DESIGN THINKING METHODS AND TECHNIQUES IN DESIGN EDUCATION

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ABSTRACT
Design Thinking is a human-centred innovation process, with an emphasis on deep understanding of consumers, holistically, integratively, creatively, and awe-inspiring. Design Thinking methods and techniques represents how the theory will be operationalized by following the process steps. These methods and techniques can assist in the project management, especially in the initial phase of inspiration and ideation. Another strategy that can collaborate in project management is agile management, mainly in the execution phase of a project. Agile management prioritizes individuals, interactions between them, customers, appropriate software to operate, and prompt response to changes. Thus, this study aims to propose a model to integrate design thinking and project management methods and techniques and to analyze students' projects and interactions to verify the applicability of these in ergonomic project management. For the development of the method, it was used the design science methodology, in four main steps called: Research Clarification, Descriptive Study I, Prescriptive Study, and Descriptive Study II. From the use of tools and techniques of design thinking in a project management exercise for students of two classes, it was revealed that the tools used facilitated the project development, helping from the search and organization of information until the deadline established for the delivery of the project.

Keywords: Design Thinking, Design Education, Project Management.

1   INTRODUCTION
The project management emerged at 50's decade, incorporation techniques, tools and concepts to improve the projects quality. At the beginning, it was used to big projects, like civil construction, defense and aerospace, but had spread and become used at business areas [1]. At the end of 90's, started the bodies of knowledge, focusing on identify the best practices in project management. The Project Management Body of Knowledge (PMBOK), developed by Project Management Institute (PMI), is the most representative of these. PMBOK presents the process that describer the activities during the project life cycle (initiating, planning, execution, control and closing). The main focus of these traditional approaches in project management is to plan very well to execute latter [2,3].
At information technology, there were great increases of the adoption of these practices, mainly at software development. However, according to Fernandez and Fernandez [4], the traditional project management can inappropriate and potential disadvantageous for structurally complex projects, uncertain and high time limited. Besides that, these approaches focus in a developed idea and not at the problem understanding, which is really important at ergonomics. Thus, this study aims to propose a process to integrate design thinking and project management methods and techniques, and analyze students' projects and interactions to verify the applicability of these in ergonomic project management.

2   DESIGN THINKING
Design Thinking (DT) is a process centred on the human being, with emphasis on the deep understanding of consumers, targeted at the innovation of products, services, processes and businesses in a holistic, integrative, creative and inspiring way. DT translates observations into insights and insights into innovation through an exploratory, iterative and non-linear process, which leads to unexpected discoveries since the process is fundamentally exploratory. DT is supported by themes that form the DT mentality: empathy, curiosity, collaboration, experimentation, visualization, flexibility, and continuous learning.

The DT process is presented differently by some authors [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15], however, the process logic is approximately the same. The main differences lie in how the stages are named and grouped. To Brown and Katz [5] and IDEO [7], DT is made of three main stages: inspiration, ideation, and implementation. Jiao and Zhang [8] also consider three stages: observation, cooperation, and idea visualization. Davis [12] presents seven stages: problem identification, statement development, ideation, evaluation, visualization, analysis, and final concept direction. Goodspeed et al. [13] present five stages: empathize, define, ideate, prototype, and test. Luchs et al. [14] presents four steps: discover, define, create, and evaluate. The British Design Council [14] presents the Double Diamond, which has 4 stages: discover, define, develop, and deliver. Although the Double Diamond is not specific to DT, it is used by more than one author [16, 17]. Stickdorn and Schneider [10] also bring four stages: explore, create, reflect, and implement. Liedtka and Ogilvie [9] propose four question-structured stages: what is?, what if?, what wows?, what works?. Carlgren et al. [15] propose a framework in which, instead of presenting stages, they present themes that should be used in the design process, connecting them to principles, practices and techniques: user focus, problem framing, visualization, experimentation, and diversity.

3 AGILE PROJECT MANAGEMENT

Agile Project management appeared as an alternative to solve these difficulties and agility is a key element for Agile Project Management. The term Agility was defined by Conforto [18] as "…the ability of the Project team to change the Project plan speedily and continuously, in response to the emerging needs of the customers, market demands and tendencies or opportunities to add value and deliver better results in an innovative and dynamic business environment."

It is important to understand the concept of agility, since it is one of the main objectives to be achieved by using Agile Project Management. Agility can be defined as the ability to deal with unexpected challenges, survive unprecedented threats from the business environment and take competitive advantage of changes and opportunities [19].

Table 1. List of success factors concepts and authors related to Agility and Innovative Results

Success factors	Concept	Agility	Innovative results
Autonomy	The extent to which the company allows individuals to work with the highest degree of freedom possible, controlling their own work and their ideas. It's a factor that drives and gives meaning to personal commitment and that should be managed at an organizational level.	[20, 21]	[22]
Coordination	The way that project stakeholders (individuals) self-manage their activities continuously by setting the performance of the team.	[21, 23, 24]	[25]
Communication	The flow of information between people effectively, either face to face, through online tools (e-mail, Skype, etc.) or through document exchange.	[26, 27]	[22, 27, 28]
Collaboration	The collaboration is to work actively together with continuous interaction between people through trust and responsibility to deliver a project (or product) or a decision. Collaboration means a joint effort to generate results.	[26, 27, 29]	[27, 28]
Continuous Education	Process created through the transformation of experience throughout a project, which when shared creates new data, new rules and new knowledge.	[29, 30]	[22, 31]
Flexibility	The ability to respond to sudden changes, adapting or reacting with little penalty in time effort, cost or performance.	[21, 23, 32]	[22, 32]

4   METHODOLOGY

For the development of the method, it was used the design science methodology, that is a method that operationalizes the construction of knowledge in this context [33]. So, this study was developed in four main steps, according to Chakrabarti [33]: (i) literature analysis, called 'Research Clarification', (ii) analysis of empirical data, called 'Descriptive Study I', (iii) synthesis of assumption and experiences, called 'Prescriptive Study', and (iv) analysis of empirical data, called 'Descriptive Study II'. According to Chakrabarti [33], the design research has objectives related to formulation and validation of models and theories, and development and validation of support founded on these models and theories.

For the first stage, 'Research Clarification', techniques and methods of design thinking existent in the literature were researched. These data were integrated to project management and agile project management.

In the second moment, a 'Descriptive Study I' was carried out, observing and analyzing experiences and facts with students of extension courses related to production engineering. A script of questions was organized and applied in these moments and the context issues were analyzed. Holtzblatt and Beyer [34] note that contextual inquiry gather the necessary data to understand how people work and, consequently, to analyze the problem. The data collected were organized and tabulated for further analysis. From this analysis, the third stage was started.

For the 'Prescriptive Study' (third stage), the model was developed, considering aspects of design thinking, project management, agile project management theories, and the experiences and facts of the descriptive study I.

Then, in the 'Descriptive Study II' (fourth stage), the model proposed was applied and evaluated with thirteen students of a Project Management discipline in 2015 (called first group) and sixteen students of the same discipline in 2016 (called second group). This discipline belongs to the Ergonomic postgraduate course, at Engineering Production Department, located in Federal University (UFRGS) in southern Brazil.

5   RESULTS AND DISCUSSION

Based on literature review, it was identified that project management models are based on a developed idea, focusing in planning the implementation of this idea. Thus, in ergonomics, a project starts from a problem identified. And at this moment Design Thinking is relevant to the process, to support the problem understanding. By the same way, to reach better results, it's important to validate the solution during the process, to ensure that this solution attends the needs of the stakeholders of the process. Based on this information, the integrated process was developed (table 2).

At the beginning, was presented the discipline plan for the students, focusing in what would be developed during the classes. This project regarded the four main phases of a project (initiating, planning, execution and closing), organized by this way: (i) initiating – inspiration and ideation; (ii) plan; (iii) execution; (iv) closing - implementation.

Table 2. Proposed process to integrate design thinking and project management methods and techniques in education

	Inspiration	Ideation	Plan	Execution	Implementation
Goal	❑ Problem Understanding ❑ Opportunity Identification	❑ Ideas Generation ❑ Ideas Selection	❑ Project Plan	❑ Execution of the plan	❑ Tangibilization of ideas
Tools	Desk research PEST 5 Human Factors Trends Matrix Empathy Map Extremes	Brainstorming Design Concept Venn Diagramm	Based on PMBOK Value Definition Canvas Scope Definition WBS Risk Analysis	Agile Project Management Charts Burndown Graphic	Prototyping Storyboard Solution Evaluation Solution Roadmap Quality Evaluation Pilot and Test Implementation Plan

The inspiration phase begins with a challenge – in this case an Ergonomic problem – and represents the problem understanding. For this phase, it's important to look at the context, considering people and their interactions, and the market. Focused on people, there are proposed three tools: 5 human factors, empathy map, and extremes. These tools have the goal to deep understand people, considering their feelings, thoughts, actions, interactions, and needs. The extremes tool has the goal to stimulate to think in a different way through a different perspective. For the context/market, it's proposed the desk research, PEST, and trends matrix. The goal is to see at the context considering multiple perspectives. Since the data obtained, there are gathered a lot elements that represents the problem understanding. Based on this it's possible to define a relevant opportunity, that is root cause of the challenge. IDEO [7] states that the process of translating insights into opportunities is to move from the current state to the glimpse of future possibilities.

The next phase is the ideas generation and selection. For this phase, it's proposed the use of brainstorming as a method to generate ideas in a divergent way. According to Seidel and Fixson, and Liedtka and Ogilvie [6, 9] much more ideas generated, better the results. For ideas refinement it's proposed design concepts, focusing on developing a common vision in the groups. For the ideas selection, it was used the Venn Diagram, based on selection criteria of Design Thinking: desirability, practicability and feasibility. IDEO [7] states designers see the world through this lens during the various stages of the design process.

With the idea selected, it was proposed to work at the project plan. This was based on PMBOK, value proposition, Canvas, scope definition, Work Breakdown Structure (WBS) and risk analysis. At this phase is important to identify the value proposition, key activities and resources, cost structure, assumptions and constraints, risks and the main activities of the project.

At the execution phase, there were used the Agile Project Management to help in the implementation plan. It's proposed the use of burndown chart graphic. This graphic is used to scale the activities along the iterations, using effort criteria. This iterative work is important because of the focus on experimentation through the prototype. The aim is to fail early, embrace changes and get better results at the end. Berczuk [35] adds that the iterative plan provides a basis for a conversation about the costs of introducing change into the solution proposed.

This phase happens overlapped to the implementation phase. For this are proposed seven tools: prototyping, storyboard, solution evaluation, solution roadmap, quality evaluation, pilot and test, and implementation plan. The goal of this phase in to tangible the solution, looking to see what works, what does not, what delivers value and what does not deliver value, in order to increase the success of the solution. According to Kumar [36], "stories have the fundamental ability to translate abstractions like a 'system' into human terms that can be easily grasped" [36]. The author adds "storyboard can be thought of as prototyping through language" [36].

This model was applied and evaluated with 29 students of post-graduation, organized in 12 groups. The classes were developed alternating theory and practice, starting from a challenge and finishing with a prototype and implementation plan. The main results observed through the implementation of the model can be explained through the development of the success factors of agile project management. The model stimulates the autonomy of the students and the group because all the tasks

had to be developed in class alternating theory and practice. Each step that was presented by professors was followed by a practice. By this way, they could feel safety to try, fail and make changes during all the process, developing flexibility. This format of the classes helped them to work coordinate its activities and self-manage the results and next steps. Working iteratively during the class helped them to maintain the communication, collaboration and continuous learning because they could share their difficulties, experiences and knowledge. With this practice they could develop a holistic view of the process of a project, integrating this to the reality of Ergonomics. Besides that, they learned that to convince about the importance of the project, they had to think about the users, stakeholders and other elements (value proposition, costs, resources, time) that could affect the decision of the project implementation success.

6   CONCLUSION

From the proposed model, this paper analyzed methods and techniques of design thinking and project management, and proposed a process to integrate design thinking and project management concepts for post-graduation students. Some difficulties were identified in the use and application of the tools used by the students, because they had never worked with these methods and techniques. However, these difficulties were transformed in new knowledges and they could develop new competences based on Agile Project Management success factors, as autonomy, coordination, communication collaboration, continuous learning and flexibility.

The use of tools and techniques of design thinking in a project management exercise for students of two classes revealed that the tools used facilitated the ergonomic project development, helping from the search and organization of information until the deadline established for the delivery of the project. One limitation of this research was the application of this study in a small, restricted located and non-probabilistic sample and, therefore, it is not possible to generalize the results. For future studies, it is suggested to apply the educational process of integrating design thinking and project management into a larger sample of students.

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