience to bear on problem: Drawing on personal experience or sticking to prejudice or assumptions.

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Category 5. Ambiguities; clarified or confused: Clear statements or confused statements.

Category 6. Linking ideas, interpretation: Linking facts, ideas and notions or repeating information without making inferences or offering an interpretation.

Category 7. Justification: Providing proof or examples or irrelevant or obscuring questions or examples.

Category 8. Critical assessment: Critical assessment or evaluation of own or others' contribution or uncritical acceptance or unreasoned rejection.

Category 9. Practical utility (grounding): Relate possible solutions to familiar situation or discuss in a vacuum.

Category 10. Width of understanding (complete picture): Widen discussion or narrow discussion.

V. Preliminary Results

Successful interactions require broad and active students' participation. The total number of students' posts was 773. So, there was a substantial participation of the students.

Considering Category 8, the results indicated that online interactions were cohesive. The students engaged critically or constructively in other students' ideas in 50% of the posts. They asked and clarified doubts in 40% of the posts and acted solo in 10% of the posts.

Regarding Category 9, the students used the guidelines as criteria to judge what is good and bad. In Task 1 the students did not know how to judge what was a good or bad usage. In tasks 2, 3, and 6, the students justified their ideas by means of the guidelines.

Considering Category 5, 6 and task 5, each group provided a distinct integration scheme for the guidelines. Each group had a different interpretation. However, they provided designs as examples for their connections. It proofs that IHC is a complex and ill-structured subject. The teacher should had confronted the different schemes and promoted discussions involving the whole class in order to converge to a solution.

Taking into account Categories 1, 2, and 7, there was 70% of relevant posts and 30% of diversions. Also, in the relevant posts, were discussed important points and issues.

Regarding Category 4, task 4 was successfully and easily performed by the students. Due to the fact that the great majority of students possessed i-phones or android interface mobile phones, the students could draw on personal experience to design the mobile interface.

Considering Category 3 and Task 7 the students successfully adapted and combined interaction patterns, being able to apply previous information to solve a problem during the Website re-design.

Taking into account Category 10, there were widen discussions, containing many different points and aspects being analyzed.

VI. Conclusion and Future Work

The main contribution of this paper is a novel framework to boost creativity in interaction design. The framework provides a structure for the elaboration of design exercises. Teaching interaction design is approached under a dialogic point of view taking advantage of dialogic processes. Dialogic processes are mapped in creative ways of thinking, so they serve to scaffold students to productive discussions. Dialogic processes are underneath creative dimensions that reveal forms of interaction design space exploration. The proposed framework provides broad and systematic interaction design space exploration and is theoretically supported by collaborative learning, many researches that address idea generation and researches involving interaction design space exploration.

The preliminary results indicated that the proposed framework has a great potential to help teachers to mediate students' creativity, through facilitating students' involvement in productive discussions, which in turn increases the quality of the design process. Students benefits from activating creative mental process during interaction design discussions and performing a better exploration of design space both in breadth and in depth, while teachers benefits from many strategies to elaborate design exercises involving usability guidelines, interaction design patterns and anti-patterns in order to boost discussions.

To ensure that the framework combined to usability guidelines, interaction design patterns and anti-patterns can indeed provide an effective connected approach to teaching HCI, we intend to further investigate its application as future work.

For at least four semesters of an HCI undergraduate course, there will be one class taught considering collaborative learning, but not the dialogic framework (control group) and another one taught by the proposed method (treatment group). Students performance will be investigated by discourse analysis in order to check if there is knowledge co-construction and advancement as well as the achievement of a deeper and wider knowledge in the collaborative settings. The discourse analysis will focus on analysis of interaction and participation Patterns [18]. We will also analyze and compare the students´ designs by means of an instrument to measure Website creativity [19] and indicators of creativity in solutions [20].

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