

An Action Research on how we developed a Hardware Startup in the Healthcare sector in Brazil

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INTRODUCTION

‘Hardware is Hard’. Expression commonly said for startups developing physical products and facing extra challenges such as supply chain, certification, intellectual property protection and regulation (DiResta, Forrest, and Vinyard, 2015). The scenario might get harder in Brazil, due to difficulties to access tools and techniques for prototyping, to recruit specialized professionals in hardware and to finance a capital-intensive venture (Startupi, 2016).

The phenomenon is more complex and also attractive in the Healthcare Sector. The WACC for Healthcare Information and Technology (HIT) in emergent market was 11.38% p.a. in Jan 2017, 0.6 percentage points above the average among 94 other sectors (Damodaran, 2017a). In contrast, the Revenue Multiples in Emerging Markets for HIT was 9.4 in Jan 2017, four times higher than the 2.29 average among 94 other sectors (Damodaran, 2017b).

In this context, the Digital Health Funding has been hitting record highs. Approximately US\$ 8 billion was invested in more than 500 companies worldwide in 2016, a figure higher than in 2015 (34%) and seven times higher than in 2010. There were 585 investment rounds, mostly in early stage, with 900 single investors. GE Ventures, a subsidiary of General Electric, made 18 investments in 2016, becoming the most active investor in the period (StartUp Health, 2016).

GE is part of the group of 262 of the world’s 500 largest corporations that have relationships with startups, the main modality being ‘Corporate Venture Capital’, followed by ‘Startup Competitions’ and ‘Accelerators and Incubators’ (Bonzom and Netessine, 2016). These are simpler and more agile modalities that allow reaching more startups in a shorter period (Weiblen and Chesbrough, 2015).

Among the startup competitions are the Hackathons (Bonzom and Netessine, 2016). And it was in one of these events, in the first Hackathon of the sector in Brazil, promoted by a multinational, that a startup was founded by three partners who met at the event, and one of them is one of the authors of this study. After that, mentored by the corporation, they continued to undertake, interviewed more than 120 companies in the sector, developed two functional prototypes, filed a patent, made a pilot and started assisting the first patient. Thus, the research problem being addressed in this paper is ‘how we developed a hardware startup in the healthcare sector in Brazil up to the first client’.

The objectives of the study are: (1) to describe and analyze the development journey of a startup since its foundation in a hackathon to the first client, and (2) to identify events in the trajectory and dimensions of the ecosystem that most contributed to the development of its product and the formatting of its business model. Therefore, the text will prioritize a longitudinal view of the case instead of specific analyses of certain events, even if intriguing. The study is justified because there are few publications addressing the development of hardware startups (DiResta, Forrest, and Vinyard, 2015), and for investigating a case in the context of an emerging economy, which brings additional challenges related to labor and capital markets characterized by institutional voids (Khanna and Palepu, 1999) and institutional development (Peng, 2003).

THEORETICAL FRAMEWORK

The literature on the development of hardware startups offers few references (DiResta, Forrest, and Vinyard, 2015). There are two widely used startup development models in general, Lean Startup (Ries, 2011) and Customer Development (Blank, 2013a), to which the Business Model Canvas (Osterwalder and Pigneur, 2010) was added to become The Startup Owner's Manual (Blank and Dorf, 2012). Derived from class notes, Customer Development focuses on the Customer Discovery and Customer Validation phases and aims to guide the entrepreneur to 'Search', through a hypothesis test, for a repeatable and scalable business model (Blank and Dorf, 2012). Based on Customer Development and on the concepts of Agile Development and Lean Manufacturing (Blank, 2013b), Lean Startup proposes the Build-Measure-Learn Feedback Loop, whose steps are to establish hypotheses, test quickly via minimal viable product, measure the actual progress of the business through funnel metrics, learn and decide to pivot or preserve. The intention is to guide and accelerate the startup to create products that customers really want (Ries, 2011). However, there is no relationship between the number of validated hypotheses and the subsequent success of the team, which may be confused with excessive feedback. So, while the experimentation approach may be effective, having a strong strategy is more important than conducting a large number of market tests (Ladd, 2016). Fleisch, Weinberger and Wortmann (2014) highlight eight business model patterns for the Internet of Things that help in the strategic positioning, namely Physical Freemium, Digital Add-on, Digital Lock-in, Product as Point of Sales, Object Self-Service, Remote Usage and Condition Monitoring, originating from Gassmann, Frankenberger, and Csik (2014) and Digitally Charged Products, and Sensor as a Service. Except for Fleisch, Weinberger and Wortmann (2014) and Gassmann, Frankenberger and Csik (2014), none of the above studies quotes the term 'hardware'.

Facing the opportunity of an iconic publication for hardware, DiResta, Forrest, and Vinyard (2015) combine Lean Startup concepts with their experiences in accelerators and hardware development and manufacturing with the purpose of offering a 'guide to turning a product idea into a hardware business'. With a content that covers classifications, development, community, market, brand, prototyping with 'Works-Like' and 'Looks-Like' versions, manufacturing, acceleration, crowdsourcing, fundraising, launch, legal and various industry information sources, it does not contain any method for managing the evolution of the idea to the development of the product, the market and the organization. Therefore, it lacks a cycle of experimentation, measurement and learning for hardware. This gap was also not filled by other publications studied (Aulet, 2013; Stock and Günther, 2016; Bilgeri, Brandt, Lang, Tesch, and Weinberger, 2015).

METHODS

With technical and scientific purposes (Thiollent, 2007), the method applied in this study combines the concepts of Action Research and Process Studies (Costa Filho and Pedroso, 2018).

The structure adopted for Action Research was that of cycles consisting of four steps: 'Plan', 'Act', 'Observe' and 'Reflect' (Riding, Fowell, and Levy, 1995). Before the cycles, it was added the 'Context' to describe the scenario in which Action Research takes place (Coughlan and Coughlan, 2002). This model was considered more appropriate to agile contexts. The figure below illustrates the four cycles:

Insert Figure 1 here

On the other hand, the literature does not provide precise definitions for each step of action research (Riding, Fowell, and Levy, 1995; Carr and Kemmis, 1986). The definitions adopted were: 1) 'Plan', which establishes the Action Plan for a specific cycle; 2) 'Act and Observe', in which actions derived from the plan are executed and monitored. In the event of revisions, as long as there is no change in scope, term or cost, it remains in the same cycle, and 3) 'Reflect', in which the Initial Plan, with or without success, is closed, and the lessons learned are extracted for the next cycle (Costa Filho and Pedroso, 2018).

The Process Studies practices, which seek patterns in the trajectory of a case studied (Pettigrew, 1997), guided the Data Collection, Demonstration and Analysis phases (Miles, Huberman, and Saldaña, 2014). In the Data Collection phase, two types of data were considered (Langley, 1999): 1) Hard Data, which includes, but is not limited to, Market Reports, Financial Information, Statistics, Technical Literature, Experiments, and Technology Trials; 2) Soft Data, which includes daily notes made by the author and entrepreneur, in the journal keeping notes style (McNiff, Lomaxm, and Whitehead, 1996), recording key discussions, decisions, observations and personal motivators (Schein, 1999) in each formal and scheduled or informal and unexpected interview, mentoring sessions, status reports, general meetings and even moments of individual reflection. The highlights of each event were usually recorded in notepad files saved in cloud directories, notebook or paper, or in e-mails and messages exchanged via apps and social networks.

The Data Demonstration followed two Process Studies techniques (Langley, 1999): 1) the Narrative Strategy to describe the cases chronologically, bringing plenty of details to later make accurate analyzes (Mello, Turrioni, Xavier, and Campos, 2012), and 2) the Visual Mapping Strategy to represent events graphically (Mello, Turrioni, Xavier, and Campos, 2012). Blank and Dorf (2012) used the Business Model Canvas (Osterwalder and Pigneur, 2010). In this study, the Business Model Architecture of Pedroso (2016) is used, for being a more comprehensive record of decisions about the Business Model. The Data Analysis consisted of the analysis of the trajectory and identification of elements of the journey and the ecosystem that most contributed to the configuration of the business model and the product. Lessons learned are presented based on these analysis.

For the analysis of the journey and identification of elements that propagate changes, we started by compiling the notes from the various sources mentioned above. Then, each event was listed in a worksheet and associated, row by row, with one of the six components of the Business Model template, namely: Management Model, Innovation Model, Operations Model, Strategic Positioning, Customer Relationship Model and Economic Model. Each component is broken down into its sub-components, such as Management Systems, Product Innovation and Production Models (Pedroso, 2016). Events without associations were classified into the domains of the Entrepreneurial Ecosystem: Policy, Finance, Culture, Supports, Human Capital and Markets (Isenberg, 2011). The figure below shows the relationship between the events and components of the Business Model:

Insert Figure 2 here

A primary matrix was thus created, based on which dynamic tables were generated to analyze the frequency of occurrence of each event, and consequently of each component and subcomponent of the Business Model and the Entrepreneurial Ecosystem. Subsequently, the

elements of the Business Model and the dimensions of the Entrepreneurial Ecosystem of greater frequency and importance were identified and discussed, both at the end of each cycle and during the four cycles, in an overview in the case analysis chapter.

Based on these analyses, we identified the elements and dimensions that most contributed to the configuration of the Startup's Business Model and Product, and based on these conclusions, contributions were made to the literature. The study is then concluded with the discussion of the potentiality and limits of the analysis of the case.

CASE DEVELOPMENT

This chapter contains the development of the Startup case, which consists of the subchapters 'Context' and the four 'Cycles' of action research.

Settings

Brazil is one of the most entrepreneurial nations in the world and stands out for the 'Internal Market Dynamics' and 'Entrepreneurial Financing', but in terms of Physical Infrastructure, Bureaucracies, Taxes and Government Policies and Education, it is far below the average in Latin America and the 65 economies analyzed (GEM, 2017).

With more than 12 million inhabitants (IBGE, 2017), São Paulo is the largest and richest city in Brazil, accounting for approximately (15%) of the Gross Domestic Product (GDP) and (6%) of the country's population (São Paulo Turismo, 2014). In an international perspective, the city was considered in 2015 as the 12th best Entrepreneurial Ecosystem in the world, being the only representative of Latin America among the top 20 (Compass, 2015). In 2017, with the study renamed as Startup Genome, no Latin American city ranked among the top 20. The downgrade is explained by the faster evolution of cities in China and Sweden. In terms of 'Size', São Paulo, with 1,600 to 2,500 'tech startups', is among the top 15 ecosystems, but below the global average in the topics of 'Funding', 'Market Reach', 'Startup Experience' and 'Talent' (Startup Genome, 2017).

With approximately 90 thousand events per year and concentrating (75%) the largest fairs in the country (Cidade de São Paulo, 2014), São Paulo is a vibrant but also uneven city. Despite the Human Development Index (HDI) of 0.805 in 2010 (UNDP, IPEA, and FJP, 2017), the difference in life expectancy within the 96 districts of the municipality reaches 25 years and in only 11 of them there are no favelas (Nossa São Paulo, 2016).

Isenberg (2011) understands that each ecosystem emerges from a unique combination of conditions and circumstances, and in an environment rich in information generation and sharing (Mason and Brown, 2013). São Paulo, with its elements in multiple connections and tensions, has the necessary ingredients to make up a favorable and peculiar context to entrepreneurship and also to entrepreneurs.

First Cycle

This section describes the first cycle of the Action Research, beginning with the 'Plan' step, followed by 'Act' and 'Observe' and ending with 'Reflect', concluding with the analysis of the cycle.

1.1 Plan: The First Cycle begins at month zero of Action Research and has the following plan drawn by one of the authors to participate in the first Hackathon of the sector in Brazil: a) Form a team that meets the requirements of the competition by lunchtime of day one, b) Define an idea to be worked on by the end of the afternoon of day one, c) Develop from scratch a functional proof of concept by the return from lunch of day two, and d) Develop a Business Model and a pitch by the end of day two to participate in the finals on day three.

1.2 Act and Observe: On day one of the Hackathon, one of the authors met those who would become his two co-founding partners. After brainstorming, they decided to develop a device for the remote monitoring of gas consumption in hospitals, aiming to improve the billing process. On the second day, they were classified for the final with criticisms to the business model, but with a functional proof of concept using components purchased the day before the competition. On the third day of the event, with one hour left to deliver the final pitch, a Home Care executive and keynote speaker of the hospital fair at which the finals of the Hackathon were taking place, entered the stand of the corporation hosting the competition and asked the team if the device could be installed in oxygen therapy cylinders to predict when it is time to change them. They said it could, exchanged contacts, pivoted the business model and the pitch with data researched on another occasion and were one of the winners of the competition, gaining six months of mentoring by one of the largest industries of medical devices in the world.

1.3 Reflect: The First Cycle ended within three days in month zero with the partial fulfillment of the Action Research Plan, being left with the need to recruit a system developer for the team, composed of a business professional, a designer and a mechatronics engineer who focused his career on the financial market.

In total, 17 events were registered in the trajectory of the First Cycle, all of them with one occurrence. Of these, seven are in the Management Model with emphasis on the formation of the complementary team, project management by sprints and the discovery and validation of hypotheses in interviews, and three in the Innovation Model, with emphasis on ideation and prototyping, mentoring and collaborative development among peers. In relation to the Entrepreneurial Ecosystem, the 'Market' dimension stood out, due to the size of the event and the existence of suppliers of components for prototyping.

Second Cycle

This section describes the second cycle of the Action Research, beginning with the 'Plan' step, followed by 'Act' and 'Observe' and ending with 'Reflect', concluding with the analysis of the cycle.

2.1 Plan: The Second Cycle begins at month one of Action Research and has the following plan based on the mentoring provided by the multinational and added by the specific challenges of the startup: a) Continue the partnership with the Home Care and Medical Gases Company in month one; b) Develop the business vision of the Startup and translate it into hypotheses by month two; c) Specify, Develop and Test the MVP by month three, d) Determine the sources of funding of the MVP by month three, e) Evaluate the results of the tests and persevere, pivot or end by month five, f) Check the Patent deposit, Corporate Agreement and Setting Up the Company by month six, g) Recruit a programmer for the Startup team by month six, and h) End the Program with the presentation of the Startup

results by month six at the Global Research Center of the Multinational that received hundreds of millions of dollars in investment.

2.2 Act and Observe: Over the next nine months, we conducted more than 120 interviews in the healthcare and technology sectors, hired three suppliers, tested 16 technologies in five versions of proofs of Concept, produced the first physical unit of the functional prototype on a proprietary electronic board built in co-invention with a company incubated in the campus of one of the largest universities in the country – where one of the authors was a master’s degree student, and we filed patent applications and for the health classification in the respective regulatory bodies. All with the founders’ equity and mentored by the multinational, in a program that did not include investments.

We conducted 17 mentoring meetings, almost twice as many as expected, and extended the program’s duration from six to 10 months so we could finalize the hardware and present it to a committee of the top management of the Multinational’s Global Research Center. In this event that would end the mentoring, the device worked correctly in a real demonstration and we proposed that this would not be the end, but the beginning of a new step in the partnership, which would include the investment from the multinational. For availability reasons, the CEO could not attend the event and we scheduled a new presentation, once again extending the conclusion of the program.

In the last days of the cycle, due to disagreements in the delivery, a supplier who would become a mentor, asked to leave, and we also negotiated and declined the proposal of one of the main accelerators in Latin America, for considering, together with the lawyers and three professionals of the sector, including an accelerated one, it was an overly expensive investment for the startup.

2.3 Reflect: The Second Cycle planned for month six, ended in month 10 due to difficulties in the selection and development of the sensing technique. We were still left with the need to recruit a software developer and, even though we had completed the general and the technology hypotheses, we lacked the design of the process to operationalize the hardware.

The trajectory of the First Cycle included 38 events, the one with the largest occurrence being ‘Discovery and validation of hypotheses in interviews’ related to ‘Management Model’. The others are mainly distributed among the ‘Innovation Model’, component with the largest number of events, with emphasis on ‘Corporate Mentoring’, ‘Ideation and prototyping’ and ‘Collaborative development with suppliers’, and the ‘Economic model’, component with the second lowest number of events, with emphasis on discussions on ‘Fundraising’ and the decision to develop the ‘First prototype with own resources’. In relation to the Entrepreneurial Ecosystem, the ‘Market’ dimension stands out, due to the major events in Healthcare, Technology or Entrepreneurship and the emergence of small-scale production chain for hardware that allowed to combine expertise for prototyping.

Third Cycle

This section describes the third cycle of the Action Research, beginning with the ‘Plan’ step, followed by ‘Act’ and Observe’ and ending with ‘Reflect’, concluding with the analysis of the cycle.

3.1 Plan: The Third Cycle begins at month 10 of Action Research and has the following plan presented in the startups' view to the Global Research Center of the Multinational: a) Get Angel Investment by month 11, b) Start the Pilot in Home Care by month 11, c) Initiate improvements in the hardware through the Call for Grant by month 12, and d) Start the Pilot in Hospitals by month 13.

3.2 Act and Observe: In the first 45 days of the Third Cycle, a pilot with three fronts – process mapping, interviews with professionals and patients, and technology trials – was planned and conducted – in partnership with the Brazilian subsidiary of one of the largest gas companies in the world, which serves hundreds of thousands of lives in more than 20 countries, and two of the largest Home Cares in Brazil.

In the final days of the pilot, the conclusion meeting of the mentoring of the two startups that won the hackathon was held with the innovation committee of the multinational, this time with the presence of the CEO. The partial results of the pilot were presented, which led, from a detailed understanding of the value chain, to the pivot in the 'Customer Segment', subcomponent of the 'Customer Relationship Model' and the 'Revenue Model', subcomponent of the 'Economic Model' (Pedroso, 2016). The corporation's concept of replicating a technology in other sectors was used to extend the application of the Startup's technology from Healthcare to the Industry. Finally, the proposal for the corporation to invest in the startup was reiterated and the CEO asked for a separate agenda in the following weeks.

The conclusion of the pilot analysis gave rise to two great results. On the technology front, the sensor reading was affected by ambient conditions. It compromised the reliability of the measurements, but it was already expected and correctable with investments in firmware. On the process mapping front, it was found that the solution did not cover some operational variables, previously unknown to the founders and that made the assumptions of the remote monitoring model completely false.

That week, the Startup received by e-mail the information that it had been awarded in a prestigious competition of one of the largest bilateral chambers of commerce in Brazil and that it would receive the trophy in a big event from the hands of the CEO of the main competitor of the mentoring Multinational on the same day that its CEO had scheduled the new meeting and that the startup would complete 366 days since its foundation at the hackathon. They prioritized the awards event. They rescheduled the meeting with CEO, who in a new meeting verbalized his intention to fund the Startup and asked for a proposal and support to build the path together, as it would be the first time for everyone. They emphasized preemptive clauses and the maintenance of the hospital segment.

On that same days, the founders held an interview with one of the largest suppliers of measuring devices in Brazil and the solution was summarily confronted. They were also mentored by an entrepreneur who founded and sold a world-class technology giant the first Home Banking platform in Brazil and became a consultant to one of the largest banks and a partner in one of the largest consulting firms in the world. Now, 30 years later and preserving the shares of the companies she has gone through, she is currently dedicated to helping young professionals to leverage their careers. In the session with the Startup, she made an analogy to the coffee market, which disputed a commodity until Nespresso innovated with a more profitable and recurring revenue model. She left this reference to the remote monitoring of the startup and looked for angel investors in her network.

The results of the pilot confirmed by the last interviews cleared up what was difficult to admit. While the startup was being awarded, the partners would gather together. With insomnia, one of them found a forgotten hardware in a catalog outside Brazil that met their needs. Days later, a self-assessment meeting was held, giving rise to a new Action Plan. They admitted the mistakes and repositioned the value proposition, the product and the development model. They saw themselves not as a maker of measuring devices or a logistics company, but rather as a communication solution with the mission to save lives by facilitating the value chain in the healthcare sector. They decided to prioritize the delivery of the service and postpone the proprietary R&D. They invested what was left of their savings to buy and adapt this market meter, whose purpose was to validate the business, not the technology.

3.3 Reflect: The Third Cycle ended in the planned month, 13, not because it was completed, but because of the pivot and the new Action Plan derived from the pilot made. The angel investment, the Call for Grant and the pilot in Hospitals were pending.

The trajectory of the Third Cycle had 35 events, the one with the largest occurrence being 'Fundraising' related to the 'Economic Model' and 'Design and validation of hypotheses in the pilot' and 'Discovery and validation of hypotheses in interviews' both related to the 'Management Model'. This, in turn, is one of the two components of largest occurrence, alongside the 'Customer Relationship Model', driven by the occurrence of 'Early Adopters' and 'Customer Segmentation'. Finally, it is noticed that two events with less occurrence had great influence in the propagation of changes. 'Ideation and Prototyping', related to the 'Innovation Model', and especially those of 'Chain facilitation', related to the 'Strategic Positioning' component. In the Ecosystem, 'Market' stands out for the network of successful entrepreneurs and clients.

Fourth Cycle

This section describes the fourth cycle of the Action Research, beginning with the 'Plan' step, followed by 'Act' and 'Observe' and ending with 'Reflect', concluding with the analysis of the cycle.

4.1 Plan: The Fourth Cycle begins at month 13 of Action Research and has the following plan derived from the post-pilot pivot: a) Receive and adapt the new hardware of the Startup by month 16, b) Resubmit the Project Plan to the Call for Grant by month 16, c) Evaluate the maintenance of the partners and the participation in the Startup by month 16, d) Develop the MVP the Startup's platform by month 17, e) Install the device in the house of the first patient by month 18, and f) Communicate the investors of the installation in the patient's house by month 18.

4.2 Act and Observe: The partners started the new cycle with the funds virtually exhausted, but certain of the problem they needed to solve and with a potential solution. They presented the plan to the overall stockholder of the pilot's gasist and confirmed the hypotheses and the Product Market Fit.

As part of the result of the Chamber of Commerce Award, the startup was selected for a new acceleration program, sponsored by a multinational pharmaceutical industry and led by a consulting firm associated with one of the largest Venture Capital Funds in Brazil. It was the end of the year and so it was decided that the acceleration would begin after New Year's Eve.

In parallel, with the guidance of a finance professor and a classmate who worked at a law firm that advised more than 20 Venture Capital funds in Brazil, both from the master's program of one of the entrepreneurs and author of this study; an investment proposal was developed for the first mentoring multinational, considering revenue projections diversified by optimistic scenarios, legal aspects, investment modalities by the corporation, and valuation weighted by national and international references, including a detailed study of more than 100 investments made by the corporation in startups in the world, but none in Brazil.

After delays caused by the supplier and the customs, the device arrived in the beginning of the year, at month 16, but it did not work due to incompatibility of the operating system and encryption in the Communication Protocol. The engineer left the daily operation to manage his other startup in the financial market, which had received investments. The business and design partners remained. They looked for help in the ecosystem and managed to solve the hardware problems with the help of three colleagues from a technical school, an IT consulting firm, and a hardware pre-accelerator.

In month 17, Carnival, they were approved after three submissions in the Call for Grant with one of the best evaluated projects in Brazil. The R&D strategy started to consolidate: It begins with own resources to validate the business with adapted technologies and continues with investments to develop proprietary technology. The value was transferred to a unit of the technical school that would hire a team to develop for the startup. Later this month, a partner, who had no more money for the rent, receives a job offer to work on a pioneering project in Latin America at a Hospital in São Paulo. He accepts, but makes it clear that he would continue with the project in parallel. The design partner joins the first class of the postgraduate program on the Internet of Things at the same Technical School, becoming a classmate of the team that will transform the prototype into a product.

Over the next three months, they go through the new acceleration, reflecting on the Startup Purpose, Blue Ocean Strategy, Sales Funnel, and Metrics. In this period, the first mentoring corporation declines the investment due to new priority projects and the startup is selected by a recent fund focused on health. They discuss the clauses with mentors and offices related to acceleration and accept them with reservations. Days before the execution of the investment agreement, the members of the fund decline for not having one of the partners full time in the startup. The value of the investment would not have cash for management compensation for more than four months.

In the Demo Day of the acceleration, the startup is awarded with a technology study and market research from a multinational in the IT sector operating in 100 countries. They also gained processing in the cloud from two suppliers and, through the Bilateral Chamber of Commerce, they gained 20 hardware units, qualifying them to serve their first 10 patients. And as it all begins with a first step, two years after the idea was born in a hackathon, with the second functional prototype operating after tests and mentoring, they establish the partnership and the real pilot with the early adopters and begin the remote monitoring of the first patient in real use at Month 25 of the Action Research.

4.3 Reflect: The Fourth Cycle planned for month 18 ended at month 25 due to delays in the receipt and adversities in hardware development, but with the activities completed. The IT developer still had to be recruited, the need for investment increased and the operation and traction challenges for the next cycle began.

The trajectory of the Third Cycle included 48 events, the one with the largest occurrence being, in isolated leadership, 'Fundraising' related to the 'Economic Model', which was the component with the largest number of events and also includes the 'Grant combined with the expertise' of the Technical School team. The others are distributed in the 'Innovation Model', with emphasis on the 'First delivery, then develop' strategy and the 'Collaborative development between suppliers' and 'peers', as well as in the 'Management Model', with emphasis on the 'Acceleration Process' and the 'Team Restructuring'. The highlight of the Ecosystem lies with 'Support Institutions' and 'Market', due to the network of support services and suppliers that contributed to the development.

CASE ANALYSIS

The purpose of this session is to conduct an analysis of the four cycles altogether. The total duration was 25 months, distributed in three days for the First Cycle (0.4%), 283 days for the Second Cycle (38%), 96 days for the Third Cycle (13%) and 355 days for the Fourth Cycle (48%). In total, there were 138 events, 17 in the First Cycle (12%), 38 in the Second Cycle (28%), 47 in the Third Cycle (34%) and 36 in the Fourth Cycle (26%). The rate of events per day of cycle is 5.7 in the First Cycle, 0.5 in the Third Cycle, and 0.1 in the Second and Fourth Cycles, demonstrating the moments of greater activity in the trajectory.

Overall, the most frequent event was 'Fundraising', which also led the Third and Fourth Cycle and is related to the 'Economic Model'. The second most frequent event was the 'Discovery and validation of hypotheses in interviews', which led the Second Cycle and was replaced by 'Design and validation of hypotheses in the pilot' in the Third Cycle, both related to the 'Management Model'. In third place, six events are tied, three related to the 'Innovation Model', namely 'Ideation and Prototyping', 'Collaborative Development among Peers' and 'Collaborative Development with Suppliers', and the others are 'Chain facilitation' related to the 'Strategic Positioning' component, 'Grant combined with the expertise' related to the 'Economic Model', and 'The Early Adopter' related to the 'Customer Relationship Model'.

Consequently, the component of highest occurrence in the overall result of the four Cycles was the 'Economic Model', also leader of Cycles three and four, followed by the Innovation Model, also leader of the Second Cycle, and, third, the 'Management Model'. Despite the highest frequency, it is understood that the prevalence of the Economic Model is due to discussions on innovation funding, but not being a propagator of changes in the Business Model. By excluding the 'Fundraising' event from the counts, the 'Innovation Model' takes the overall leadership, followed by the 'Management Model'.

In this scenario, there is an alternation of the first and second place between the Innovation and Management Models throughout the cycles. In First Cycle, the Management Model leads as a result of the team, the project management and the discoveries via interviews, followed by the Innovation Model, due to ideation and prototyping. In the Second Cycle, focused on developing the prototype, the Innovation Model leads as a result of collaborative development and the mentoring sessions with the corporation, followed by the Management Model, as a result of the findings through interviews. In the Third Cycle, focused on the pilot, the Management Model takes the lead, as a result of the validation of hypotheses in the pilot, followed by the Innovation Model, due to ideation and prototyping. In the Fourth Cycle, focusing on development, the Innovation Model takes the lead, due to the collaborative development, followed by the Management Model, as a result of the definitions of the process of acceleration and the restructuring of the team. Despite the low frequency, the decisions of

the component 'Strategic Positioning' have strong influence in the Third Cycle, in addition to the decisions to develop the 'First prototype with own resources' and 'First validating the business with adapted hardware and then investing in proprietary technology' of Cycles two and three, respectively.

Regarding the influence of the Entrepreneurial Ecosystem, the main factor was the 'Market', including the network of suppliers of components for prototyping, manufacturers of hardware for small scale, national medium and large companies with investment in IT support services and the high frequency of events in the Health, Technology or Entrepreneurship Sector, which allowed the partners to get to know each other, meet the mentors, suppliers, partners and project enthusiasts. Also noteworthy was the existence of Support Institutions, especially education institutions, in which the partners participated, including courses at Universities, Postgraduate programs and Foundations.

It is concluded, therefore, that the configuration of the Business Model and the Product of the Startup, in the pre-operational phase, was the result of the propagation of changes in the Innovation and Management Models, with specific directions of the Strategic Positioning and Investment Strategy in R&D, related to the Economic Model. The management of the startup guided towards the discovery and validation associated with the use of its own resources with the ones of third parties, combining them in the development cycle, consists of the factors that configured the Business Model and the Product of the Startup. This journey was only possible because it found a breeding ground, albeit difficult, in the market and support institutions of the Entrepreneurial Ecosystem of São Paulo.

CONTRIBUTIONS FROM PRACTICE TO LITERATURE

The reflections of the case to the literature refer to three lessons learned from the startup: 1) Start by mapping the process in practice prior to prototyping, 2) First validate the market with own resources by investing little in adapted hardware, or even manually, before heavily investing in a proprietary technology, and 3) Positioning in the market with a pre-defined strategy for hardware and software to protect from distracting demands.

With respect to the first reflection, Blank and Dorf (2012) indicate the construction of hypotheses of the Business Model Canvas (Osterwalder and Pigneur, 2010). The experience of the Startup indicates that it is necessary to map in detail the process related to the target problem of hardware startups, before initiating the prototyping. When the Startup of the case made the pilot, it mapped out processes and discovered that the technology it was developing for more than nine months did not encompass some features of the operation, making the monitoring model completely false. If it had invested and started by mapping the process in practice, it would have identified, by direct observation, hypotheses that were not brought in the interviews, probably because they were already deemed natural by professionals in the sector. This would have saved months and resources wasted on a prototype based on assumptions validated in interviews, but not true in practice.

DiResta, Forrest, and Vinyard (2015) suggest in 'Types for Prototyping', that 'If your core differentiator is a new type of technology such as a sensor, it's important to prove that functionality, possibly through computer analysis, before embarking on a series of prototypes for a product that might not work'. The Startup's experience in developing a sensing technology shows that it is more important to first validate the market with hardware adapted from third parties or, in the limit, to provide the services manually in the concierge model

(Ries, 2011), and then decide whether it is worth investing in the development of proprietary technology. This practice was also used by a Brazilian startup that received an investment of approximately US\$1 million for monitoring products via RFID and that started the provision of its services with hardware adapted from the market. The startup of the case further mentions that in ecosystems with scarce funding, it is important to invest its own assets in the first prototype to validate the market more rapidly, since it does not take time negotiating with angel investors, and mainly preserve the equity from a low valuation. The biggest problem is not prototyping a product that may not work, but rather one that will not sell. The startup believes that it has 99 hardware problems, but business isn't one.

Finally, the importance of strategic positioning is related to excessive demands that large companies could make to startups. For having numerous challenges related to the efficiency in the execution of the Business Model (Blank, 2013a), large companies may have needs related to the prototype of the startup, but there are already solutions in the market that sufficiently meet the problem and that would not be interesting for the value proposition of the startup. One of the companies interviewed in the case showed interest in mapping routes based on the monitoring information provided by the prototype and requested the development of a customized software, separate remote monitoring in prototyping. First, the startup positioned itself as a communications company, getting rid of related, but not strategic, software development demands. Second, with the help of the mentoring with the corporations, they pondered on two possible compensation models for the software and hardware. One of the options was that the access to the software and data would only be made possible with the hardware marketed by the company. The startup named this model as 'Black Jack' because it takes a specific pair of cards to win the game. The other strategy is that data and software could be used on devices of any brand. One of the startups interviewed by the author operating in the Industry 4.0, applies its algorithm indifferently on hardware of several brands. The startup named this model as 'Agnostic Hardware', as it does not rely on data sent from a specific brand. It is important to reflect on the positioning of the product, to protect from non-priority demands to the startup, especially when dealing with large corporations. There are, therefore, two product strategies for hardware and software; 1) Black Jack when sold altogether; 2) Agnostic Hardware when the software is sold independently.

CONCLUSION

This article consisted of a longitudinal study of two years distributed into four cycles of Action Research directed to a particular case, situational and emerging from practice. Although the intention was not to generate universal knowledge (Coughlan and Coughlan, 2002), the analysis of the trajectory identifying the influence of the Management Model and Innovation Model and the lessons learned about validation, prototyping and positioning move from the private to the whole, seeking to make sense to other authors and entrepreneurs (Eden and Huxcham, 1996).

Focusing on understanding the trajectory in the ecosystem of an emerging market, the particularity of this study lies in the Action Research method, making it virtually impossible to obtain the same data, analyses and theories through other methods (Schein, 1999; Eden and Huxcham, 1996), such as the analysis of the concurrent events of the pilot, pivoting, award and mentoring, or the practical examples of the attributes of the Entrepreneurial Ecosystem Market, such as the support of educational institutions with which the entrepreneurs were associated and had a personal network of contacts across the campus.

While the action research enables this depth of analysis to the comprehensiveness of the scope, there is a potential risk towards the researcher's own bias (Coughlan and Coughlan, 2002). We sought to neutralize personal bias through the test and verification of the cycles and assumptions by third parties (Argyris, Putnam, and Smith, 1985), including the mentors of the Startup across the corporation and the acceleration; as well as in the discussions with the co-author of the study.

As a limitation, we believe that the registration and classification of events may have variations and biases, even with rigorous cycles and the verification by third parties. Although the classifications could change some elements, the authors believe that the Management Models and the Innovation Models remain as the main models in the characterization of the product and business and that the lessons learned may inspire future entrepreneurs and researchers in the construction of references for the development of startups, especially hardware startups born in emerging markets. The constraints of access to capital and resources lead to different approaches to market and product development. Necessity is the mother of creativity. Everyday factors for entrepreneurs in emergent markets.

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FIGURES AND TABLES

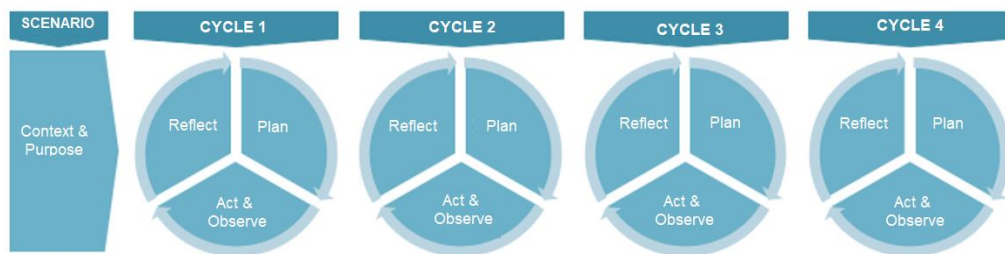


Figure 1: Action Research Cycles (Costa Filho and Pedroso, 2018)

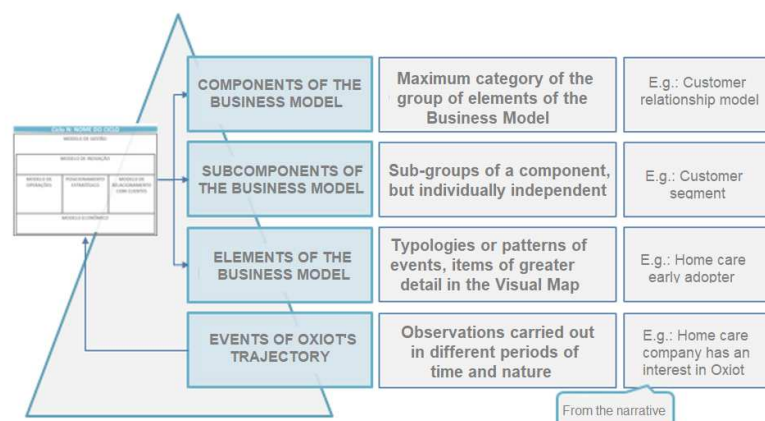


Figure 2: Association of events of the journey with elements of the Business Model Cycles (Costa Filho and Pedroso, 2018)