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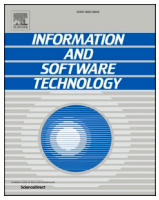

Does maturity level influence the use of Agile UX methods by digital startups? Evaluating design thinking, lean startup, and lean user experience

Fernando Henrique Lermen [a,b,1,*], Paula Kvitko de Moura [c,1], Vanessa Becker Bertoni [d], Paola Graciano [e], Guilherme Luz Tortorella [f,g,h]

[a] Department of Industrial Engineering, State University of Paraná, R. Comendador Correia Júnior, 117, Paranaguá, 83203-560, Brazil
[b] Industrial Engineering Department, Universidad Tecnológica del Perú, Av. Arequipa 265, Lima, 15046, Peru
[c] Graduate Program in Civil Engineering. Federal University of Rio Grande do Sul. Av. Osvaldo Aranha, 99, third floor, Porto Alegre, 90035–190, Brazil
[d] Management Department. University of Kentucky. 550 S Limestone, Lexington, 40506, United States
[e] Graduate Program in Business, Federal University of Rio Grande do Sul, Rua Washington Luiz, 855, Porto Alegre, 90010-460, Brazil
[f] Department of Mechanical Engineering, University of Melbourne, Grattan St, Melbourne, 3052, Australia
[g] IAE Business School, Universidad Austral, Buenos Aires, Argentina
[h] Department of Production and Systems Engineering, Universidade Federal de Santa Catarina, Florianopolis, Brazil

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ABSTRACT

Context: Agile UX methods such as Design Thinking, Lean Startup, and Lean User Experience have been employed to deliver customer value and improve organizational performance. However, there is a lack of studies that assess how these tools are used at different stages of maturity of digital startups.
Objective: The present study aims to compare the knowledge of graduated, incubated, and pre-incubated digital startups at university incubators concerning the use of Agile UX methods so that weaknesses and opportunities can be identified to provide co founders and scholars with new strategic insights.
Method: Six reduced focus groups were conducted with 14 members of the six selected startups via multiple case studies. Answers were registered by researchers and then analyzed using an inductive process and codification.
Results: The results indicated that digital startups had contact with consumers through market research, viability analysis, and product discontinuity. However, except for one startup, deficiencies in co-founders' participation throughout developing products and services projects were identified. As far as the multiple case studies are concerned, Design Thinking and Lean Startup were employed by four of the startups, while two of them used the Lean User Experience method due to its higher maturity level.
Conclusion: Although all Agile UX methods were employed, all six digital startups reported having made adaptations to the methods or to have used them only partially. Finally, it was concluded that the maturity level influences the Agile UX methods of each digital startup according to its nature and its stage of development in the market.

1. Introduction

Companies have been facing constant changes in the international competitive scenario, which led to a search for continuous improvement [1–3]. Given the increased competitiveness of markets and technological advances, developing Agile UX products and services has become essential for companies' success and a good performance supported by resilient thinking [4–6]. Traditionally, new product development involves innovative tools consisting of stages separated by Stage-Gates® [7]. Cooper [8] defined Stage-Gate as a conceptual and operational model whose purpose is to conduct new product development projects, ensuring the efficiency of phases from the initial idea to its launch on the market. In this process, it is only possible for the project team to advance to the next phase when the Gates indicate that it is the right time; that is, the team cannot advance to later phases until all requirements from the previous phase are met, thus the need for an agile method for the development of innovative products [9].

The agile manifesto emerged with the intention of demystifying stage

* Corresponding author.
E-mail address: fernando-lermen@hotmail.com (F.H. Lermen).
[1] Authors contributed equally.

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gates in projects following only the PMBOK [10–12]. Agile UX refers to a set of methods that systematically results in the desired user experience outcome and is carried out following Agile principles [13]; moreover, Agile UX aims to develop an innovative offer, especially when it is intended to reach potential users in uncertain times. In practice, compliance with phase requirements does not always happen entirely in companies [14,15]. The Agile UX usually employed a set of methods in the software area and then suffered adaptations for applications in digital startups [13,16,17]. Consumers also participate through several rounds of interactions [18,19]. Other sets of methods can also support Agile UX. For example, Design Thinking can be used to design innovative solutions to meet user needs through a deep understanding of the issues they aim to solve. Lean Startup, as well as Design Thinking, focuses on creating innovation through customer-centric development primarily through MVP (minimum viable product) creation and testing using proper scientific method [20,21]. On the other hand, Lean User Experience (Lean UX) applies lean principles to design solutions meant to generate value for users [22]. In combination with Agile UX methods, these three methods work as complementary assets towards the same goal: to shorten the solution development cycle that generates user value.

The main goal of digital startups is to develop a plethora of viable and innovative products and services, focusing on delivering value to potential users [23–25]. The main set of Agile UX methods [26,27] is composed by three approaches: Design Thinking, Lean Startup, and Lean UX (Mansoori, and Lackeus, 2019; [28,29]). According to Buchanan [30], Design Thinking is based on a user-centered approach with multidisciplinary teams aiming to solve complex problems and generate innovative solutions starting from a problem identification stage. Alternatively, Ries [31] proposed Lean Startup as an Agile UX method for startups to develop solutions and test them through several rounds of interactions with users. Finally, Lean UX is a method that provides a fundamental change in the way products are designed for customers [32].

Usually, Agile UX methods are applied in graduated, incubated, and pre-incubated (maturity level) startups to create innovative offers to deliver customers value [33,34]. The maturity level of startups influences their nature, functioning as a measurement of their stage of development in their relations with the market, the universities, and other companies [35]. According to Veira [36], there are three main stages for startup maturity: graduated (startups in the process of becoming well-established companies, providing technology in the form of products and services); incubated (startups incubated in a university or company, and/or inserted in an innovation ecosystem), and pre-incubated (startups with promising ideas that seek to be inserted in incubators for further business development).

Although previous studies have evaluated how Agile UX methods are applied by digital startups, only a few papers have explored the role of maturity level in the use of such methods [37–39]. Therefore, this research aims to help fill such gap by answering the following question: *Does maturity level influence the use of Agile UX methods by digital startups?* This study seeks to compare the knowledge of graduated, incubated, and pre-incubated digital startups in university incubators concerning the use of Agile UX methods. Apart from discussing levels of knowledge among the participant firms, this research looks to correlate the maturity level of digital startups with the Agile UX methods employed by each of them. Finally, four assumptions were raised to elucidate the assessment of the digital startups' current situation: (*i*) startups use consumer-oriented Agile UX methods (Lean Startup, Design Thinking, Lean User Experience) partially; (*ii*) the type of business influences the choice for each Agile UX method; (*iii*) startup consolidation time impacts the use of Agile UX methods; and (*iv*) the maturity level influences the knowledge on Agile UX methods, with graduated startups being more knowledgeable than their incubated and pre-incubated peers. Finally, this study has a dyad of contributions. Theoretically, this study provides knowledge about Agile UX methodologies in the context of digital startups and compares the literature with the maturity levels and tools to provide insights for future research. As practical contributions, the present research promotes several discussions on Agile UX methods and their associated tools, encouraging new startups to use those resources in their business models. The managerial implications include providing practitioners with best practices and insights on how to implement Agile UX methods in digital startups and businesses. Such discussions also encompass the association of each level of startup maturity with the Agile UX methods chosen, thus identifying how similar startups could adopt such resources according to their particular level of maturity in technological incubators.

The sections in this paper are organized in the following extracts. Section 2 presents the literature review, offering definitions for three Agile UX methods: Design Thinking, Lean Startup, and Lean UX. Section 3 presents the methodological procedure separated in interviewed startups selection; focus group application; data collection and registration, along with data and content analysis. Section 4 deals with the results and discussions enhanced by this study. Finally, Section 5 presents the conclusion achieved, summarizing contributions, limitations, and suggestions for future research.

2. Agile UX methods: Lean startup, design thinking, and Lean user experience

The traditional methods used in Research and Development (R&D) have encountered limitations while adapted to innovation projects mainly due to unclear requirements at the beginning of such projects. It is important to clarify that user testing only occurs when the prototype of the solution has already been developed according to the stakeholders' requirements. Thus, there is a difference between consumers and users, considering that consumers pay for the solution (i.e., product or service), while users use the solution without necessarily being the purchasers. Even so, this article uses the two terms interchangeably. Thus, this study intends to address three Agile UX methods normally applied in combination with one another (i.e., [20,40–42). These are Design Thinking, Lean Startup, and Lean User Experience (Lean UX), as depicted in Fig. 1.

This section also seeks to identify temporal changes by discussing studies related to the three agile methods (Design Thinking, Lean Startup, and Lean UX) in discussion. The involvement of potential customers in this endeavor is crucial.

2.1. Design thinking

Design Thinking (DT) was firstly introduced by Buchanan [30] and has been recently adopted in management in association with innovation and creative problem-solving. Brown [44] popularized DT in order to incorporate customer needs and values into an iterative process of rapid development of multiple solutions. The iterative process is also based on learning, involving customer feedback at every stage of DT until it converges to the most reliable and feasible solutions to create customer value [45]. DT has been applied in different sectors and industries. The business sector has implemented DT to innovate and bring solutions faster to the market [46]. Healthcare and social organizations have applied DT to develop empathy with customers and to create solutions collaboratively [47,48]. Companies such as IBM and Toyota have reportedly used DT to deeply understand customers' needs in order to develop Agile UX solutions [49].

Plattner, Meinel and Leifer [43] developed one of DT's most used models as presented in Fig. 1a. The first step consists in uncovering the problem's underlying meanings through research and interviews [50, 48]. The second step –observation– aims to collect insights about current issues through an immersion in customer context [51,52]. Some examples of tools used to observe and interact with the customer are ethnography methods, customer self-documentation, and customer's journey map [49]. The data collected are then synthesized into

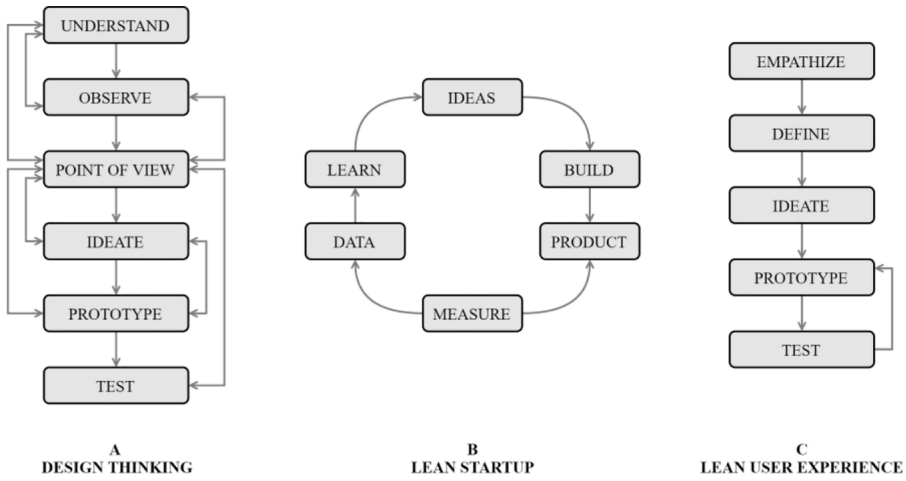

Fig. 1. Agile UX Methods.
Source: Design Thinking (Adapted from Plattner, Meinel and Leifer, [43]), Lean Startup (Adapted from [31]), and Lean UX (Adapted from [32]).

significant statements to define points of view that might lead to the generation of solutions [53,54]. Techniques such as brainstorming, brainwriting, and co-creation are considerably useful in providing solutions once customer issues were identified [53]. These techniques are combined, evaluated, synthesized, and refined until the most promising proposals are selected to be further examined [55]. DT proposes prototypes to make solutions more tangible for hypothesis tests (i.e., storyboard and role-play) [45]. Customer interaction with prototypes provides reliable feedback on how they respond to the solution developed and how it can be refined to fulfill current needs [55,51]. This part of the DT method is highly iterative as the designated solution goes continually from ideation to prototyping and testing until it meets customer's requirements [54].

2.2. Lean startup

Lean Startup (LS) was preconized by Ries [31] as an Agile UX method based on lean thinking (i.e., elimination of waste, short cycle time, small batches, and the involvement of customers early in the process) to assist entrepreneurs in building a successful startup. Besides, Ries [31] advocated that LS can be applied in any company size, sector, or industry. This method has been mainly employed in software startups [56], as in the studies of Taipale [57], Münch [58], Nirwan and Dhewanto [59], and Nguyen-duc and Abrahamsson [60]. These authors applied LS in software startups to reduce the high uncertainty surrounding the launch of a new solution and to accelerate such phase.

Ries [31] introduced the Build–Measure–Learn (BML) loop as the core of the LS model (Fig. 1b). The BML loop starts with the development of a business model by startups' founders based on the offered idea with the intention of formulating hypotheses to test and measure customer feedback [31,61]. Meanwhile, business model canvas, lean canvas, and value proposition canvas are usually employed to support entrepreneurs in the formulation and validation of such hypotheses [31,62]. The first testing of hypotheses should validate the core idea of the problem, the possible solution, market context, and customer profile by interacting with potential early adopters. This data collection is frequently obtained by interviews, observation, or surveys [63,64]. After validating the problem-solution fit, the first version of the product built with the minimum set of features and resources (Minimum Viable Product—MVP) is released to customers to allow faster and valuable feedback. Solution features are assessed through different tests, such as split test or multivariate tests [31,65]. The feedback from MVPs tests is used to advance and improve solutions iteratively [66,67]. The outcomes of the validated learning phase are three-fold: pivoting (to make a critical change in hypotheses), persevering (to continue on the same path), or perishing and abandoning the proposed solution [31,68].

2.3. Lean user experience

Lean User Experience (Lean UX) is a term that encompasses a set of core principles oriented to the application of lean principles to customer experience design [32,69,70]. Lean UX is an Agile UX method focused on a limited, well-defined set of research questions aimed at orienting the product development cycle, independently of the research methods applied. Gothelf and Seiden (2013) stated that Lean UX is collaborative and functional, as it does not work in isolation from the rest of the product team, but in continuous engagement with it. Isomursu et al. [71] explored the role of Lean UX studies on agile software development, with results showing that the adoption of agile working practices has placed customer experience design into a central and essential role in developing software, products, or services in this type of organization. Holifield et al. [72] described the process of training and educating students in building enterprise information systems, also developing templates and standards to support these students in completing their courses.

Lean UX model (Fig. 1c) makes intensive use of the Minimum Viable Product (MVP) realization, as it supports test assumptions as a means to achieve desired outcomes, minimizing the work wasted in unproven ideas. This concept is an integral part of how Lean UX minimizes waste (Gotherlf and Seiden, 2013). Klein [32] stated that research plans could be elaborated with customers' participation in Lean UX in order to perform usability tests of prototypes with a specific type of customer, or a recruited small number of participants selected in short time.

3. Methodological procedures

In order to compare how pre-incubated, incubated, and graduated digital startups employ Agile UX methods (Design Thinking, Lean Startup, and Lean UX), multiple case studies were performed in six focus groups. A theoretical sampling approach recommended by Eisenhardt and Graebner [73] for case selection was adopted, defining the population targeted by the study as Brazilian digital startups of different maturity levels. Being a qualitative approach, the interviews do not need to contemplate a group of respondents that is statistically representative of the population; thus, a convenience sample was chosen [74].

However, despite much planning, some aspects needed to be verified, following the steps proposed by Aaker et al. [75], that is, the selection of interviewees, the question script, and data registry. Fig. 2 presents this study's methodological sequence based on Aaker et al. [75], including the fourth section concerning data and content analysis.

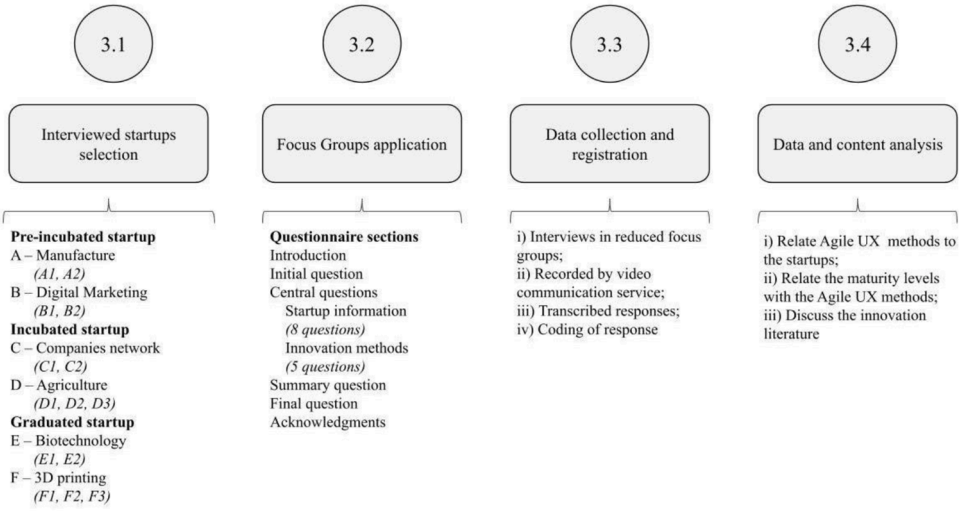

Fig. 2. Methodological sequence to test Agile UX methods.
Source: Adapted from Aaker et al. [75]

3.1. Interviewed startups selection

This qualitative study uses multiple case studies involving two startups for each maturity level, leading to a total of six focus groups with representatives of digital startups (pre-incubated—startups A and B, incubated—startups C and D, and graduated—startups E and F). Moreover, all interviewees had access to workshops concerning Lean Startup, Design Thinking, and Lean UX to ensure that their level of understanding would be adequate. It is worth clarifying that each startup obtained such data from reduced focus groups. Caporale et al. [76] mentioned the focus group technique as an essential step toward data collection and pointed out by Psomas [77] as an underestimated tool in Lean Management research. Therefore, 14 professionals from digital startups were interviewed, in the reasoning one focus group for each startup (containing two to three professionals each). Table 1 shows information about the interviewed startups.

Startup A operates in the energy harnessing market, developing innovative solutions to transform energy waste into opportunities for power generation, cogeneration, and energy efficiency. This startup emerged from an incubation process and has been trying to find space in the Brazilian market. Digital startup B is a creative organization that promotes digital business transformation for companies by creating and developing scalable solutions. This startup is reportedly showing good results in the market with the application of Industry 4.0 technologies.

Startup C, it is a knowledge-sharing network between companies, in which employees from one company are able to schedule a visit to learn directly from an employee of another company in the same network. This firm is in the pivot phase, seeking to fit into the market adequately. Digital startup D is focused on sustainability engineering in search of water-based industrial solutions for energy efficiency in agriculture substitution for fossil fuel combustion processes. At the time interviews were performed, this firm had just pivoted its business model and was working on delivering energy solutions beyond its traditional post-harvest equipment.

The focus of startup E is to develop cancer immunotherapy based on autologous cells, along with the development of biotechnological solutions for the clinical and pharmaceutical industries. Although graduated, this company is still in the incubation process, having placed headquarters in three countries of the American continent. Finally, digital startup F delivers 3D printing solutions, going from machines and equipment to printed products. At the time interviews were conducted, this startup had a partnership with a technology incubator, and its

Table 1
Digital startups information derived from focus groups.

Maturity Level	Digital startup ID	Digital Product or Service or Product-Service System (PSS)	Foundation year	Interviewed	Number of employees	Target audience
Pre incubated	Startup A	Smart turbines for heat generation in manufacturing industries	2019	-Founder (*A1*) -Head of business and operations (*A2*)	3	Slaughterhouses Grain processing Metal mechanics
Pre incubated	Startup B	Digital marketing for companies and entrepreneurs	2019	-CEO (*B1*) -Head of Marketing (*B2*)	5	Entrepreneurs Companies Incubators
Incubated	Startup C	Network to knowledge management between companies	2016	-Founder (*C1*) -Commercial Manager (*C2*) -Head of Marketing (*C3*)	6	Unemployed Companies HR manager
Incubated	Startup D	Sustainable drying machine for grain in the post-harvest process	2017	-Founder (*D1*) -Cofounder (*D2*) -Head of Engineering (*D3*)	5	Cooperative Grain Processing Farmers
Graduated	Startup E	Biotechnologies for healthcare and pharmaceutical innovation	2013	-CEO (*E1*) -Commercial Manager (*E2*)	4	Hospitals Medical industry Pharmaceutical industry
Graduated	Startup F	Additive manufacture solutions, including prototypes by 3D print	2015	-CEO (*F1*) -Head of Engineering (*F2*)	7	Universities Entrepreneurs R&D department

headquarters were external.

Knowledge regarding Agile UX methods was adopted as the main criteria for the selection of respondents to ensure they would be able to evaluate their company's performance in such methods and the role played by customers in pre-incubated, incubated, and graduated maturity levels. The maturity level presented in Table 1 is related to the group each startup is inserted in the technological incubators. The startups in this study were linked to technology incubators affiliated with two Brazilian universities, one was a public institution and the other private.

3.2. Focus group application

This research was carried out through multiple case studies based on a brief script composed of questions developed during the focus groups discussions. This script worked as a general guideline containing basic research questions but enhancing researchers to ask for additional information. The questions were formulated based on a literature review over Agile UX methods. Additionally, questions with the most mentioned processes in empirical studies with startups (such as MVP and Pivot development) were included. The intent with this supplementary step was to collect information from the respondents on how their solutions were developed and the challenges encountered during implementation. Table 2 shows the script referenced during focus groups sessions.

3.3. Data collection and registration

The answers were collected online through an online conference held in June 2020. The focus group sessions followed the script described in Table 2 and participants were given a consent statement to sign before engaging in the questionnaire. The document included the ethical guidelines regarded by this study and information on data privacy protection. Data were registered through audio recordings, verbatim transcription, and text analysis [78].

Table 2
- Script applied during focus groups meetings.

Section of the questionnaire	Information to collect
Introduction	Clarification of research goals/Confirmation of the interest of respondents in taking part in the research/ Personal information secrecy/The paper will be published.
Initial question	How many years have you worked with Agile UX methods and startups?
Central questions	*Digital startup Information* a) Are there similar products to yours on the market? If not, how do you assess competition, economic viability, and target audience requirements? b) Is there active customer participation at any stage of the development process? If yes, at what stages and how does it occur? c) Are customer interaction loops performed during the processes? d) Are there customer feedback mechanisms for a product under development? *Agile UX methods* a) Do you know the Design Thinking method? Does your company use it? b) Do you know the Lean Startup method? Does your company use it? c) Do you know the Lean User Experience method? Does your company use it? d) Do you employ the Minimum Viable Product (MVP) tool? e) Do you employ the project's Pivot stage?
Summary Question	Revise answers with the respondent and confirm understanding of the questionnaire.
Summary Question	Would you like to point out any other issue about Agile UX methods?
Acknowledgments	Reinforce the importance of the respondent's participation in the interview.

The focus group meetings lasted approximately 55 min. These six shortened meetings helped to assess the information from different perspectives. This was believed to be an appropriate strategy as the respondents belonged to different organizational levels in their company. The responses were then transcribed and coded using Microsoft Excel®.

3.4. Data and content analysis

The data collected during the reduced focus groups were analyzed in an iterative process based on Grounded Theory [79], which indicates the employment of an inductive process to draw theories from empirical data. The grounded theory depends on the techniques used to encode data [80]. Following the "line by line" approach, each dialog line was broken into initial codes that later evolved into analytical or focused codes.

Although participants were at different stages of the incubation process (and in different technology incubators), the study identified that their practical knowledge of Agile UX methods was adequate due to innovation and entrepreneurship training at the incubators. The checking of participants' prior knowledge was necessary to avoid divergent views about the three Agile UX methods. Next, patterns of answers were identified in the codifications meaning to detect similarities in tool implementation by the participating startups.

Next, for content analysis, the steps designed by Elo and Kyngäs [81] were followed: open coding, category creation, and abstraction. In these steps, the objective was to identify answers to the questions. For that purpose, relevant insights were highlighted during the analysis of the coded information from the six reduced focus groups. This evaluation presented similarities among answers (as exemplified by some of the interviewees' quotes mentioned in Section 4).

From the data and content analysis, the results of the six reduced focus groups made it possible to identify whether digital startups made use of Agile UX methods and their level of knowledge on such methods. In addition, it was investigated how such methods were employed: in their entirety, partially, or if there was a combination/adaptation of both. Another aspect investigated was the relationship between digital startup maturity level and the way project development was conducted. As a last step, startup development processes were mapped in order to reveal flaws and indicate improvements on the implementation or adaptation of Agile UX methods. These findings might support new startups in the identification of problems and in the proposition of new digital solutions to the market.

4. Results and discussion

During the interviews with the professionals of digital startups, the research aims were elucidated and consent to participate in the focus groups was evaluated, being developed in the following order: two pre-incubated startups (A and B), two incubated startups (C and D), and two graduated startups (E and F). Table 3 summarizes the main results of the focus groups developed from multiple case studies perspectives.

The pre-incubated startups (A and B) reported only the application of Design Thinking tools (adopting six and seven tools, respectively). The incubated startups (C and D) informed the application of both Design Thinking and Lean Startup methods. Finally, the graduated startups (E and F) conveyed the use of the three methods (Design Thinking, Lean Startup, and Lean UX), having employed all tools listed, except for Similar Market Products (startup F).

On the path to search for early adopters (Table 3), only startups B and F are focused on entrepreneurs. Identification of early adopters from startups A (grain processing), C (companies), D (farmers), and E (pharmaceutical industry) were found to be diversified. Some authors [82,31] explain the difficulty in acquiring early adopters—some pre-incubated digital startups fail to cater to early adopters' needs or

Table 3
Main results from focus groups.

	Pre- Incubated startup A	*Pre- Incubated startup B*	*Incubated startup* C	*Incubated startup* D	*Graduated startup E*	*Graduated startup F*
Early adopters' identification	X	X	X	X	X	X
Similar market products		X	X		X	
Competition analysis	X	X	X	X	X	X
Customer feedback *Qualitative methods (Interview, Focus Group, Observations)*	X	X	X	X	X	X
Customer feedback *Quantitative methods (Conjoint Analysis, Funnel Analysis, Cohort Analysis, or Decompositional Approach)*					X	X
Iteration process	X	X	X	X	X	X
Pivot	X	X	X	X		
MVP	X	X	X	X	X	X
Design Thinking Tools	X	X	X	X	X	X
Lean Startup Tools			X	X	X	X
Lean User Experience Tools					X	X

requirements by delaying the launch of products or services. Before entering the market, companies are looking for early adopters who are willing to pay for digital products or services. Interviewee A2 reports that "*the relevance sits not only in identifying early adopters but in predicting if digital startup offers will be innovative enough to conquer their investment*".

Startups typically confront significant resource constraints and considerable uncertainty about the viability of their proposed business model [61]. It is worth mentioning that similar final products can indeed be important, not only for crafting and implementing initial strategies in their proposed business model, but to identify strategies to diversify competitions. Table 3 shows which startups share similar markets: products (startup A and startup E), services (startup A, startup C, and startup F), and Product Service Systems (PSS) (startup D). During the research, five months after the interview, startup C reportedly retired due to a lack of market strategy and a struggle to engage human resources managers. Interviewee C1 commented that "*we are having difficulties at attracting companies willing to adopt our service*". Furthermore, it is suggested that incubators carry out awareness and re-education programs for startups [83].

Even though startups C, D, E, and F carried out a complex competition analysis, critically analyzing the business model using tools such as benchmarking, SWOT analysis, trend analysis, and BCG Matrix is recommended [84–86]. In parallel, digital startups A and B used desk research analysis to identify possible market competitors [87]. Regarding the business model structure, the competition was not part of the elements proposed in their main screen, a suggestion to startups A and B was to implement the Lean Canvas [88], the main Lean Startup tool. Completion analysis is an element a startup may require to make novel inroads into a market.

All digital startups in the study collected customer feedback. Qualitative methods for collecting feedback, such as interviews, focus groups, and observation, were adopted by all startups. In contrast, quantitative methods, such as conjoint analysis and funnel analysis, were used only by three startups (E and F). Pre-incubated and incubated startups employed only qualitative methods to improve product and service development. Meanwhile, quantitative methods were used before previous information was collected by qualitative methods (after the pre-incubated maturity level). Although Design Thinking, Lean Startup, and Lean UX involve continuous customer feedback, pre-incubated startups used Design Thinking first, which involves many qualitative tools. Then, the higher the maturity level, the more Agile UX methods are required to collect the feedback. Most Design Thinking, Lean Startup, and Lean UX studies show examples of qualitative feedback methods and related problems about how to reach the customer, how many people to interview, and how to integrate the feedback in ongoing activities (i.e., [64] and Nguyen-duc et al., 2017). Indeed, most digital startups from this study reported similar problems involving qualitative feedback. Interviewer E2 commented: "*we periodically call customers to ask for feedback, but it is a hard process to integrate what customers want with what is possible to develop*". Few studies in the literature explored quantitative feedback methods (i.e., [61,8589]) as the graduated startups in this study reported using this method only to measure customer satisfaction with the product. The CEO of startup F also commented "*we started (2019) to measure customer satisfaction periodically last year; we asked them by email to give a rating from 1 to 10 of how satisfied they were with the product and to add the reason for the rating)*".

The pre-incubated and incubated startups reportedly pivot, making changes in the business model and hypotheses to test. These startups conducted tests to evaluate the hypotheses of their solutions based on their business models. As the incubated and pre-incubated startups are still in an experimentation stage, they stated the need to pivot the solution by redirecting their business according to user demand. Contrary, startups E and F do not pivot but perform minor changes because they already have consolidated products on the market. Indeed, different maturity levels are associated with different types of pivots. The pivots from pre-incubated startups A and B are associated with customer need, customer segment, value capturing, and business architecture. DT tools such as brainstorming, empathy map, and customer journey support the pre-incubated startups to understand the new changes to be performed. For example, startup A already pivoted the capture value method, whereas startup B pivoted the customer segment according to product feedback. An example in that direction was given by interviewee B2: "*we thought that self-employed professionals be the first to get interested in our product, but after feedback and lack of interest from customers, we realized that our product would be more advantageous for more consolidated companies*". As incubated startups already have the customer and the problem defined, the pivot types are associated with the solution. Examples of pivots performed by the two startups are the customer channel and the technology involved in product development. Interviewee D2 commented that "*initially, the focus of the startup was only to develop machines, but after feedback, it became necessary to insert the offer of products and services that fully met the needs of Brazilian farmers*".

The pre-incubated startups started with presentations with videos and slides as MVPs because the solution was not consolidated. These startups also explore the solution idea with prototypes as it is described in a comment by interviewer A1: "*we used a turbine prototype to present the idea to stakeholders looking for their feedback and if they would be willing to pay for the product*". Indeed, many studies indicate the use of prototypes to experiment and test ideas (i.e., [46,90]). Digital startups incubated took 6 to 12 months to create the MVP since the product had characteristics that did not allow it to be developed in a short time. Nonetheless, startup D failed to recognize that interest in the product was not enough to keep it on the market. The graduated startups already have a consolidated product, but they carry out tests and collect feedback when they launch a new feature or additional resources. Interviewer F2 said: "*before adding our last tool, we did a market analysis to assess what the competitors were doing and what would be the customer acceptance. When we decided to launch the tool, we did the split test to assess*

which version had the greatest improvement."

The only tool used by all startups was the Business Model Canvas (BMC) proposed by Osterwalder and Pigneur [91]. Although some startups have reportedly used business model innovation as an Agile UX method, the startups in this study consider it as a tool to support the solution development process. Being a lean agile tool, it tends to improve the decision-making process and to initiate the preliminary steps to create business solutions able to reflect users' demands. Indeed, startups connected with the innovation ecosystem, as the ones in this study, use Agile UX methods in conjunction with BMC. Startups A and B used the BMC combined with Design Thinking tools, that is, persona, empathy map and journey map. Interviewer B1 commented: "*we create different personas according to the position of the company we are going to present our solution to, such as the CEO, employees and the financial administrator*". As opposed to pre-incubated startups, startups C and D used more LS tools. Startup D, for example, employed different LS tools: value proposition canvas, lean canvas, stakeholders map, requirements engineering, and hypothesis test (da luz Peralta, 2020b). Startups E and F used multivariate analysis, conjoint analysis, artificial neural networks, and design of experience. Startup F was incubated in an engineering school and had access to professionals with expertise in quantitative analysis and creation of surveys, facilitating the understanding of customer perception on a large scale. Fig. 3 shows the position of each startup by maturity level versus Agile UX methods adopted.

Startup A is in the quadrant Q1 because it had not yet reached the problem-solution fit. Thus, this startup still employs most of the Design Thinking tools such as brainstorming, ethnographic research, and prototypes. Startup B was migrating to the Q4 quadrant because it has already reached the problem-solution fit but was starting to develop the product for the market, using Lean Startup tools. Startup C and D, situated in quadrant Q5, were ready to employ the new product development or the new service development approaches to launch the offer to the market. Both startups were still using LS tools to test and collect feedback from customers and stakeholders, but also in a quantitative perspective. Startup E and F (Q9) were already well situated in their innovation ecosystem. Both had already tested all possible hypotheses with qualitative and quantitative tests.

As for the theoretical implications, this study provides knowledge on Agile UX methodologies in the context of digital startups and compares the literature with the maturity levels and tools in order to provide insights for future research. The managerial implications involve delivering to academics and practitioners the best practices and insights to use the knowledge acquired in this study when applying this triad of Agile UX methods in digital startups and small, medium, and large companies. Finally, Agile UX methods and tools are highlighted as practical contributions, encouraging new startups to incorporate these capabilities into their business models. Although this study expands the evaluation of Agile UX methods in digital startups, it is still necessary for future studies to analyze how the context of application in each case study influences the level of maturity of startups. In regard to this issue, the propositions developed by Silva et al. [92] could be useful.

Regarding the assumptions presented in the introduction section, it is possible to conclude that the first one ("startups use consumer-oriented Agile UX methods partially") was validated, as at least six tools were reported by the startups participating in the study. Assumptions two ("the type of business influences the choice for each Agile UX method") and three ("startup consolidation time impacts the use of Agile UX methods") were not validated, with results indicating the level of maturity to be a more representative variable.

Further studies are needed to identify if the type of business and the time of consolidation can influence the choice of the Agile UX method in

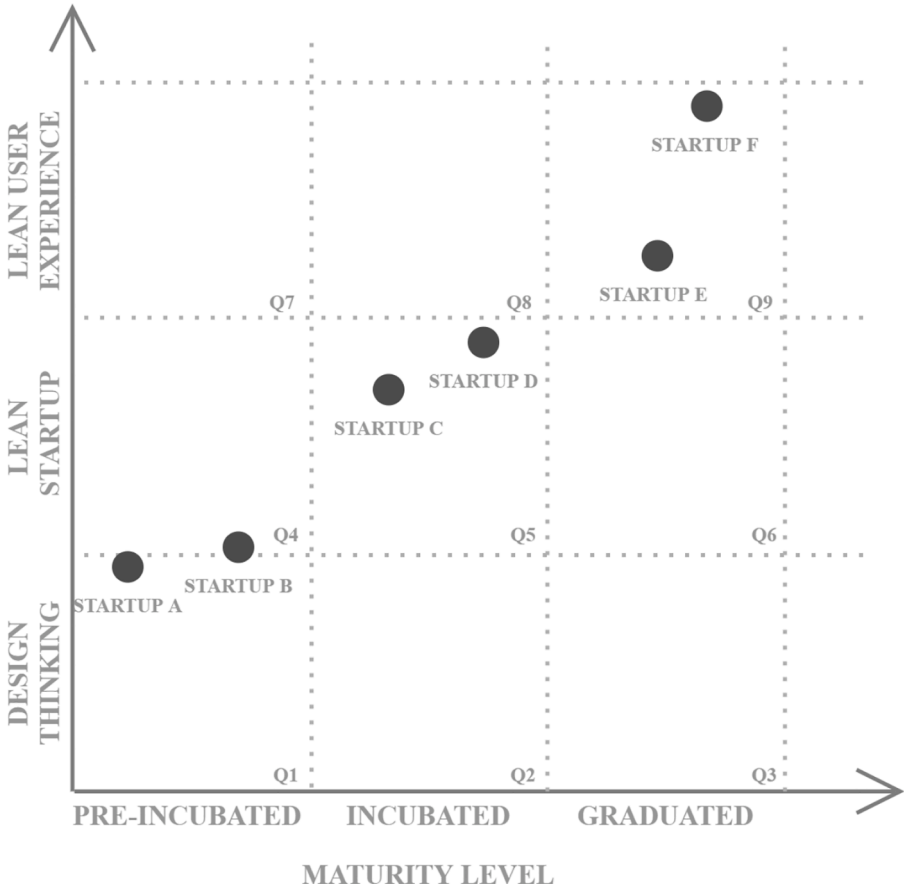

Fig. 3. Startups positions by maturity level versus Agile UX methods.

digital startups. One suggestion of approach is the General Linear Model [93]. So far, based on the startups addressed in this study, the choice of the Agile UX method seems to be more related to the firm's maturity level than to the type of business it fits in. Finally, the fourth assumption ("the maturity level influences the knowledge of Agile UX methods") was confirmed. Fig. 3 presents distinctions that consolidate the associations between maturity level and the Agile UX methods employed.

5. Conclusions

This study aimed to compare the knowledge of graduated, incubated, and pre-incubated startups in university incubators concerning Agile UX methods to assess digital startups perception. Through focus groups, data collection, and content analysis, members of two pre-incubated startups (A and B), two incubated startups (C and D), and two graduated startups (E and F), were studied. Results show that digital startups have contact with consumers through market research, viability analysis, and product discontinuity. However, except for startup E, deficiencies in co-founders' participation throughout developing products and services projects were found to be severe.

It was noticed that pre-incubated and incubated companies tend to be more concerned with identifying problems and proposing solutions, focusing on the current scenario. Concurrently, graduated companies are more concerned with scaling their solutions because their position in the market is already well-established. Still, it is important to highlight that graduated companies must continue to analyze their competitors and be in tune with market trends to avoid obsolescence.

As a limitation, this study presents a sample of only six digital startups, meaning the generalization of its results is highly questionable. Larger samples and cross-country validation of the instruments of data collection are required. Moreover, this study considered the most used methods of Agile UX by incubators, leaving aside several other methods. Finally, the sample of respondents per focus group (two to three participants) is relatively low, despite the fact that having respondents from the same startup might have led to biases in the focus group discussions.

It is suggested that future studies replicate this research with a larger number of startups in a quantitative perspective to demonstrate how each type of digital startup adopts the Agile UX methods. It is also necessary to investigate the existence of standards regarding the choice and adaptation of Agile UX methods considering the products or services provided by digital startups. Finally, the evaluation of whether the application of Agile UX methods for digital startups is influenced by regional case studies is highly encouraged.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Fernando Henrique Lermen Ph.D., is Assistant Professor at State University of Paraná, Brazil. He holds a master's and Ph.D. degree in Industrial Engineering from Federal University of Rio Grande do Sul, Brazil. He also holds a bachelor's degree in Agro-industrial Engineering. Currently, he is an visitant researcher at Technological University of Peru. His-research mainly spans the topics of innovation, value approaches, product-service system, and agroindustry.

Paula Kvitko de Moura is currently a Ph.D. candidate for the Graduate Program in Civil Engineering from the Federal University of Rio Grande do Sul (UFRGS). She holds a master's degree in Civil Engineering from the Graduate Program in Civil Engineering from the UFRGS, Brazil. She also holds a bachelor's degree in Architecture and Urbanism. Her research mainly spans the topics of Innovation, Sustainability, and Innovative methods for Construction Industry.

Vanessa Becker Bertoni is Ph.D. in Industrial Engineering by Federal University of Rio Grande do Sul (UFRGS). She holds a master's degree in Industrial Engineering from the Graduate Program in Industrial Engineering from the UFRGS, Brazil. She also holds a bachelor's degree in Business Administration. Currently she is researcher from University

of Kentucky. Her research mainly spans the topics of Healthcare Systems, Network Analysis, and Resilience Engineering.

Paola Graciano is a Ph.D. candidate in Management at the Federal University of Rio Grande do Sul (UFRGS). She obtained her master's degree in Innovation, Technology, and Sustainability at the same institution (2019). Her studies are concentrated on applying human cognition to management and sustainable consumer behavior.

Guilherme Luz Tortorella is an Adjunct Professor of Industrial Engineering at the Federal University of Santa Catarina He also has Post-Doctorate, Doctorate, and master's in industrial engineering and Bachelor in Mechanical Engineering, all of these at the Federal University of Rio Grande do Sul - UFRGS. He also is researcher and faculty in Department of Mechanical Engineering at University of Melbourne and IAE Business School at Universidad Austral.