Innovation & Management Review
ISSN: 2515-8961
revistarai@usp.br
Universidade de São Paulo
Brasil

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Innovation & Management Review, vol. 17, no. 3, 2020, July-September, pp. 267-284
Universidade de São Paulo
Brasil

Describing the design thinking and extreme programming activities during a technology innovation academic workshop

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Received 30 March 2019
Revised 1 October 2019
6 December 2019
Accepted 17 December 2019

Abstract

Purpose – This paper aims to describe the students' experience in adopting design thinking (DT) and extreme programming (XP) throughout a course of technology innovation workshop in a master of business administration (MBA) degree program.

Design/methodology/approach – This study analyzes data (performed process and achieved results) from the students' reports and the instructor's observations about three courses held in 2016, 2017 and 2018. In each course, there were students conducting activities to understand, develop, and validate the market, customer, user and prototype.

Findings – This paper identifies that the processes of DT and XP promote active and collaborative learning relationships. The adopted activities along with a mix of different backgrounds from the students can promote good insights to understand the user problem and build a technological solution with incremental innovation.

Research limitations/implications – This paper describes only a unique view from the instructor's knowledge; therefore, others might present different scenarios and results.

Originality/value – The paper contributes to the characterization of DT and XP activities when teaching technological innovation in a MBA.

Keywords Design thinking, Extreme programming, Experience, Master business administration

Paper type Technical paper

1. Introduction

The innovation process is a relevant topic for innovation research (Wolfe, 1994; Organisation for Economic Cooperation & Development and Statistical Office of the European Communities, 2005; Crossan & Apaydin, 2010; Usai, Scuotto, Murray, Fiano & Dezi, 2018). Whenever a heterogeneous group of students conducts an innovation process, having different backgrounds and skills (computer science, economy, administration, pharmacy and engineering), the challenge to perform and spread innovation may be greater, but innovation activities may be more enriching.

Innovation & Management Review
Vol. 17 No. 3, 2020
pp. 267-284
Emerald Publishing Limited
2515-8961
DOI 10.1108/INMR-03-2019-0039

Students in a master of business administration (MBA) program can also innovate for a while "[. . .] whether a set of activities could guide them, without those activities several obstacles can emerge such as, asking more interesting questions to discover more original ideas [. . .]" (Liedtka, 2018, September) and whether students are encouraged to try innovative behavior during the classes.

Marin-Garcia, Andres, Atares-Huerta, Aznar-Mas and Garcia-Carbonell (2016) propose a framework to foster innovative behavior in the workplace. Creativity, critical thinking, initiative, teamwork and networking are competencies that must be materialized through several innovative behaviors as, for example: *thinking differently*, *finding new ways to implement ideas*, *evaluating advantages and disadvantages* and *sharing relevant information with suitable stakeholders*.

Technological innovation workshops (TIW), in an MBA, is a course that aims to provide students with an experience with activities to identify and validate innovative ideas, define business models for the selected ideas and develop and validate technological products such as software prototypes in an agile way. These prototypes must show some kind of innovation.

Instructors in these courses, such as managers in a company, cannot have the ability on innovation teams "[. . .] as designers have to do face-to-face research with customers, getting deeply immersed in their perspectives, co-creating with stakeholders, and designing and executing experiments," (Liedtka, 2018, September) as well as they cannot be prepared to foster those innovative behaviors in the students.

After non-systematic research in several MBA degree programs and primary studies in the scientific literature, TIW may still be deprived of concrete theoretical background and basic principles, as there was no case of a TIW being performed during the MBA degree programs. Even when we run the string "technological innovation workshop" on search engines, there is no evidence to support us on how to perform a TIW course during an MBA degree program. Besides, small and medium-sized technology companies are not systematically innovating (Silva, Oliveira, & Moraes, 2016; Teza, Buchele, de Souza, & Dandolini, 2016).

In the context of large companies, there are empirical studies for innovation management proposing process models (Verworn & Herstatt, 2002; Barbieri & Teixeira, 2016).

In those models for industrial context, this study perceived some conditions to applied in the academic context. Thus, could a systematic set of activities be adapted to achieve the goals of a TIW course during an MBA degree program?

In 2016, MBA students with diverse skills commenced a TIW course whose goal was to build a software or some type of technological prototype with some innovation in an agile way. The prototype scoping and requirements were volatile leading to several changes during the development.

Considering this demand, the initial planning for the first TIW course was to adopt an agile process – extreme programming (XP) – to guide the students to deliver the prototype under volatile domains. XP provides practices stimulating students to develop their prototypes in volatile domains (Beck & Andres, 2004).

After the first experience in 2016 and the premise that MBA students should ask more interesting questions, the same instructor adopted, for the next workshops, the design thinking (DT) approach to guide students during the innovation process to mitigate the risks associated with innovation obstacles (Macedo, Miguel, & Casarotto Filho, 2015) and foster an innovative behavior.

This article focuses on reporting the DT and XP activities adopted by the students, how they introduced them, what results in they reached, and the lessons learned. This report may be relevant to instructors to plan similar TIWs in MBA courses.

The remainder of this paper is structured as follows: Section 2 presents a brief discussion of innovation through TIW, DT and XP topics. This is followed by a presentation of the adopted research methodology in Section 3. Section 4 presents the results from the experience. Section 5 presents a discussion and lessons learned from that experience. Section 6 presents the conclusion and suggestions for further research.

2. Background

2.1 Challenges in the innovation process

There are many challenges to perform a sequence of activities that provide innovations, especially during the TIW in a MBA. For example, to foster ideas, skills and develop prototypes that result in technological products with some innovation, how should the instructor encourage the students to ask a more interesting question to discover more original ideas? How should the students elicit pains or needs from customers if those do not yet exist? And, how to encourage the students to let go of bad ideas? (Liedtka, 2018, September). In several cases, the main challenge for the students is to recognize whether the problem or idea might generate an innovative solution.

Marin-Garcia *et al.* (2016) propose a framework that addresses these challenges through stimulating innovative behaviors. Creativity, critical thinking, initiative, teamwork and networking are competences realized through several behaviors as, for example: *thinking differently*, *finding new ways to implement ideas*, *evaluating advantages and disadvantages* and *anticipating how events will take place*. This last behavior can face the challenge *to elicit pains still non-existent from customers*.

2.2 Design thinking

DT is a person-centered model for innovation (Macedo *et al.*, 2015; Santos, Bianchi, & Borini, 2018) and can be defined as:

> A discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity (Brown, 2008, June).

Because it guides management students to focus on building innovative new businesses, encouraging students to explore idea recognition and moving from divergent to convergent thinking (Newton & Riggs, 2016).

The DT process has activities to:

- Discover the problem or idea, which addresses the challenges *ask a more interesting question* and *elicit pains still non-existent*;
- Interpret the links and interactions between information, objects and stakeholders, which again deals with the same challenges;
- Decide, which critical elements would provide the most value to the customer, which deals with the challenge *encourage the students to let go of bad ideas*; and
- Propose an minimum viable product (MVP).

During the DT discovery activity, students must immerse themselves in customer preferences and behaviors to draw inferences about their needs. However, to stimulate the students *to ask a more interesting question about the customer pains*, maybe some still non-existent, students build a rich picture that links tendencies, challenges and stakeholders; they make a *persona* to describe their profile; and rewrite the idea or problem to mitigate bias as the previous solution in mind before commencing DT activities.

After the interpretation activity, students can perform tasks like co-creation and brainstorming of ideas. At this moment, students can *throw away bad ideas*, rewrite or integrate them as a concept (Seidel & Fixson, 2013) that synthesizes ideas and insights translating to something to be developed.

Finally, students should propose an MVP through prototyping to represent the solution and test the hypothesis about the idea, and develop a business model canvas (Osterwalder, Pigneur, Clark, & Smith, 2010) to design the business and proposed idea.

2.3 Extreme programming

XP is an agile method categorized according to agile manifesto[1] values and principles, accomplished through the 24 technical practices, such as pair programming, user stories, weekly cycle, root-cause analysis and code-and-test (Beck & Andres, 2004). These practices are grouped into four phases, namely, exploration, planning, iterations to release and productionizing (Amber, 2018).

XP has not the ability to allow alone the innovation (Sohaib, Solanki, Dhaliwa, Hussain & Asif, 2019), as agile methods focus on working software from a technical perspective when the stakeholders need a solution. Therefore, XP has been aligned with the DT approach (Smrtic & Grinstein, 2004; Siebra, Filho, Silva, & Santos, 2008; Richter, Schildhauer, & Jackson, 2018), which also needs to mature and integrate to another approach (Corral & Fronza, 2018; Seidel & Fixson, 2013; Engberts & Borgman, 2018; Jensen, Lozano, & Steinert, 2016) – especially agile methods.

For example, Sohaib *et al.* (2019) combine DT practices such as *persona* with the XP *exploration phase* to improve the understanding of customers' needs.

In Broschinsky and Baker (2008) and Corral and Fronza (2018), the software development team needed to improve their communication with the customer, and then the staff of human-factor developed a *user persona* (DT activity) to integrate to *user stories* (XP practice) during the software development. In these studies, *ask a more interesting question* led to pivoting of ideas/solutions, that is, the students *finding a new way to implement ideas* when they brainstormed the solutions and redefined the problem, two DT activities.

Jensen *et al.* (2016) aim that agile methods and DT are similar and complementary, because both focus on user needs and their participation in the innovation process, where DT activities discover and identify the scoping of the requirements and agile methods build a solution for this MVP.

Both DT and XP have a set of powerful activities that can provoke the student *to ask more interesting questions* and *elicit pains, maybe those still non-existent*, by discovering user needs and develop novel solution (Jensen *et al.*, 2016) providing the active learning, feedback, collaboration and engagement of the participants, making tangible ideas and aiding the *team to recognize whether the idea will generate innovation*. This is an action of evaluating advantages and disadvantages in the idea and solution – an innovative behavior.

Although there are some studies, in fact, we need more evidence to understand these approaches and its integration, as Marin-Garcia *et al.* (2016) highlight mentioning that there are gaps in the academic research about innovation skills acquired by students.

2.4 Innovation activities for students in technological innovation workshops

The evaluation of a MBA (Ministério da Educação – Coordenação de Aperfeiçoamento de Pessoal de Nível Superior Diretoria de Avaliação, 2016) has valued the creation of products and solutions for organizations and students are stimulated to develop the solutions to their customers in several workshops during the MBA, however, it is still necessary that students explore possibilities for innovative new businesses (Meira, 2013). A TIW should consider a set of activities to guide and put together students with different types of skills to foster innovation enables them to architect those innovative new businesses.

Traditional processes, such as *spiral* (Boehm, Brown, & Turner, 2005) and *waterfall* (Larman, 2003) guide to building these solutions, focusing on engineering artifacts, basically, technical activities to transform user needs into software prioritizing quality, documentation, coding and artifact structures. And, innovative behavior can be included among the activities of engineering. However, for volatile domains with a high probability of change on requirements and scoping, traditional processes are not recommended. Instead of them, agile methods like XP are more appropriate (Larman, 2003).

As the students in a TIW should build software prototypes in a short time box (30 h in 4 months), XP is more appropriate because it aims to deliver versions of the prototype frequently in a few weeks. DT has been adopted in some cases (Jensen *et al.*, 2016; Seidel & Fixson, 2013) aiming to create innovative products from scratch.

To guide students to mitigate risks associated with those challenges, DT and XP can aid them in a rationalized way. Even though the complete innovation process may not be accomplished during a TIW in an MBA, as a common feature of an innovation process is its introduction on the market (OECD, 2005), exercising some innovation activities may foster an innovative behavior in students to face the challenge of recognizing whether the idea will generate an innovative solution.

Moreover, DT and XP activities can foster business students when in their organizations to take advantage of digital transformation in a cost-effective manner developing solutions that meet customer pains with low costs, waste and time (Gurusamy, Srinivasaraghavan, & Adikari, 2016, July).

3. Methodology

The empirical base of this study considered three TIW courses (2016, 2017 and 2018). MBA students delivered a technical report about the performed process as a final evaluation for the course. This study analyzed this evidence alongside the instructor's observations regarding the performed process and achieved results.

The same instructor conducted these three courses; and the MBA students adopted DT and/or XP practices to understand, develop, and validate the market, customer, user and MVP. These courses took place between August and December – a four-month period for each course.

During the classes, after the instructor has presented DT and/or XP approaches for all courses, he observed whether the students applied DT and/or XP activities, annotating what of them were exercised and what artifacts were drafted until they build the software prototypes.

For this performed scenario, this experience has applied inductive, descriptive, interpretive, qualitative, observational and archival research and discourse analysis characteristics (Wohlin & Aurum, 2015). It is applied because the instructor provided the theoretical base (DT and XP) to improve the existing application. It is inductive because this study aims to move from a specific experience to the general arguments in the future. It is descriptive because the study describes the phenomenon ("what and how" occurred the course, experience). It is interpretive because the study aims to understand a specific situation from the participants' perspective. It is qualitative because the data refers to written documents and descriptions from the instructor's observation. It has observational (from the instructor) and archival research (technical report from the students) as data collection methods. Finally, it uses discourse analysis because it is a common method to provide a deeper understanding of qualitative research when the data is, for example, documents such as the student's reports. In this analysis is described whether the set of activities from DT or XP adopted by the students and recorded in their reports provides evidence to link to the innovative behaviors highlighted in Marin-Garcia *et al.* (2016) and the challenge for the students in recognizing whether the problem or idea might generate an innovative solution.

3.1 Course requirements-goals

Each course encouraged the students to develop prototypes with some type of innovation for society. The MBA students could solicit intellectual property rights[2] on the prototype or organize a start-up on it. To conclude the course, the MBA students met the following requirements: to perform a methodology (DT and/or XP activities), to deliver a prototype and to write a technical report.

3.2 Team context

For each course, the instructor organized the teams with students having distinct backgrounds or technical skills. For example, in the course of 2016, there was a team with members from a hospital direction, an economist, a computer science undergraduate (CC) students and a manager. In the course of 2017, there was a team in which the members were a pharmacist, CC students, a manager and a product engineer. The CC students were not MBA students, they were invited to complement the team background, as they had skills to build software or at least, a software prototype.

In the course of 2016, MBA students performed just XP practices. At least one CC student collaborated with the team. Three established teams: Team 1 – market list, Team 2 – business plan and Team 3 – seguradora.

In the course of 2017, MBA students performed XP and DT activities. At least one CC student collaborated with the team. Three established teams: Team 1 – Recept-Ação, Team 2 – AcaWorks and Team 3 – Mangô.

In the course of 2018, the MBA students performed only DT activities. One established team, Team 1 – Terceira Idade.

3.3 Methodology executed steps

The TIW required 30 h of meetings with the instructor during a period of 4 months. Each course was divided into 6 lectures, each meeting taking 5 h.

Following the course syllabus, during the first lecture, the instructor introduced the technological innovation topic. The instructor discussed innovation concepts, cases of start-ups and products in software technology with the students. Afterward, in a one-hour session – the students suggested several innovative ideas and voted for those of greater interest to them.

During the second lecture, in 2016, the instructor did not present DT concepts, the students had to perform only XP practices (write *user stories* with customers and *planning game*) to understand and validate the problem. In 2017 and 2018, the instructor also presented DT concepts, as a tool for students to validate the idea and prototype. In this lecture, the students defined the project scoping by mapping stakeholders and their interactions.

In 2017 and 2018, between the second and the third lectures, for approximately 15 days, the students *mapped relevant stakeholders* and their interactions, identified *marketing tendencies*, understood *the stakeholder environment*, investigated *insights from other contexts* and experienced *user experience*. During the third lecture, the students presented artifacts related to previously performed activities. For example, they exhibited a diagram of stakeholders and interactions among them with some explanatory notes. They validated the idea through the informal pitch[3]. The instructor asked the team to explain "what is the pain of the mapped stakeholders?" and "what is the value proposition to mitigate or solve that pain?" This meeting was an opportunity for the team pivot[4] on its idea (challenge).

For the third lecture, the main activity was to refine the project scoping by presenting a pitch of 10 min for each team. The team explained their idea, who the stakeholders were and what pains they presented, which problem would be resolved, which was the target-market and which was the business model.

Between the third and the fourth lectures, the students from 2016 ran XP common practices as *user stories*, *planning of iteration* and *drafts of screens* (prototypes). The students from 2017 and 2018 performed DT activities to validate their idea. They built a *rich picture* that linked tendencies, challenges and stakeholders; made a *persona* to describe relevant stakeholder profiles; and *rewrite the idea or problem* to mitigate their bias (a previous solution in mind before commencing DT activities). All courses (2016, 2017 and 2018) completed these activities during the fourth lecture. The instructor discussed with each team, separately, considering the built artifacts and performed activities.

The main activity in the fourth lecture was to define the MVP as several students had difficulty meeting outside the classroom.

Between the fourth and the fifth lectures, the students from 2016 accomplished the *business model canvas*, without performing DT activities. We validated them during the fifth class through the presentation for all students. The students from 2017 and 2018 made the DT activities to *ideation* and proposed a model to understand their business performance. *Ideation* focused on the same activities to explore the stakeholders, problems and tendencies to solve their pains. *Business model canvas* captured their business performance.

In the fifth lecture, each team prepared their *business model canvas* presentation and validated with the instructor and other teams.

Finally, between the fifth and the sixth lectures, the students proposed a final MVP through the *prototyping* to represent the solution and test their hypothesis about the idea. Each team presented its prototype in the sixth lecture and delivered a technical report. Then, a pitch of 30 min was consolidated and presented for each team.

4. Results

This section describes the activities performed by students, their perceptions about the DT and XP processes, and some snapshots of the prototypes they developed. Intermediary artifacts such as *business model canvas*, *user stories* and pitch' slides were developed by the teams; however, this article does not focus on them.

4.1 Activities performed by the teams

4.1.1 Excerpts from the team reports – 2016. Table I presents the activities and outcomes accomplished by the teams during the course in 2016. *Analyze the market* listed the

				4 – develop-prototype	
Activities	1 – analyze-market	2 – develop-business-model	3 – validate-canvas	4.1 – specify-prototype-requirements	4.2 – coding-prototype
Outcomes	List-competitors-features	Canvas	Expert-feedbacks	User-stories	Code-testings

Source: Research data

Table I. Performed activities: 2016 – Teams 1, 2 and 3 competitors and features; *develop a business model* produced a canvas model to understand the business; *validate the canvas* focused on collecting feedbacks from experts to adjust the model; and *develop the prototype* wrapped technical practices – user stories, acceptance testing, test-driven development and pair programming (Beck & Andres, 2004) – for building a working software prototype.

Two teams reported perceptions about the activities. Team 1 reported, "[. . .] the Prototype activity is an excellent tool to exchange information between business and technical stakeholders." The computer science students also reported "[. . .] immaturity with the adopted tools" because it was their first experience with those technologies. Team 2 reported "Little time to develop the prototype; XP meets the team's goals," and "[. . .] the prototype validated the idea and team's expectations."

Team 3 just provided feedback about the activities informally (during discussions with the instructor in the classroom). They said the process was "interesting" and "[. . .] it aided in the development of an appropriate business model."

No team mentioned any innovation aspects as the experimentation of new technologies, processes or innovator business models. All the teams focused on developing product features. They demanded more time to develop a comprehensive product, as the process did not plan an MVP as a possibility. Figure 1 shows the developed prototypes.

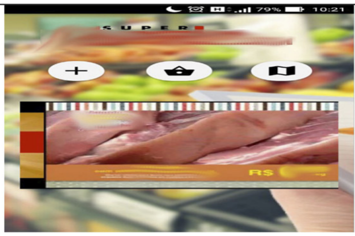
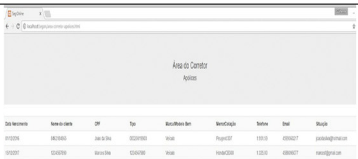
4.1.2 Excerpts from the team reports – 2017. Table II presents the activities and outcomes achieved by the teams during the course in 2017. *Discovery* observed what the customers do; *interpret* provided links and interactions among information, objects, stakeholders to prioritization; *decide* identified critical elements that promote value and differentiation; *propose* developed prototypes as video and storyboard; and *develop the prototype* wrapped technical practices – user stories, acceptance testing, test-driven development and pair programming (Beck & Andres, 2004) – to build a working software.

Team 1 identified the proposed challenge in the course as a "complex and demanding task," thus they demanded a process to handle that activity. Team 2 highlighted some activities, for instance, "brainstorming was a rich approach to generate ideas." They also reported, "the activities were extremely positive for us." Team 3 did not report perceptions about the activities; however, they pivoted on the idea (changed the direction of the business model) sometimes during the course and, for this reason, some comments about the process emerged as "this adopted process made the pivoting."

Again, teams did not mention any innovation aspects. All the teams focused on developing product features. However, as the DT and XP *specify requirements* activities ran in parallel and collaboratively, it was observed teams performed some DT activities as XP tasks during the iterations to elicit user requirements. For example, *stakeholder mapping* and *persona* (DT activities) were not only inputs to describe *user stories* (XP practice) but also were performed concomitantly by all the students (business and technical) as a XP task. Figure 2 shows the developed prototypes.

4.1.3 Excerpts from the team report – 2018. Table III presents the performed activities and outcomes by the team during the course in 2018. *Discovery* observed what the customers do; *interpret* established links and interactions among information, objects, and stakeholders to prioritization; *decide* identified critical elements that promote value and differentiation; and *propose* developed a video-prototype and business model canvas

Team 1 reported the performed activities to build a video-prototype to alert the elderly to prevent falls at home. They reported "[. . .] we can understand the needs and main problems faced by the elderly [. . .]." Team 1 also highlighted "[. . .] it was possible to show a proposal to improve the society [. . .]." Team 1 performed the activity Discovery through two interviews with the elderly, in those the students took pictures and moving images from

Team 1 developed an app to create grocery-shopping lists. The idea was to connect the supermarket database to get basic data about the item (size, value, etc), then, to calculate the total value for the shopping. The main prototyped functionalities are: Include, Get, and Edit Item in a Product List; Show on a map the nearby Supermarkets.	 A personalized view for a specific Supermarket **Source:** Junior *et al.*, 2016
Team 2 developed a prototype to manage projects and business. The prototype provided a business plan. The main prototyped functionalities are: Login to access the system, Include a new Customer, Include a new Business, and Configure payment type.	 View to start a new business plan **Source:** Baldi *et al.*, 2016
Team 3 developed an online platform to solicit insurance quotes, provide a relationship with the insurance agent, and get data about insurance policies. The main prototyped functionalities are: Include a new insurance agent, a new insurance quotes; List the insurance policies by customer.	 Listing policies by customer **Source:** Ribas, Vanzetto, Sampaio, Junior & Almeida, 2016

Source: Research data

Figure 1.
Prototypes-2016

Activities	1.1 discovery	1.2 interpret	1.3 decide	1.4 propose	2.1 specify-requirement	2.2 code
	1 design-thinking				2 implement-prototype	
Outcomes	Stakeholder-mapping Field-observation Insight-list	Persona Re-defining-problem	Principle-design Brainstorming Value-proposition	Prototype Business-model-canvas	User-stories User-acceptance-tests	Code-test

Source: Research data

Table II.
Performed activities: 2017 – Teams 1, 2 and 3

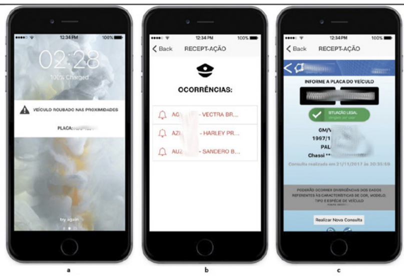
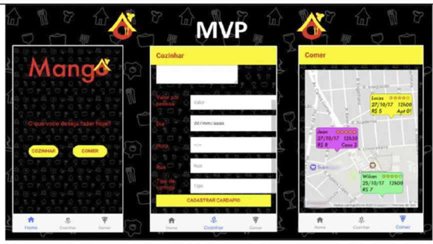
Team 1. Prototype to centralize and integrate the communication of thefts and robberies of cars connecting the police departments in working in that occurrence. The main prototyped functionalities are: Include a new occurrence with the car information; Show the occurrence to the policemen; Send the occurrence to the policemen's smartphone.	 Three views to alert policemen, listing occurrences, and details of an occurrence **Source:** Lorenzetti, Grander, Coelho & Bittencourt, 2017
Team 2. Prototype to share the services (between consumers and providers) in the review and translating of manuscripts from academics. The main prototyped functionalities are: Include a new customer and Include a new service provider and Include a new service (review or translating of manuscripts).	 Landing page for the AcaWorks **Source:** Machado *et al.*,2017
Team 3. Prototype to share meals among communities, as an example, the university students. The main prototyped functionalities are: Include a new provider of meals and their meal options; Show nearby providers of meals for the customer on a map.	 Views of an MVP named of Mangô **Source:** Valenga *et al.*,2017

Figure 2.
Prototypes-2017

Source: Research data

Table III.
Performed activities: 2018 – Team 1

Activities	1 design-thinking			
	1.1 discovery	1.2 interpret	1.3 decide	1.4 propose
Outcomes	Stakeholder-mapping (by interviews) Field-observation	Persona Re-defining-problem	Brainstorming	Prototype Business-model-canvas

Source: Research data

their homes; and one interview with a municipal secretary director of social service in Cascavel city (Paraná-Brazil). Also, one team member had contact with doctors and health agents, who provided essential information about care with the elderly. Team 1 also performed persona and re-defining the problem. Their members did not mention a perception about those activities; however, they pivoted on the idea between the third and fourth meetings. They justified the pivoting highlighting "the impact on society that the prototype could provide at the end of the course" (observation captured by the instructor during the fourth lecture).

Team 1 did not mention any innovation aspects. Team members focused on developing the prototype. Figure 3 shows the developed prototype.

For both the 2016 and 2017 courses, the aid of CC students resulted in working software prototypes. In 2018, with only the MBA students, a video-experience was built. On the other hand, in 2016 and 2017 there were common debates on the technical feasibility to building the prototypes between CC and business students. These debates can enrich the skills of innovation in the classroom environment for both types of students.

As can be noted in Tables I, II and III, different methods were used each year. It is difficult to understand which method was better. However, in 2016, without DT practices, the teams scoped their projects early (in the first lecture) and they neither pivoted idea nor considered an MVP.

The outcomes from these seven teams can be characterized as incremental innovation because they only add small technological improvements to their business segments. In particular, the prototypes presented similarities and differences between them. See Table IV.

Only the developed prototype in the course of 2018 was not developed as an app because there were not team members with technical skills to code a software solution. This same team also was unique to pivot the original idea into another one. All the other teams (in the courses of 2016 and 2017) had CC students and did not pivot the original idea. In all the teams and courses the ideas have emerged from one member for each team, and that student convinced the others to prototype a solution for your idea.

Video to disseminate information about preventing falls with the elderly population in a dynamic and assertive way. The main prototyped functionality is to show how elderly people can prevent falls in their home activities. The video shows common tips for daily life in this population.

Views of an MVP - video for the elderly population

Source: Freitas, Santos, Pasqualotto, Lazzari & Faoro, 2018

Source: Research data

Figure 3.
Prototype-2018

5. Discussion

In this section, it is presented separately for each experience (courses in 2016, 2017 and 2018) the adopted activities and a preliminary discussion on the results yielded by the teams. After, some lessons learned from the instructor's view are presented.

5.1 Adopted activities

In the first experience – 2016 – the ideas emerged from business students' experiences in their companies. They were not stimulated to explore alternative ideas. A simple combination of the activities' *market analysis, business model canvas* and *prototyping* could be sufficient to meet the course goals. Teams provided positive feedback about the activities highlighting the *prototyping* and *business model canvas*. *Prototyping* promotes the idea and solution validation because it enables evaluation of the potential for further ideation, that is, "it solves problems, [. . .], you can prototype just about anything - a new product or service or a special promotion" (Kelley, 2001). *Business model canvas* understands how a business can be structured (Osterwalder *et al.*, 2010). Thus, these two activities could guide the students to reach the essence of the course, that is, to develop a technological product with some novelty to its consumers.

However, the time for the prototype development was insufficient, because students decided to develop a comprehensive app (software product). To address the innovation in the project, the app required its development done through modern technologies. The students had to learn new tools to build apps.

In the second experience – 2017 – a startup (Ries, 2011) mindset inspired the process. The DT practices were conducted and combined with XP practices, mainly the prototyping, because both could be suitable for the course's goals, the startup mindset (Brown, 2008; Sohaib *et al.*, 2019) and starting the creativity (Hargadon & Sutton, 1997; Brown, 2008).

As in previous experience, in this course of 2017, teams evaluated the process positively to develop innovative ideas, however, the instructor suggested that the students focus on what was most important to the customer through an MVP (from a startup mindset). Thus, the time was not a problem, although the CC students took a lot of time to learn new technologies to the MVP development.

Students did not do all possible DT tasks such as *Era Map*, however, they developed at least one result for each DT activity.

The activities focused on two main views of startup mindset, *idea* and *solution validation*. Thus, the students had to demonstrate their validations to convince the audience through the *pitches*. The ideas emerged from the experiences of the students, like in the course of 2016. DT practices encouraged all the teams to try other customer pains, stimulating all

Table IV. Similarities and differences between the prototypes

	2016			2017			2018
Similarity	Team 1	Team 2	Team 3	Team 1	Team 2	Team 3	Team 1
Coded prototype?	Yes	Yes	Yes	Yes	Yes	Yes	No
Incremental innovation?	No	No	No	No	No	No	No
Pivoted?	No	No	No	No	No	No	Yes
CC students?	Yes	Yes	Yes	Yes	Yes	Yes	No
XP activities?	Yes	Yes	Yes	Yes	Yes	Yes	No
DT activities?	No	No	No	Yes	Yes	Yes	Yes
One member provided the idea?	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Research data

teams to pivot their idea, however, these teams were focused on building their prototypes. They did not pivot on their idea and they did not *ask a more interesting question* or *elicit pains still inexistent*. Maybe some brainstorming sessions closely linked to prototyping (Seidel & Fixson, 2013) could be more effective to stimulate the team to *think differently* and/or *elicit pains still nonexistent*.

The mix of student backgrounds (technical and business) promoted different views and debates about business feasibility. CC students developed the prototypes and MBA students analyzed the business model, market segments, competitors, partners and supplier alternatives.

In the third experience, in 2018, Team 1 had no aid of CC students, so XP practices had no relevance for them whether DT practices were adopted.

The instructor noted that Team 1 pivoted on the original challenge because its members would like to have an impact on the community with social innovation. As one of the member's works in a big health company that used to develop social actions to its public, Team 1 decided, after three lectures, to pivot on that idea. In this decision, DT encouraged Team 1 when its members had to discover the pains of their future consumers (stakeholders). This can be linked to an innovative behavior, for example, *thinking differently* (Marin-garcia *et al.*, 2016) and the challenge *to let go of bad ideas* (Liedtka, 2018, September).

Analyzing all the courses – 2016, 2017 and 2018 – teams accomplished the activities in a systematic way to reach the course's goal, as advocated by Drucker (2002).

These adopted activities can recognize customer needs and innovation opportunities, building ideas and solutions, learning, feedback and sharing with potential customers. These aspects are aligned with some innovative behavior from the framework in Marin-Garcia *et al.* (2016), mainly *teamwork* (*sharing relevant information with suitable stakeholders*) and *networking* (*coordinating work with others*). However, *creativity* (in particular, *thinking differently*) and *critical thinking* (for example, *estimating the risks of possible alternatives*) were observed during the classes and evidenced in the student's reports in only one team (in the course of 2018) because of *pivoting* on the original idea. It is interesting another study to test if DT or XP activities could address those two last innovative behaviors.

Finally, the reflection from Jan Bosch, "Does Agile Kill Innovation?"[5], should be highlighted in this study, as it discusses whether the XP activities reduce the innovation mindset of students. Revisiting the results from the teams' reports, only in the explicit DT activities, the students showed some innovative behavior (mainly *teamwork* and *networking*). When the teams performed XP tasks without the TIW students (and without DT activities), the CC students focused only on feature development for the solutions. However, in some interactions between the TIW and CC students, they performed DT activities inside the XP practices, as they were not conflicting. For example, they enriched *user stories* with *persona* and *stakeholder mapping* during the discovery and interpret DT activities.

This combination prompted the teams to address innovation concerns during the XP iteration. Thus, this study agrees with the idea of *agile does not kill innovation* whether tasks and activities from both processes could be integrated. In the same direction, to confirm the combination between XP and DT can be appropriate when thinking in a process to develop technological innovation, other studies provide alternatives: Gurusamy *et al.* (2016) propose a framework to build products addressing customer pains with low costs, waste and time, this framework combines DT and agile approach to add value to innovative developments;

and Sohaib *et al.* (2019) propose a framework that combines DT practices, for example, *empathy* and *persona*, adapted into XP *exploration phase* and *prototyping*.

5.2 Lessons learned

As the instructor of these three courses, I draw attention to a fact identified in the meetings. Students described ideas, participated in several philosophical debates about current technologies and business model in the classroom, but they dedicated some time to accomplish the idea and prototype validation activities in the field (out of the classroom), as they had to divide their time among other school courses and professional activities. These validation activities need a high commitment to the project out of the classroom.

In the classroom, conversely, the student engagement was encouraged on three aspects suggested in Zepke and Leach (2010):

(1) The DT and XP created experiences for students that challenged, enriched and extended their academic abilities;

(2) The course attracted students from diverse backgrounds as previously mentioned; and

(3) Active citizenship was promoted, as the ideas focused on resolving some social problems.

For example, the Recept-Ação project had the intention of decreasing car theft.

As evidence that synthesizes the results of these three courses, the innovations focused on the relationship between customer and producer of service, like a tendency of "uberization" (improvements of the cost or logistics between customers and providers of existing services). Then, the presented ideas in the courses can be classified as incremental innovation (Rowly, Baregheh, & Sambrook, 2011).

This fact can be associated to the low innovative behavior presented by the students, for example, the students did not *ask a more interesting question,* and did not exercise the *thinking differently* and *anticipating how events will take place* (Marin-garcia *et al.*, 2016), as

- those ideas proposed by the students emerged only from one member and the others were convinced and motivated to build a solution for that challenge; and
- the TIW did not provide all the three strategic aspects (people, process and place) (Jensen *et al.*, 2016) to foster a DT mindset, in particular, the three TIW courses did not create the workspace (place) that "creates an atmosphere of openness to idea sharing and experimenting."

Thus, all the teams dedicate more time to build the prototypes. A similar result is found in Corral and Fronza (2018), in which teams applied DT activities concentrated on the construction of the MVP.

6. Conclusion

Despite the low engagement out of the classroom, the activities adopted along with a mix of different backgrounds from the students can promote good insights to understand the user problem and build a technological solution with some novelty. Students indicate that DT and XP approaches aid to develop an innovative idea and solution prototype.

In the classroom, DT and XP processes create effective and collaborative learning, fostering learning relationships and creating backgrounds for the students that are challenged to improve their academic skills. However, the teams did not define working software – a primary measure of progress in XP – as working software and validated learning – a primary measure of progress in DT – as the primary measures of progress.

As a result of that experience, the students presented prototypes and business models for their ideas. However, innovation has been considered incremental, without disruption.

For future experiences, students will be able to choose a challenging problem in their companies, which will be an invitation to engage with the idea and solution validation. The domain experts from these companies should attend the course to bring pains and problems from their stakeholders and work together with the students to validate the idea and MVPs.

For future research, it is necessary to map the practices, techniques and tools that technology start-ups are adopting to identify their business models and developing MVPs to understand whether it is possible to develop a model to guide those startup teams to reach their objectives. Some students who participated in this course migrated to departments related to innovation in their companies after finishing it, future work could understand which (how and why) techniques they are adopting when they perform activities like innovation management or hackathons.

Moreover, there are studies combining DT and XP method, however, it is necessary to understand whether values and principles from agile methods are met in the integration, for instance, *persona* and *stakeholder mapping* (DT activities) enrich *user story* (XP practice) without performing an upfront and comprehensive requirements specification, as XP practices aim to perform this specification in an incremental and iterative way.

Finally, even though there are some other human variables in learning, this article does not discuss them. Then, the elements: *out of the classroom*, *little time to perform the activities in the field* and the *poor ability to execute technical tasks* could be explored, with appropriate conceptual frameworks, to test if the students' engagement is negatively affected during the idea and solution validation activities.

Notes

1. http://agilemanifesto.org/
2. www.inpi.gov.br/
3. Pitch is a presentation of an idea to the Instructor and colleagues to evaluate its business model.
4. When the business model is not working, the team changes the idea around another pain, stakeholders or business model, for example.
5. Available in www.linkedin.com/pulse/does-agile-kill-innovation-jan-bosch/

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