

Title: Case-Study:
Printoo – from here to the Internet of Things



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Abstract

This thesis is a pedagogical case study on Strategy applied to Innovation, using Printoo – a product by Ynvisible – as a setting. Hence, the focus of this case is to describe and analyze the challenge of this company and its managers to define a fit strategy for its new, innovative product.

Printoo's concept is highly innovative and it is inserted in an area of technological development with great potential – Printed Electronics. Several tools and trends influence this area, such as the Makers culture, Crowdfunding, Open-Source and the increasing use of Technology in Education. Furthermore, there is a debate on implementing the concept of the Internet of Things – in which Printed Electronics may have a role.

From the interviews and analysis performed, this paper has two key conclusions. The first one is that Ynvisible should focus on both Printoo – a series of kits of Printed Electronics technologies components – and on the company's own proprietary Electrochromic displays – that are included in Printoo – in order to maximize the power it has over the potential profits that will derive from this innovation, because Printoo is highly imitable and the displays are not. Nevertheless, Printoo is an important marketing tool to promote Ynvisible's displays and other components from suppliers.

The second conclusion is that Education is an important market that Printoo should address, and that the approach should combine continuous improvement – of the technologies that the kits contain and of the experiences they allow to perform – and service improvement – as courses and workshops – which actually Ynvisible is starting to do. Other markets are also important, such as the Makers, Open Source market and the Prototyping market.

List of Abbreviations

2D	Two-dimensional
3D	Three-dimensional
CAGR	Compound Annual Growth Rate
CENIMAT	Centro de Investigação de Materiais (Center for Investigation of Materials)
CENTI	Centre for Nanotechnology and Smart Materials
DC	Direct Current
DIY	Do It Yourself
FABLAB	Fabrication Laboratory
FCTUNL	Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (Faculty of Sciences and Technology of the New University of Lisbon)
FEUP	Faculdade de Engenharia da Universidade do Porto (Faculty of Engineering of the University of Porto)
HW	Hardware
IDE	Integrated Development Environment
IoT	Internet of Things
ISORG	Image Sensor ORGanic
LED	Light-Emitting Diode
NBA	National Basketball Association
OE-a	Organic Electronics Association
OLED	Organic Light-Emitting Diode
SME	Small and medium-sized enterprises
R&D	Research and Development
RC	Remote Control
VTT	Valtion Teknillinen Tutkimuskeskus (State Technical Research Center)

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Case Preface

It was June 2015 and Inês Henriques, CEO of Ynvisible, was making forecasts of the performance for the next years of the company's new product, the Printoo, along with Manuel Câmara, New Products Manager. Printoo was an innovative integration of Printed Electronics flexible, paper-thin components such as Ynvisible's printed displays and third-parties' sensors, motors, light strips and batteries. Ynvisible's focus had been to develop Printed Electronics technologies and to commercialize them. Nonetheless, after an acquisition process of the company was not completed, the company decided to embrace new, disruptive ideas, eventually creating Printoo – a series of kits with the objective of serving as a flagship for Printed Electronics technologies and components, hence promoting a whole industry.¹

Ynvisible unveiled Printoo with a very successful crowdfunding campaign on April 2014, raising 80,336\$. After quality tests and component improvements, the company claims to be ready to deliver the first kits to the backers of this campaign, in October 2015. Meanwhile, Ynvisible is defining its strategy for the next steps, namely which markets will it address and how. If initially the company pitched the product for researchers, product designers and makers – those who would want the kits to prototype their products and creations but did not have access to these technologies – now this campaign showed them that the Education was also interested.

Printoo was presented as a tool to allow product designers to give life to everyday objects, “*An internet of everything*”, suggesting that Printed Technologies could have a significant role in turning real the concept of the Internet of Things – anticipated as revolutionary for several industries. Inês Henriques and Manuel Câmara need to further show the target audience what small applications these technologies can have in bigger scale intelligent objects and what can Printoo contribute to the adoption of newly introduced technologies.²

President and Founder of Ynvisible António Câmara is carefully seeing which strategy will his team implement in spite of this challenge. During his time as a Masters' student in the United States, he participated in a study that ultimately led to the introduction of 3-point shots in the National Basketball Association league rules in the 1979/80 season, with the objective of rewarding players that risked to throw the ball from a longer distance. Since then, many NBA games have been decided with 3-point shots, but even the best player only succeeds around once every two shots. Printoo is an innovative product. It belongs to an industry of isolated, not yet manufactured and commercialized in high-volume components. And it aims to have a role in a revolutionary concept. Printoo is a clear “*3-point shot*” try, and it requires the fittest strategy.³

¹ Printoo consists of Printed Electronics components kits - <http://www.printoo.pt/>. Printed Electronics is a subgroup of Electronics in which components are paper-thin and flexible.

² Internet of Things is a concept in which objects will be interconnected in order to share information and decisions over the environment.

³ Based on an article from Correio da Manhã where António Câmara is interviewed - http://www.cmjornal.xl.pt/domingo/detalhe/a_realidade_diminuida_de_antonio_camara.html.

1. Introduction

1.1. Motivation

The focus of this case is to describe and analyze the challenge of a company – Ynvisible – and its managers to define a fit strategy for its new, innovative product – Printoo.

Printoo had very good feedback from the market so far. Moreover, the sector of technological development has great potential. However, much due to the novelty brought by the product's concept, the markets have high uncertainty. Hence, it is crucial to assess where does the company and its product stand in terms of imitability and of complementary assets, to discuss how to profit from this innovation.⁴

Printoo consists in a series of kits with Electronics components, with new technologies, to allow users to create products or to simply experiment. Traditionally, a product like Printoo would be either introduced as an educational tool, or as a recreational consumer product – a customizable, technological toy – or as an intermediary in the value chain of other players – mostly component manufacturers – and thus promote the adoption of its technologies mainly for product design and prototyping. Hence, in face of such variety of targets, it is necessary to determine which technologies to combine in the product, and to which markets.⁵

The story of Printoo will describe what the first focus of the company was and how it realigned its target after a first promotion step, before it even produced the first units. At first, the company primarily focused both on promoting the adoption of its components' technologies and allow product prototyping, and on being a recreational tool for non-professional creation design. Later on, the main focus was adjusted to assessing the potential of being an educational tool.

After presenting this challenge, the strategy for the future of Printoo is evaluated, in terms of potentiating the value of its innovation and of choosing the best markets given the set of technologies it can hold. This challenge is described with a qualitative approach, using the available information at the current moment of Printoo's timeline and also the opinions of company members and partners, through interviews. As such, this case does not intent to be a quantitative, financial assessment of neither the company nor its product. The purpose of describing this challenge is to serve as the basis for class discussion, not to illustrate either effective or ineffective handling of an administrative situation. The objective is that the discussion is focuses on two main aspects: to define a strategy for Printoo, to be applied in its next stages, in order to attain significant commercial value; and to preview how Printoo can contribute to the adoption of new technologies and concepts, namely the Internet of Things.

The sequence of the thesis first introduces the history of Ynvisible and of YDreams – the company from which it was born – on section 1. Then, Printoo and its key technologies are overviewed, as well as the product's purpose and component details, on section 2. After this context is given, the

⁴ Imitability and Complementary Assets are variables used to assess who ultimately profits from an innovation, in the Teece Model (Teece, 1986)

⁵ Types of Innovation can be identified in face of the markets and technologies used, in Types of Innovation framework (Rothaermel, 2013)

ecosystem of this company is presented in section 3 – its structure, partners, recent financial performance, competitors, and trends and communities that surround, and may influence Printoo. Next, in section 4, the initial steps performed by Printoo, such as its funding and launch campaign, marketing mix, potential roles it may have in Education and in the adoption of new technologies, and main markets that may be targeted. Finally, in section 5, having considered all previous information and Printoo's current scenario, it is discussed with theoretical strategic frameworks how Ynvisible can strategically maximize Printoo's potential value as a form of innovation, among different alternative strategies.

1.2. History of Ynvisible

Ynvisible is a Portuguese start-up, spin-out from YDreams (see **History of YDreams**, in Appendices), also with headquarters in Lisbon, Portugal. António Câmara is the company's President, and Inês Henriques its CEO. (see **Exhibit 1**)

In 2005, before Ynvisible was created, YDreams and Faculty of Sciences and Technology of the New University of Lisbon started a joint research initiative, in the domain areas of interactivity and interface design and electrochromic technology. In 2006, three Portuguese industrial partners sponsored the initiative, with the purpose of studying the viability of assembling electrochromic displays using as substrates the materials manufactured by those partners, namely paper and textile. The continued R&D effort in this technological area motivated YDreams to create a spin-out company – Ynvisible – focused on the development and commercialization of this electrochromic displays technology⁶.

According to Inês Henriques, Ynvisible was created, not around a technology, but around a vision: *“to expand interaction in everyday's objects. To add information, actions and reactions in products and things that didn't have them”*. She also believes that, as a spin-out of YDreams, Ynvisible inherited a culture of innovation: *“It was already on their DNA”*. For Manuel Câmara – New Products Manager at Ynvisible – innovation comes from necessity – as the company has a new technology, with no established market, and so needs to start imagining new products to integrate it.⁷

1.3. Overview of Printoo

Printoo is a modular platform that intends to bring everyday objects to life, by giving people the ability to embed computational power into such object and devices. The product consists of a series of kits, each composed of various Printed Electronics components that can all be connected to each other, namely, Ynvisible's printed displays and printed sensors, motors, LED light strips and printed batteries from other companies. (see **Exhibit 2**)

⁶ Electrochromics consists in the capability of some materials to change colour due to induced electric charge. The purpose of Ynvisible was based on Ynvisible site - <http://www.ynvisible.com/>.

⁷ Based on the interviews with Inês Henriques and with Manuel Câmara.

Wired magazine described it as “*An internet of everything, powered by thin gadgetry*”, due to the flexible, modular, and thin electronic components that constitute Printoo kits, allowing customers “*to fabricate complex electromechanical gadgets*”.⁸

Printoo was funded in Kickstarter, a crowdfunding portal⁹. Currently, Ynvisible started producing units of Printoo and will soon deliver them to first clients, and in parallel is developing new kits.

2. Main Technologies and Concepts of Printoo

2.1. Printed Electronics

Printed Electronics – also known as Organic Electronics – is a subgroup of Electronics, in which components are paper-thin, flexible and lightweight. This type of Electronics can be made with different technologies and organic materials. Fields of application of these technologies encompass, for example, intelligent packaging, OLED lighting, printed antennas, printed sensors, flexible displays, flexible solar cells, printed batteries and printed circuits. Printed Electronics displays can be based on Electrochromics – for instance, Ynvisible’s displays – which basically allow a material to change color with the application of electricity. Despite the advantages of Printed Electronics components, these still do not have the same performance as their traditional, non-printed counterparts.¹⁰

In 2015, these technologies are in general already in a production stage and not only in research laboratories and prototypes activities. Several key industry sectors are starting to implement products based on Printed Electronics, such as the Automotive, Pharmaceutical, Consumer Electronics and Packaging industries. These technologies are being applied for instance in the new Boeing 787 Dreamliner to shade windows. In the car industry, as lighter weight is one driver”, thin films with LED strips are starting to substitute existing lighting solutions¹¹. Other current possible applications are interactive journals, posters and price tags and smart packages, shelves and tickets.

The global market for Organic and Printed Electronics had a value of \$2.2 billion in 2011, of 8 billion dollars in 2012, and of \$16 billion in 2013 – of which \$6.3 billion are due to printed sensors – and is projected to have a value of more than \$44.3 billion in 2021, much due to expected transition from OLED displays to printed versions.¹²

In parallel, 3D printing has a strong highlight, with predictions of bringing a new era of manufacturing, more democratized. Many 3D printed objects can be a fit basis for the application of Printed Electronics components, with the objective of having intelligent objects.¹³

⁸ Based on an article from Wired about the purpose of Printoo - <http://www.wired.com/2014/05/using-paper-thin-electronics-to-create-physical-web-browsers/>.

⁹ Kickstarter is a crowdfunding portal - <https://www.kickstarter.com/>.

¹⁰ Based on *The Potential of Printed Electronics and Personal Fabrication in Driving the Internet of Things* (2015) by Rosa, Câmara and Gouveia.

¹¹ Based on the interview with Jani-Mikael Kuusisto.

¹² Source: OE-a (Organic and Printed Electronics), on *Organic and Printed Electronics 4th Edition* (2011).

¹³ 3D printing process consist in of the deposit of the desired material in successive layers to create a physical object from a digital file.

2.2. Internet of Things

The “*Internet of Things*” term refers to a concept in which there is a pervasive presence in the environment of a variety of objects that through connections are able to interact with each other. Such objects can make themselves recognizable and obtain intelligence by making or enabling context decisions, thanks to communication and broader information of their environment. The main areas of interest to achieve the IoT are hardware, software, modeling, connection modes, integration and security.¹⁴

In 2015 more than 99% of objects in the physical world remain unconnected, but it is estimated that 50 billion devices and objects will be connected to the Internet by 2020, much due to increase of population’s access to Internet and houses with Wi-Fi and the decrease of the price of sensors and devices . This is predicted to allow new applications and services in several, due to the collaboration of things that are interconnected. It is also predicted that the IoT will be the driver for a major change in several industries and domains such as smart cities, intelligent buildings, healthcare and pharmaceuticals, agriculture, industrial machinery and processes, logistics and transports, retail, public safety, consumer electronics and smart clothing. It is estimated that the IoT will create an economic impact of \$2.7 trillion to \$6.2 trillion annually by 2025, of which the largest impact would be in Healthcare and Manufacturing. The Healthcare applications can have an economic impact of \$1.1 trillion to \$2.5 trillion by 2025, and Manufacturing can have an impact of \$0.9 trillion to \$2.3 trillion by 2025. The Industrial IoT will add \$14.2 trillion to the global economy by 2030.¹⁵

There is now significant progress made yet, however only 6% of business leaders believe that the idea is simply hype. Moreover, among IoT early-adopting companies 62% claim it has increased their customer responsiveness¹⁶.

3. Specifics of Printoo

3.1. Purpose of Printoo

The main purpose of Printoo was to make a set of Printed Electronics technologies and components more known and accessible to researchers and product developers – both corporate or individuals that want to prototype products.

These technologies would become more accessible because a prepared kit of several components that can be integrated would simplify their use for creators. CEO Inês Henriques stated that “*We were getting a lot of requests from different types of people wanting to have access to our displays, but there wasn’t an easy way to do that*”. With such a kit, anyone could buy and use different types of Printed Electronics technologies – even without significant expertise to join the components – and

¹⁴ “The Internet of Things” is a term invented by Kevin Ashton.

¹⁵ The term “Industrial Internet of Things” refers to IoT applied to optimize the industrial process. Based on *Winning with the Industrial Internet of Things (2015)*, Accenture, and on *Disruptive technologies: Advances that will transform life, business, and the global economy (2013)*, McKinsey.

¹⁶ Based on *Internet of Things: Science Fiction or Business Fact? (2014)*, Harvard Business Review, on *The Internet of Things Business Index (2013)*, The Economist Intelligence Unit, and on Cisco website - <http://www.cisco.com/web/solutions/trends/iot/portfolio.html>.

freely “*program a certain object for your own purpose or for your own lifestyle needs*”, as Ynvisible stated.

Moreover, these technologies would be promoted, to make both Ynvisible’s own electrochromic displays and all other Printed Electronics components more recognizable, as to induce an increase of the industry market value. By knowing such components and their applications – with products, not just single, isolated components – companies would be interested. According to Manuel Câmara, Printoo would allow to make electronics the most “invisible” possible in the design of new products. According to Inês Henriques, “*Brand owners were really seeking ways to transfer the type of experiences that people were having online into the physical world*”. Moreover, Inês Henriques thinks that manufacturer brands felt their physical products being surpassed by online experiences: “*In some cases, if you ask big brand A who their main competitor is, the answer is not going to be brand B. They would tell you that their competitor is the online world*”.¹⁷

3.2. Elements of Printoo

Printoo is a modular platform that encompasses Printed Electronics components. As so, the product consists of different kits, each one with several modules. All components come from companies from Europe, except one type of batteries that comes from the United States, and the flexible circuits, which are made in China. The assembly is made in Portugal, however, as Manuel Câmara predicted: “*It is probable that in the future the assembly starts being made in China, because it will eventually be cheaper*”.¹⁸

The first Printoo product packs, besides running Arduino software, will include novel printed modules including LED light strips from VTT, printed batteries from Blue Spark and Enfucell, thin organic photodetectors from ISORG, printed polymer solar cells from Mekoprint, and Ynvisible’s own transparent printed displays.¹⁹ (see **Exhibits 2 and 3**)

The various modules and components that make part of Printoo are further identified. The Printoo Core Module, which is a microcontroller from company Atmel with approximately 35mm in length, 35mm in width, 2mm of thickness and 4g of weight. This microcontroller is compatible, and programmable, with the Arduino IDE.

The Ynvisible Display Driver, which can have two electrochromic displays connected.

The Printed Battery Connector, which is basically a printed battery and that allows batteries to be connected it. Such batteries can be from Enfucell (produced by Xymox) or Blue Spark (produced by Blue Spark). The Blue Spark Ultra-thin Battery and the Enfucell Soft Battery are also Printoo components, as well as a Coin Battery Holder. Enfucell is a Finnish Printed Electronics products research and development company. Blue Spark is an American company that produces printed batteries.

¹⁷ Based on an article from IQ Intel with Inês Henriques - <http://iq.intel.com/how-maker-friendly-tools-are-embedding-internet-connectivity-into-everyday-objects/>, and on interviews with Inês Henriques and with Manuel Câmara.

¹⁸ Based on interview with Manuel Câmara.

¹⁹ VTT is a Finnish research institute - <http://www.vttresearch.com/>. BlueSpark is a thin film batteries producer - <http://www.bluesparktechnologies.com/>. Enfucell is a printed batteries developer and manufacturer - <http://www.enfucell.com/>. ISORG is an organics and printed electronics manufacturer - <http://www.isorg.fr/>. Mekoprint is an electronic printing solutions company - <http://mekoprint.dk/>. Atmel is an American semiconductors company.

The Sensor Module, that consists of an Accelerometer, a Light Sensor (phototransistor), a Temperature sensor and a Button. The Solar Cell Connector, that allows to connect solar panels. The Conductive Ink Adapter, with pads for conductive ink²⁰. The Capacitive Sensing Keys, which are sensors that detect and measure proximity and position, and thus are useful to create human interface devices. The DC (direct current) Motors Drivers, which allow two motors to be connected. These motors convert electrical energy to mechanical energy.

The Ynvisible Electrochromic Display – using a patented technology from Ynvisible – with 500 microns of thickness.

The Organic Photodetector Slider from ISORG, composed of six organic photodetectors, coupled with LEDs, which allows the detection of hand movement over it. ISORG is a French company that manufactures Organic and Printed Electronics devices. The Polymer Solar Cell – a solar cell with made with polymers, which are large molecules that produce electricity from sunlight – from Mekoprint. Mekoprint is a Danish manufacture-to-order company. The LED Strip – a flexible strip of surface mounted printed LEDs (light-emitting diodes), of 350 microns of thickness – from VTT. VTT Technical Research Centre of Finland Ltd. is a Finnish research and technology company.

Printoo platform is fully compatible and programmable with the Arduino Integrated Development Environment. Arduino is an Italian open-source computer hardware and software company and project, which is based on microcontroller boards that use Atmel AVR microcontrollers or Atmel ARM processors. Moreover, for programming such microcontrollers, the Arduino platform provides an integrated development environment that supports C, C++ and Java programming languages, and that was designed to simplify programming to those unfamiliar with software development. For this reason, Printoo core components use this IDE for users to program them, in order to make creations easier for someone that is not acquainted with software programming.²¹

4. Ecosystem of Printoo

4.1. Company structure and Partners

Ynvisible has now twelve employees, although the size of structure has changed along the last three years, between ten and twenty employees. (see **Exhibit 4**) The company does not have rigid departments, but a flexible team. Inês Henriques describes the structure as following: *“Our clearest division is between those doing research on our laboratory and those responsible for the management, design and marketing of our projects and products²²”*. According to Manuel Câmara, the company has a great balance: *“On the scientific side there is a high number of PhD’s. On the product development side there is a mixture of designers and engineers, and freedom to think about projects”*. Ynvisible does not have people specifically allocated to Printoo nor to the remaining projects with

²⁰ Conductive ink is an ink that results in a printed object which conducts electricity.

²¹ An integrated development environment (IDE) is a software application that provides comprehensive facilities to computer programmers for software development, according to Wikipedia. AVR and ARM are processors based on reduced instruction set computing architecture, meaning that they require fewer transistors than typical processors.

²² Based on my interview with Inês Henriques.

clients. According to Manuel Câmara, the team currently allocates between 80% and 90% of their time to Printoo”.²³

As Ynvisible is a research and development company, the company considers that a fit network of partners is very important. We are witnessing a strong demand for product applications pushing industry growth and initiating new trends. SME’s are collaborating more frequently with external innovation partners than large companies. The benefits of specialization and collaboration seem more obvious today.²⁴

Their first partner was the Faculty of Science and Technology of the New University of Lisbon. As the company started focusing in developing Printed Electronics technologies, they started collaborating with the Chemistry unit within this Portuguese Faculty. More recently, Ynvisible also has partnerships with other education and research institutions such as FEUP (Faculty of Engineering of the University of Porto), CENIMAT and CENTI.²⁵

Corporates are crucial for Ynvisible, as Printoo is an integration of different components from different suppliers. Thus, the majority of such Printed Electronics component producers are considered strategic partners to Ynvisible. These include BlueSpark, Enfucell, Mekoprint, Pragmatic, ISORG and Finland’s VTT.²⁶

Science4you, a Portuguese toy company that integrates electronic components on some of their toys, considers that the value of strong partnerships is intangible, and maybe impossible to fairly assess. In Nuno Dias’ opinion, the notion that a strong partner chooses them means that they consider their products fit for the market: *“We certainly know that this partnerships’ value is big – if Oxford put their “stamp” on our products, it surely is because they believe they have something different and interesting.”*²⁷

4.2. Financial performance²⁸

Research and development are the basis of Ynvisible’s business, and as that core function demands for capable workforce, from its first year of existence until 2011/2012 Ynvisible quickly surpassed 500,000€ in employee salaries. (see **Exhibit 5**) Also, external services and supplies reached 419,893.00 in 2012. As for sales and services rendered, the company was able to reach 9,664.43€ in 2011, growing to 68,035.06€ in 2012. As so, the company’s strategy for the three initial years of its existence focused mainly on developing technology for upcoming products and services that would make it able to be profitable. In these three years, the net profit was -172,089.07€ in 2010, -

²³ Based on my interview with Manuel Câmara.

²⁴ Based on *Open Innovation in SME's: how can small companies and start-ups benefit from open innovation strategies (2012)*, Wim Vanhaverbeke.

²⁵ FCT UNL is the Faculty of Sciences and Technology of the New University of Lisbon. FEUP is the Faculty of Engineering of the University of Porto. CENIMAT is the Center for Investigation of Materials of UNL. CENTI is the Centre for Nanotechnology and Smart Materials. Based on interview with Manuel Câmara.

²⁶ Based on interview with Manuel Câmara.

²⁷ Based on interview with Nuno Dias.

²⁸ This section is based on the simplified financial reports of Ynvisible and Ydreams retrieved from the web and available on Exhibits 5 and 6.

574,994.27 in 2011 and -601,992.13 in 2012. The company's current debt reached 860,419.50€ in 2012. And its operational cash-flow amounted to -904,098.91€ also in 2012, due to the still insufficient sales and services rendered. Finally, a result of – 1,407,907.67 would transit to 2013.²⁹

As for YDreams, from 2006 to 2012 the company had consecutively negative net profit results, with a figure of -2,020,521.66 in 2012. (see **Exhibit 6**) Along this period, this mother company always had a sales figure lower than the expenses with employee salaries and external services and supplies combined, whereas employee salaries reached 75% of all sales and services rendered in 2012, actually the best proportion along this period. This proportion reached its worst figures in 2010, where employee salaries reached 166% of all sales and services rendered that year. YDreams' sales and services rendered, after two more successful years – 2008 and 2009 – with figures above 4,000,000€, rapidly declined to a figure of 2,591,191.66 in 2010, never again reaching above 4,000,000€. This may have contributed to a reduction of the number of employees 2011 onwards, the year in which news of failure in salaries payment went public. In 2012, fiscal losses already surpassed 14,800,000€, and such losses absorbed the capital stock entirely, as in the previous year. This situation, mainly after 2010, potentially led to the 2015 situation, with the company's special revitalization request to avoid insolvency.³⁰

It is normally expected, when analyzing the financial performance of a startup, that the Cash Flow from Operations of Ynvisible is hardly positive or even negative, that the Cash Flow from Investing is largely negative and that the Cash Flow from Financing is very positive. This can be considered normal since a startup will absorb significant external financing – bank loans – and internal financing – shareholders or equity – while investing significantly and seeing very little operational profits in the immediate run. What is less expectable is the high relative portion attributed to salaries expenses, which would force the mark up on the products to be significantly higher, and the return to be much higher. It would be more expectable that the salaries expenses would be a compressible portion of the costs and that does not seem to be the case in this company. As shown after, this situation was also present in YDreams, and ideally should be prevented by Ynvisible.

4.3. Maker Culture

The maker culture is basically a community composed of DIY enthusiasts with interests in technology, electronics and robotics, as well as in more traditional crafts such as metalworking and woodworking. This community gives preference to practical skills – to learn them and to apply them in designs, either

²⁹ Salaries surpassed 500 thousand €: 494,892.89€ in 2011, and 542,494.81€ in 2012]. Operational cash-flow was -872,549.82 in 2011.

³⁰ Salaries in YDreams, were figure was above 100% of sales in 2011 (107%) and 2007 (105%). YDreams' sales were 4,935,250.81€ in 2008 and 4,703,587.74 in 2009. Reduction of employees and salaries being late in 2011 Based on an article from Correio da Manhã - http://www.cmjornal.xl.pt/domingo/detalhe/a_realidade_diminuida_de_antonio_camara.html.

these are professional prototypes or hobby creations. Makers have their own widely read, pioneer publication—the magazine *Make* - and their own exhibitions – the Maker Fairs.³¹

The number of makers, and their influence, is difficult to assess, nevertheless, *Make* magazine stated that “*Maker Faire has reached over 2.3 million attendees globally, since it launched in California in 2006*”. In 2014, there were 131 Maker Fairs around the world. There are approximately 135 million people that are makers, in the United States. It is predicted that makers will have a higher impact outside the domains of the movement itself in the near future. For instance, in 2013 Deloitte proclaimed that the Maker ecosystem will disrupt today’s large enterprise, by promoting open platforms and collaborative ideas.³²

Nevertheless, in the hardware and electronics manufacturing industry, open platforms are still rare, as it is more common to protect one’s Intellectual Property by closing information within. In Manuel Câmara’s opinion, the majority of companies with whom Ynvisible works have a much closed environment, and he believes that the mindset of Makers is really a very different way of doing things on a corporate level.³³

The purpose and the future of the Makers movement was debated namely by two of the leaders of such movement. Chris Anderson, CEO of 3D Robotics and former editor-in-chief of *Wired* magazine, published “*Makers*” in 2012. In 2014, Mark Hatch, CEO of TechShop – a chain of makerspaces – published “*The Maker Movement Manifesto*”. Both books promise a revolution. For Chris Anderson, this movement represents a democratization of invention, similar to the one that defines the past two decades of Internet history, and so that now could be similar regarding manufacturing.³⁴

4.4. Open Innovation

According to Henry Chesbrough, Open innovation is the antithesis of the traditional vertical integration model where internal R&D activities lead to internally developed products. “*Open Innovation suggests that valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well*”. Chesbrough also considers that two main points of differentiation between Open Innovation and prior theories of innovation are the equal level of importance given to external and internal knowledge and “*the centrality of the business model in converting R&D into commercial value*”³⁵. According to McKinsey, these two points are also key factors for one to be an innovation leader, as they should involve a broad array of partners in the idea generation process, and embrace open innovation to gather ideas from many sources³⁶.

³¹ DIY literally means “do it yourself”, and refers to the execution of tasks without paid experts. *Make* magazine, according to MakerFaire (<http://makerfaire.com/maker-movement/>) was launched in 2005, and was a catalyst for a tech-influenced DIY community, that has come to be identified as the Makers Movement.

³² Based on *The impact of Maker Movement* (2013), Deloitte, and on article from Maker Faire Nova - <http://makerfairenova.com/2015/02/16/do-you-know-how-many-maker-faires-there-were-in-2014/>, and on Time - <http://time.com/104210/maker-faire-maker-movement/>.

³³ Based on interview with Manuel Câmara.

³⁴ Based on an article from New Yorker -<http://www.newyorker.com/magazine/2014/01/13/making-it-2>.

³⁵ Based on *Open Innovation: a new paradigm for understanding industrial innovation* (2005), Henry Chesbrough.

³⁶ Based on *Innovation Management: strategies for success and leadership* (2008), ATKearney.

Assessing Ynvisible from this perspective, it is already clear that the second point of differentiation is present in Ynvisible's strategy – since a major reason for the creation of Printoo, was to bring commercial value to their electrochromic displays, born from the technology they have developed. As for the first point of differentiation, one can consider that Printoo already gathers knowledge from the diverse suppliers and their components that are integrated in Printoo, however this will only be fully assessable once the product starts being produced and sold to more customers – as only then one will assess the level of participation of external parties and customers, as well as the level of acceptance and usage of such ideas on the evolution and adaptation of Printoo, by Ynvisible. Nonetheless, it is expectable that it will be the case, since according to Manuel Câmara, Printoo will be mainly a product platform, or framework, for contributors to customize and exploit, and ultimately to extend the framework's functionality³⁷.

Additionally, Ynvisible has the technology for some of the components, but does not have the manufacturing capability nor the distribution channels for the remaining components, especially on a high-volume scenario. The lack of strength in these two variables, according to Flanders, makes Open Innovation a logical step for many SMEs to take, and with the expected benefits of accelerating the development of new products and expanding the markets for use of such products. This is also probably the case of Printoo, since, as mentioned by Jani-Mikael Kussisto (from partner and supplier VTT), VTT is a potential customer of Printoo, not to make direct profit from it, but to promote a product that contains VTT's components. Ultimately, VTT's objective is to increase the market for their components, along with the market for Printoo, while having manufacturing capability and distribution channels established for such objective³⁸.

Finally, McKinsey considers that the usage of Open Innovation improves the success rate of new products, and this is the main concern of Ynvisible, as it has high expectations that Printoo can bring a significant, recurrent monthly cash-flow to the company, as stated by Manuel Câmara³⁹.

4.5. Crowdfunding

Crowdfunding is the form of funding a project by raising monetary contributions from the crowd – a large number of people – typically using the internet. Using this method, a company, a group or an individual, may engage a community of people to network and pool their money and knowledge together. The crowdfunding model has three types of actors: the project initiator who proposes the idea or project to be funded, the individuals or groups who support the idea, and a moderating organization – the platform. Overall, the crowdfunding economy was valued at \$5.1 billion in 2013.⁴⁰

³⁷ Based on interview with Manuel Câmara.

³⁸ Based on interview with Manuel Câmara and with Jani-Mikael Kuusisto and on *Open Innovation in SME's: how can small companies and start-ups benefit from open innovation strategies* (2012), Wim Vanhaverbeke.

³⁹ Based on interview with Manuel Câmara and on *Innovation Management: strategies for success and leadership* (2008), AT Kearney.

⁴⁰ Based on an article from Forbes - <http://www.forbes.com/sites/hsbc/2014/08/05/crowdfundings-untapped-potential-in-emerging-markets/>.

Currently there are multiple platforms, of which Gofundme and Kickstarter were the most successful in 2014. Gofundme reached a total raised amount of \$470 million, from 6,000,000 donors. Along all its existence, this platform raised a total of over \$1.25 billion. Kickstarter reached a total raised amount of \$440 million, from 3,300,000 backers. In Gofundme's co-founder Brad Damphousse's opinion, Kickstarter helped popularize crowdfunding in the areas of creative projects, music and film, while GoFundMe's is a personal fundraising platform that is focused on enabling people to raise money for personal causes and life events".⁴¹

Crowdfunding is very interrelated with the DIY and Makers cultures, as the emergence of this form of capital raising has allowed makers and inventors access to resources otherwise unavailable, when trying to finance the design of new products.

By using these platforms, a company with a product such as Printoo can have access to a community of early-adopters and raise awareness and support on potential clients. They also give entrepreneurs the potential to scale up a new venture, and so even large-scale investors have become less necessary. However, to accomplish this level of awareness and build up on disperse small investors, one needs hard work to catch the attention of others, in a way that they fund a project.⁴²

4.6. LEGO Mindstorms case and Competition

In this section some of Printoo's competitors are identified, namely LEGO Mindstorms. This particular product is a classic case where similar tools and trends to ones conditioning Printoo were applied. LEGO Mindstorms is recurrently used as a case study for open innovation.

LEGO Mindstorms is a series of kits that contain software and hardware to create customizable, programmable robots. The Mindstorms Robotics Invention System kit was composed of Lego parts, modular sensors and motors, plus an intelligent brick computer to control all the system that was created at the MIT Media Lab⁴³.

The LEGO Company started sponsoring the MIT Media Lab in 1985, when the Media Lab opened. In 1998, a first prototype of a programmable brick computer was developed, and also that year LEGO launched the Mindstorms construction kit. This partnership between LEGO Company and MIT allowed a brick toy capable of interacting with the physical world, through sensors and motors. However, MIT's Programmable Brick technology wasn't only used for learning and play purposes, but also as a rapid prototyping tool, for example by the U.S. Postal Service⁴⁴.

According to Eric Von Hippel: "*Within three weeks of introduction, a thousand hackers were working on it. Within a few weeks, they have vastly improved it*". Despite having initial reservations on accepting such external input, LEGO accepted this external activity, after realizing its benefits. This

⁴¹ Based on crowdfunding.com (top 10 crowdfunding portals) - <http://www.crowdfunding.com/>, and on gofundme.com - <https://www.gofundme.com/blog/2015/01/13/gofundme-tops-kickstarter-as-worlds-1-crowdfunding-platform/>.

⁴² Based on an article from New Yorker - <http://www.newyorker.com/magazine/2014/01/13/making-it-2>.

⁴³ LEGO Mindstorms on <http://www.lego.com/en-us/mindstorms/?domainredir=mindstorms.lego.com> MIT Media Lab is an interdisciplinary research laboratory at the Massachusetts Institute of Technology.

⁴⁴ Based on MIT Media Lab - <https://www.media.mit.edu/sponsorship/getting-value/collaborations/mindstorms>.

external interest in contributing was so impactful, that 70% of customers were over the age of 18, which wasn't expected by LEGO. Moreover, LEGO Mindstorms customers founded clubs and tried to create further innovations. LEGO thus decided to create LEGO Factory, welcoming external input by allowing customers to create new models and sell such models on the LEGO website.⁴⁵

Lego Mindstorms is considered to be a classic example of Open Innovation model where the company has allowed customers to create designs. As so, it is still a good example for companies with innovative products that allow for prototyping and that are to address the Education and the Toy industries. According to Manuel Câmara, this is the case for Printoo, as Ynvisible is starting to address two markets: prototyping and Education. The existence of products – and some successful – on these two markets, is not necessarily a threat, in Câmara's opinion. In fact, it is quite the opposite as both of these markets have a trait in common: *"They are not monopolist markets at all, and thus are markets with many small niches and segments that are possible to be occupied."*⁴⁶

In the prototyping market, there are Arduino and Raspberry Pi, but also many other products with different type of boards for prototyping. Raspberry Pi has sold a total of more than five million units until February 2015. Câmara considers that, although in fact there is a lot of competition, on the other side there are a lot of different needs that consumers have, and that all of these competitor products address different sets of needs⁴⁷.

In the Education market, even though there are more successful products such as LEGO Mindstorms and the more recent Little Bits, Câmara considers that competition is much lower because the sector has many geographical zones, year ranges, subjects and different learning needs. As such, there is no leader, or at least the existing leaders are not ones who block the entry of new companies. For instance, in Câmara's perspective, Little Bits is good for children until ten or twelve years old, while Mindstorms is good for children from ten to sixteen that want to do robotics. Little Bits has raised additional \$44,000,000 in funding in June 2015, totalizing \$60,000,000 of funding since it started.

Hence, Ynvisible sees previous successful cases – and the other players in the Education market in general – not as a threat, but as drivers of the current exponential increase of the market regarding the adoption of technology, creating opportunities that not entirely addressed by those companies: *"Namely, Little Bits has grown and having hype because it is introducing in schools what is necessary to teach about technology, and so they target younger ages, leaving older ages with the need for other types of kits and products"*.⁴⁸

⁴⁵ Based on presentation by Eric Von Hippel, Head of Innovation Group at MIT - http://library.fora.tv/2008/04/08/MITs_Eric_von_Hippel_Open_Innovation.

⁴⁶ Based on an article from IdeaConnection - <http://www.ideaconnection.com/open-innovation-success/Lego-Success-Built-on-Open-Innovation-00258.html>, and on interview with Manuel Câmara.

⁴⁷ Based on interview with Manuel Câmara, and on Rapsberry Pi - <https://www.raspberrypi.org/blog/five-million-sold/>.

⁴⁸ Based on interview with Manuel Câmara.

5. Initial Strategy for Printoo

5.1. Kickstarter campaign

Printoo was first funded in Kickstarter, a Crowdfunding platform. Ynvisible's strategy until now was to first globally address the technology and innovation enthusiasts and early-adopters, the makers – and the company considered that a crowdfunding campaign would be ideal for that end.

On the Kickstarter campaign, the company pledged for 20,000\$. (see **Exhibit 7**) After the campaign launch on April 17th 2014, it received 80,336\$, from 560 backers. Only 16% of all campaigns launched in Kickstarter are able to reach funding between 20,000\$ and 100,000\$. According to Manuel Câmara, Ynvisible knew relatively well what would be the target audience, but did not have a clear notion of how many people would be interested. Once finished, the campaign was considered a success by Ynvisible, because it proved that there was demand for Printoo. This success was much due not only to the novelty of the technologies it encompassed – at least for a significant part of the target audience – but also to references made by YCombinator, Make and Wired, along the pledging period⁴⁹. (see **Exhibit 8**)

According to CEO Inês Câmara, Ynvisible's assessment of the target was based on feedback of both their previous projects and their online shop. Based on these inputs, Ynvisible assumed that their target would be composed of two groups. First, the makers, the technology enthusiasts, who wanted to create but did not quite have access to the technologies. Second, the people from research and development departments in companies, who wanted to be able to rapidly prototype and to design products, using Printed and Flexible Electronics⁵⁰.

In terms of product timeline, in the campaign Ynvisible previewed that Printoo kits for the Kickstarter funders would be produced until August 2014, and shipped during September 2014. (see **Exhibit 9**) Nevertheless, between August and September, boards have failed Ynvisible's quality tests, and as so, in November the company updated the estimated delivery time to December – estimative that eventually was not accomplished. Between March and April 2015, Ynvisible inserted further updates on Kickstarter: *"In order to produce Printoo we had to change a few components due to manufacturers' delivery times and, at the same time, we had to keep in mind that function, cost and quality could not be compromised"*. Finally, in July 2015 – after the anxiety of some backers – Ynvisible stated that technical problems were solved and Printoo kits would be shipped to backer during October 2015⁵¹.

In terms of impact, the campaign did not only helped to promote and fund the product, but it also gave two important major lessons, according to Inês Henriques. The first lesson is that the number of makers and developers interested – the assumed target – was even bigger than anticipated, and that alone would have made the campaign a success. Among these developers, many were from

⁴⁹ Based on KickStarter campaign - <https://www.kickstarter.com/projects/1030661323/printoo-paper-thin-flexible-arduinotm-compatible-m>, on Kickstarter Printoo launch video - https://www.youtube.com/watch?v=Xgsp_xm08W8, and on interview with Manuel Câmara.

⁵⁰ Based on interview with Inês Henriques.

⁵¹ Based on Kickstarter Printoo campaign updates - <https://www.kickstarter.com/projects/1030661323/printoo-paper-thin-flexible-arduinotm-compatible-m>.

companies that bought several components for the more expensive kits. The second lesson was, surprisingly, that the Education sector was also interested in Printoo.⁵²

Ynvisible received enthusiastic feedback by several Educational institutions and Professors – showing not only interest in having the product, but also to collaborate in order to evolve Printoo: “*we have several research institutes and universities that are already interested in doing modules for the Printoo*” – as mentioned by Manuel Câmara. During and after the campaign, universities in Spain, the United States, Finland and Germany showed interest in making new modules for the Printoo. The following are examples of feedback comments from Professors, during the campaign: “*I just backed your project. I teach high school at a New York City public high school and my students will be very excited to learn about your projects. Please let me know if there is any opportunity to work on development with you or do any beta testing!*”; “*Your project, on Kickstarter, certainly looks interesting and I can think of many projects where it would be useful. I would be looking at the age range 13+ for your product. Your RC Modelling Pack would seem to fit my thoughts at the moment but wearable technology might go down well with youngsters.*”

5.2. Marketing mix

Printoo is also available for sale on Printoo’s website online shop, although orders are only to be dispatched after the fulfilment of the Kickstarter orders. Ynvisible also has another online shop, existent since the company’s creation, before the idea and campaign of Printoo. This online shop sells products – such as postcards, bookmarks and hangers – intended to demonstrate the functionalities of Ynvisible’s own electrochromic displays.⁵³ (see **Exhibit 10**)

In parallel to the Kickstarter campaign, Ynvisible engaged in other promotion actions in order to enhance the exposure of Printoo. The main promotion actions were the hiring of a public relations company in San Francisco, USA, in order to access journalists in main media; direct contact with Hackerspaces and FABLABs; direct contact with key influencers; Facebook ads; and YouTube videos. Also, Ynvisible started to give Summer Camps on the summer of 2015 in Portugal, and are planning more actions like these for the next year, along with several local schools. Currently on this format, the participating teachers are hired by the company.⁵⁴

Currently, Printoo is set mainly in six different kits⁵⁵. (see **Exhibits 2 and 3**) The “Printoo Core Kit” is composed of one Core, one Coin Battery Holder and two Ynvisible Displays, and is set at \$52. The “Basic Pack” is composed of one Core, one Coin Battery Holder, one Sensor, one Ink Adaptor, four Ynvisible Displays, one Capacitive Keys and one Blue Spark Battery, and is set at \$107. The “RC Modeling Pack” is composed of one Core, one Sensor, one LED, one Solar Cell Connector and one Motor Driver, and is set at \$132. The “Printed Pack” is composed of one Core, one Coin Battery Holder, one Sensor, one Solar Cell Connector, one Capacitive Keys, one Ink Adapter, four Ynvisible

⁵² Based on interview with Inês Henriques and with Manuel Câmara.

⁵³ Printoo online shop - <http://www.printoo.pt/shop/>. Ynvisible online shop - <http://www.ynvisible.com/shop/>.

⁵⁴ FABLAB is a fabrication laboratory, where people design creations. Based on interview with Manuel Câmara.

⁵⁵ Printoo kits on <http://www.printoo.pt/shop/#pack>.

Displays, one Mekoprint Solar Cell, one Blue Spark Battery and one Enfucell Battery, and is set at \$147. The “Printed Prime Pack” is composed of one Core, one Coin Battery Holder, one Sensor, one Lithium Holder, one Ink Adapter, one Capacitive Keys, eight Ynvisible Displays, one ISORG Photodetector, one Mekoprint Solar Cell, one Blue Spark Battery and one Enfucell Battery, and is set at \$272. Finally, the “Ultimate Blimp Pack” is composed of two Core, one Coin Battery Holder, one Printed Battery, one Sensor Module, one LED, one Lithium Holder, one Motor Driver, one Ink Adapter, eight Ynvisible Displays, one ISORG Photodetector, one Mekoprint Solar Cell, one VTT LED strip and one Blue Spark Battery and one Enfucell Battery, and is set at \$552.

Each single component is also available, with prices ranging from \$1.25 to \$33, namely Ynvisible Electrochromic Display, set at \$3.10 and Ynvisible Display Driver, set at \$15.

Although these are the current available kits, others are being developed, for several different reasons combined. The first reason to have new kits is that once Printoo starts being shipped, and Ynvisible starts getting feedback from customers, new needs will be unveiled. The second reason is that each kit needs to be improved – via the replacement of components with better and less expensive ones – which means that some kits might have to be changed. The third reason is due to the previously unexpected target of the Education market, for which it is presumably interesting to have kits with both printed, flexible electronics and traditional electronics. Finally, the fourth reason – as suspected by Manuel Câmara – is “*if certain companies as Disney or Bosch, that have big R&D sectors, would be willing to spend a few thousands of euros for a kit with a very wide range of modules*”, then Ynvisible could have kits more focused on that type of consumer.⁵⁶

Relatively to the current pricing strategy, Ynvisible considers it won't be able to reduce costs unless volume increases exponentially. As so, they suspect they will not be able to reduce costs in a way to reduce prices in the short-term. An exception can exist in the kits that are being developed for the Education market, as these kits mix rigid boards with flexible boards and are expected to represent a higher sales volume – and so, such sets are expected to be cheaper than the remaining sets.

On the distribution level, Ynvisible is currently addressing possible resellers of Printoo kits. However, considers it can control the distribution for the more professional market – a more niche market – exclusively using the online shop.⁵⁷

5.3. A Role in the adoption of new technologies

“*As technology becomes ubiquitous, it also becomes invisible*” can be seen on Printoo's Kickstarter video, quoting Kevin Kelly, Wired co-founder, before being stated that Printoo allows to “*bring everyday objects to life*”. Inês Henriques claims: “*We are set to develop Electrochromics as the visual interface technology for the internet of things*”, describing Printoo as an attempt to enable what she

⁵⁶ Based on interview with Inês Henriques and with Manuel Câmara.

⁵⁷ Based on interview with Manuel Câmara.

calls the “Internet of Print”. In her opinion, “*3D printing gets a lot of attention*”, but she believes 2D printers have an important role to play in the future of the Internet of Things.⁵⁸

Printed Electronics can be one of the technological key enablers for realizing the Internet of Things as it allows to embed electronic type functionality in almost anything – which is not possible with traditional electronics. The IoT is also about relations between objects and humans and not only among objects – and these technologies can contribute to explore this interaction. However, this application can only be made at a small object level that then can be integrated into larger, smart objects. For this to be possible, it is still necessary to be possible to integrate all these Printed Electronics technologies in a way that allows high volume, low cost production. Thin Film is one company that promises to do that in the short-term.

The role for Printoo in that is to enable to prototype, design these new products that have embedded intelligence. But in Manuel Câmara’s perspective, Printoo can also contribute to a paradigm shift in the hardware industry – for it to get more open. In his opinion, the way hardware companies have been maintaining their value is through patents and intellectual property, and most of all, they keep everything secret and do non-disclosure agreements. And Printoo is the idea that what matters for those companies is not to protect their intellectual property, but rather to make product designers adopt their technologies by being available to them.⁵⁹

5.4. A Role in Education

The Education market is a possible target for the Printoo, as researchers and university professors can use it in their projects and classes, as well as parents can buy the sets to use them with their children outside classrooms. Moreover, this sector is ideal to induce the dissemination of the technologies involved and the search of useful applications.⁶⁰

While these benefits are certainly important for Ynvisible, it needs to communicate and promote Printoo and its technologies to this target audience. According to Science4you – a Portuguese company that conceives educational toys embedded with scientific concepts for children – “*Whenever there is a technological breakthrough, one never knows what applications will come from it. Also, when new applications appear, for us adults it is often hard to adapt to them, whereas for a child is more prone be willing to learn it*”.

Science4you has the objective of maximizing children’s learning and taste for science. With that in mind, they disseminate technology applications that are already being commercialized and basic

⁵⁸ Based on an article from Wired about Inês Henriques -<http://www.wired.com/2014/05/using-paper-thin-electronics-to-create-physical-web-browsers/>.

⁵⁹ Based on interview with Manuel Câmara and with Jani-Mikael Kuusisto. Thin Film is a printed rewritable manufacturer - <http://www.thinfilm.no/company/>.

⁶⁰ Science4you is a Portuguese educational toy company. Based on interview with Nuno Dias.

knowledge behind applications to children. Nonetheless, they think it's very hard to assess their impact on such dissemination. "*We can only assess the acceptance of our products in the market*".⁶¹

Science4you conceives their products accordingly to schools' educational program contents, so that children experiment after learning the theory. It also dialogues with its partner institutions, especially world renowned Science Universities, to get further fitness approval of their products. "*The value of these partnerships is almost unmeasurable, although we have perfect notion that it is very high. If Oxford University and University of Lisbon put their stamp on our products, then it's because they consider them interesting.*" For Printoo, aligning with educational programs can be more complex, as Printed Electronics knowledge is targeted at different age ranges and not standard programs.

Nevertheless, Ynvisible is also addressing and assessing this market, with "Inventors' Club" and Summer Camp initiatives, to further reveal these potential customers' needs. Besides these initiatives, there are all the University and High School professors that gave feedback to Ynvisible, telling they would like to use Printoo in their classes in order to test and evolve the product.⁶²

It is possible to identify other specific trends in the Education sector that can be relevant for Printoo. For instance, consumer perceptions of technology in the classroom are changing, as the majority of students believe technology improves the learning experience, although most classrooms have limited access to technology at best. Another trend is the valorization of creativity and taste for technological knowledge by educational institutions. For instance, MIT (Massachusetts Institute of Technology) started evaluating students' maker portfolios as part of the application process. Finally, there is a strong increasing need for computer programming skills. The Hour of Code initiative – created to engage young students with computer science – has involved more than 190 million people since it was created. As so, educational tools that engage students so that they are interested in learning software programming are in demand.⁶³

5.5. Potential clients and applicable Industries

Two markets seem the fittest for Printoo: Prototyping and Education, in Ynvisible's perspective.⁶⁴ (see **Exhibit 11**)

The Rapid Prototyping market is expected to grow from \$1.5 billion in 2012 to more than \$5 billion by 2020. Additionally – and in case Printoo is directed to an open format – the Open Source Hardware market is expected to total around \$1 billion in 2015, after turning over nearly \$50 million in 2013. On the Education market: the Technology segment of the Education's subdivision of primary and

⁶¹ Based on interview with Nuno Dias.

⁶² Based on interview with Nuno Dias and with Inês Henriques.

⁶³ Based on *The impact of Maker Movement* (2013), Deloitte, and on Hour of Code initiative - <https://hourofcode.com/>.

⁶⁴ Based on interviews with Inês Henriques, with Manuel Câmara and with Jani-Mikael Kuusisto from VTT. VTT is a research institute owned by the government of Finland and that develops Printed Electronics technologies since the late 1990s.

secondary schools totaled \$18.3 billion in 2012 in the United States alone. Also, the Robotics segment of all the Education subdivisions totaled nearly \$1.26 billion in 2014.⁶⁵

The Prototyping market encompasses early-adopters, researchers and product designers. These customers can use Printoo to prototype products potentially for several industries, nevertheless the ones for which Printoo seems more fit are Packaging, Healthcare and Wearables. (see **Exhibit 12**)

This market is interesting because it is more open to radically think what it is possible to do with electronics, and how to pass from single components to meaningful products. For component providers this is equally interesting because these users represent the best way to test new components. For the professional segment of this market – a niche segment, presumably composed of R&D departments of large companies and Printed Electronic clusters – the company believes it can control sales directly using their online shop. However, to be able to address the major part of this market, Ynvisible intends to search for possible Printoo kits resellers. Manuel Câmara sees future sales in this market as more opportunistic and with a more complex scalability.

This market requires that single components are put together in a smart way, so that they do not need to have significant knowledge of the technologies and so that they can prototype with designs that are the closest possible to the final model. Probably it is even more crucial to recurrently have new kits with new modules – both with new functionalities and same ones but with improved performance. Being a market of early-adopters, it is harder to present something new. Competition on this market is also more intense.

In this market, Printoo component supplier VTT is the first higher-volume, corporate client for Printoo.

The Education market is the main target, as Ynvisible believes that the Kickstarter campaign showed it so should be. Ynvisible believes this market is bigger, with more opportunities to enter, easier to address and prone to give more predictable sales levels.

In order to explore and understand this market, Ynvisible has several initiatives. The first one is “The Inventors”, a program of workshops and classes that it is giving in a few Portuguese schools. These classes address Electronics in general. Another initiative is Summer Camps. Ynvisible has hired teachers and organized several camps in Portugal in the summer of 2015 and is discussing with schools to plan more for the following years. In both of these initiatives it has used new kits that allow to make learning experiences – for instance, a Space automated vehicle replica made of cardboard, controlled with the smartphone – and assessed which experiences students liked.

Ynvisible is preparing new kits around Printoo and probably with non-printed, traditional components – because Printed Electronics are probably not interesting for children – to be more appropriate for

⁶⁵ Based on Educational Week blog - http://blogs.edweek.org/edweek/DigitalEducation/2012/05/sizing_up_the_ed_tech_market.html, on Wintergreen research - <http://www.wintergreenresearch.com/reports/Educational%20&%20Entertainment%20Robots.htm>, on Linux User - <http://www.linuxuser.co.uk/news/open-source-hardware-worth-1billion-by-2015>, on Siemens - <http://www.siemens.com/innovation/en/home/pictures-of-the-future/industry-and-automation/Additive-manufacturing-facts-and-forecasts.html>, and on Market Watch - <http://www.marketwatch.com/story/education-technology-spend-reaches-13-billion-2014-06-11>.

learning experiences. (see **Exhibit 13**) These kits will be prepared with manuals to give the classes – and so the start-up will scale the model with this approach.⁶⁶

5.6. Key Success Factors

According to Inês Henriques and Manuel Câmara, and also to Ynvisible partners such as VTT's Senior Scientist Jani-Mikael Kuusisto, there are four key factors in which Ynvisible has to succeed, and as such, the definition of the strategy for the next steps should take these factors in account.⁶⁷

The first critical factor is that Ynvisible has to be in a tight collaboration with strategic partners such as component makers, research institutes and educational institutions to potentiate innovation and reach competitive advantage. This network is relevant to get the new components and use them smartly on new kits, which can impact in product quality and price and in a constant adaptation to customers' new needs and preferences. Ultimately, this aspect also can prevent Ynvisible from exhausting the market.

An additional critical factor is brand strength. Printoo needs increased marketing actions, in order to be considered a top of mind product within the genre – the reference solution for prototyping and design products using Printed Electronics technologies and components.

Distribution is also critical. In Manuel Câmara's opinion: *"For hardware companies, distribution is one of the main entry barriers. Because established companies are already in the store and it's much easier for them, because they already deliver a high volume of products, allowing them to have higher scale and better margins"*. The company intends to maintain online sale forms, which potentiates higher margins and are easier to establish. However, in order to reach higher volumes, Ynvisible will need relevant retailers.

Finally, Ynvisible has the challenge of finding investors who believe that Printoo will commercially valuable. In Jani-Mikael Kuusisto's opinion, such an investor could be, for instance, a company with strategic interest in the electronics field. This challenge, if succeeded, will make available the necessary capital to advance to higher volume production. Kuusisto believes that this aspect is often overlooked in this industry, and he also states: *"We have in our space a lot of companies with too small resources that are attempting to do something bigger than what they actually can, with those resources."*

6. Defining a Strategy for the future of Printoo

After describing, analyzing and understanding the story behind the company and the project, this section deals with the strategic context and analysis for the future of the project. Printoo's different strategies are identified and explained using several theoretical strategy frameworks.

⁶⁶ Based on interviews with Inês Henriques, with Manuel Câmara and with Jani-Mikael Kuusisto.

⁶⁷ Based on interviews with Inês Henriques, with Manuel Câmara and with Jani-Mikael Kuusisto.

First of all, it is necessary to categorize Printoo’s innovation approach so far. According to Frank Rothaermel, in order to categorize innovations one should measure the degree of newness of both technologies and markets. In this section, the Education market encompasses the Education Technology segment and the Education Robotics segment. The Open-Source Hardware market is the sector of non-professional Makers. Rapid Prototyping market is the sector of professional researcher and product designers, and in which Printoo is an intermediary in the value chain.

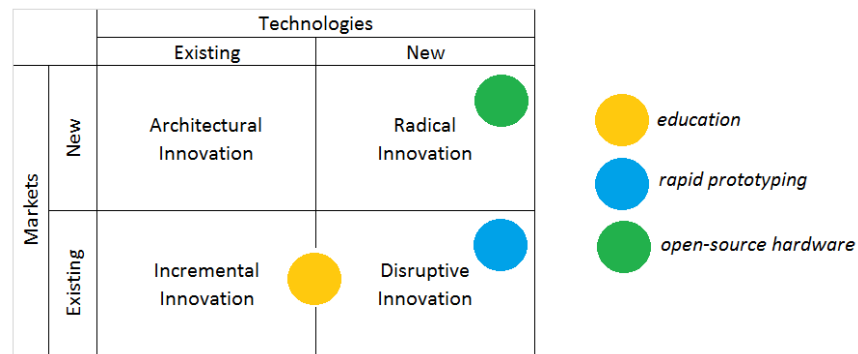


Figure 1 - Types of Innovation: categorization of innovations considering degree of newness in terms of technology and markets (source: Rothaermel, 2013)

According to the interviews made, Printed Technologies are new to most markets, except to a section of the Prototyping industry. Nevertheless, for non-corporate makers and designers, these technologies are more prone to be new. For the Education sector, both Printed and traditional Electronics are to be present in Printoo. The traditional components are not new to the market.

In terms of markets, the professional sector of the Prototyping market is an existing market for these technologies and components, although not integrated in the same manner. Similar kits, although with different components were already made for the Education market, despite not being addressed by Ynvisible yet. The Makers, open-source hardware sector is still new and increasing for products such as this.

Overall, the alternatives chosen by Ynvisible so far are classified as following. A mixture of incremental and disruptive innovation in the case of having an educational tool, as Printoo could have both Printed and traditional Electronics. As an intermediary in the value chain of other component manufacturers, addressing mostly professional Rapid Prototyping, Printoo is disruptive innovation. According to Frank Rothaermel, incremental innovations can be important to become embedded in a network of suppliers and buyers, and thus to reinforce that network. As a recreational consumer product for the non-professional makers – identified as open-source hardware sector – Printoo will be radical innovation, as it derives from new knowledge. This can be interesting for Printoo in the long-term if there is a follow-up with incremental innovation when the market is more mature, although it is uncertain how the market will progress – and how much more innovation would the market demand from the company.

To face the future, Ynvisible needs to decide which strategy to adopt relatively to its innovation. Namely, the start-up needs to decide what company structure to adopt when Printoo starts being produced and sold. According to CEO Inês Henriques and New Products Manager Manuel Câmara, a probable scenario is for Printoo to become a spin-off company – dedicated only to the product – and for Ynvisible to keep focused in developing Printed Electronics technologies, as it was before the creation of Printoo. But for this to happen, and for Printoo to be a viable company, it needs to have a recurring cash-flow every month.

Nonetheless, as one company or divided, it is crucial to assess who as more control of potential profits to come from Printoo. According to David Teece (Teece, 1986), two factors have great influence in assessing who will ultimately profit from a specific innovation. The first factor is the level of imitability of the technology by competitors. In the case of Printoo, this level depends on the set of components that each kit will comprise.

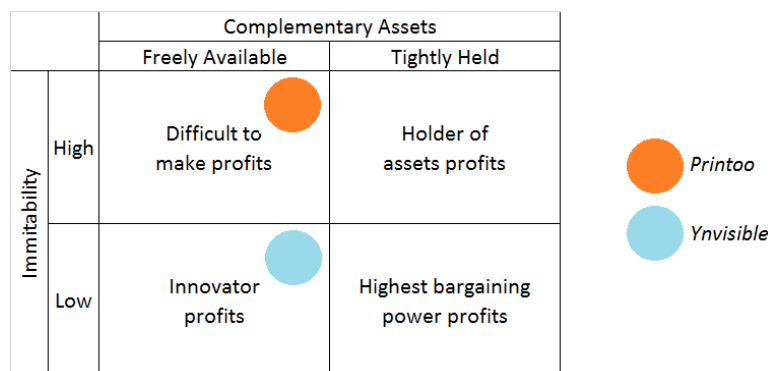


Figure 2 - The Teece model: assessment of who will ultimately profit from an innovation, given its levels of imitability and complementary assets (source: Teece, 1986)

Several components within Printoo have technologies that are new and not easy to imitate, nevertheless, the majority of those technologies belong to, and are produced by partners, not to Ynvisible. In spite of this, one possibility would be to Ynvisible to consider on focusing more on its Electrochromic displays and less on Printoo, if it wants to focus on what is less imitable, thus claiming profits related to its own technology. Printoo as a product is highly imitable, in the sense that it can be easy for a competitor to launch a similar series of component sets. However this can further vary depending on which set of components each kit has and what kits are launched – adding traditional electronics can make Printoo even more imitable, yet more interesting to some markets.

The second dimension is complementary assets – all the activities that are connected to the core innovation such as brand, strategic alliances, manufacturing capability and distribution channels.

Ynvisible is not strong in manufacturing nor in the distribution channels, as it only manufactures its displays and it is still negotiating distribution channels for Printoo. According to interviews made, the company is apparently focusing on brand as well as strategic alliances, although it is not clear that these alliances cannot be surpassed by other players, which makes complementary assets apparently freely available given the present resources of the company.

Overall, it seems that Ynvisible can potentially hold profits on its displays – “Innovator Profits” quadrant – and have difficulty in having profit on the rest of Printoo – “Difficult to make Profits” quadrant – nevertheless Printoo may contribute to promote all industry technologies, hence giving a share of that higher profit while it continues to be a relevant product. In order to make complementary assets tightly held, the question whether branding is the key remains.

Fundamentally, choosing the right set of technologies and the more appropriate markets is critical, otherwise the company may struggle to turn Printoo profitable.

Value	rapid prototyping	\$2.52 bn
	open-source hw	\$1 bn
	education	\$24.41 bn

Figure 3 – Industry Attractiveness: value measure of each industry, given its market value (source: Freire, 1997)

Growth	rapid prototyping	18.8%
	open-source hw	347.2%
	education	8.0%

Figure 4 – Industry Attractiveness: growth measure of each industry, based on its CAGR (source: Freire, 1997)

As referred before, the Rapid Prototyping market grows from \$1.5 billion in 2012 to \$5 billion by 2020. This represents an 18.8% CAGR, and an estimated value of \$2.52 billion in 2015. The Open Source Hardware market grows from \$50 million in 2013 to \$1 billion in 2015. This represents a 347.2% CARG. The Education market encompasses the Technology segment – \$18.3 billion in 2012 – and the Robotics segment – \$1.26 billion in 2014. Education Technology spending is expected to have a CAGR of 8%, meaning that the Education sector in 2015 totals \$24.41 billion.⁶⁸

Porter’s Five Forces model (Porter, 2006) was used as to identify the level of competition within the three markets, to further estimate possible margin. The values refer to my own assessment of the variables based on the interviews undertaken in the thesis.

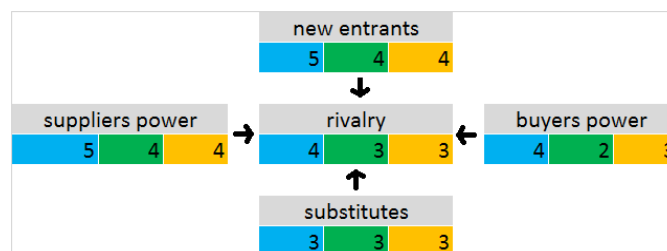


Figure 5 – Five Forces model: analysis of the level of competition within an industry, given its levels of suppliers’ power and buyers’ power and existence of new entrants, substitutes and rivalry (source: Porter, 2006)

⁶⁸ CAGR is the compound annual growth rate. Based on Marketwatch - <http://www.marketwatch.com/story/education-technology-spend-reaches-13-billion-2014-06-11>.

Margin	rapid prototyping	4.2
	open-source hw	3.2
	education	3.4

Figure 6 – Industry Attractiveness: margin measure of each industry, as an average of the levels of each of Porter's Five Forces model (source: Freire, 1997)

According to interviews made, margin in Rapid Prototyping is mainly affected by the high power of component suppliers, as in this market there are mainly R&D departments of large companies that can go directly to such suppliers. Such large companies also have more buying power, than buyers on Education, and even more than smaller maker buyers. It is generally easy for competitors to enter, mainly in the Prototyping market, where any component manufacturer can do the same as Ynvisible with Printoo. There is also high rivalry in this market, as stated by Manuel Câmara in interview.

Risk	rapid prototyping	4
	open-source hw	5
	education	2

Figure 7 – Industry Attractiveness: risk measure of each industry (source: Freire, 1997)

In the opinion of the interviewees, open-source has more risk than Rapid Prototyping as it is more uncertain because it is a new, upcoming market composed by communities that may switch trends. Education is a more stable and predictable in terms of product needs, as Manuel Câmara assessed.

ATTRACTIVENESS	rapid prototyping	\$3.143 bn	Average
	open-source hw	\$2.862 bn	Average
	education	\$44.817 bn	High

Figure 8 – Industry Attractiveness: estimation of market attractiveness, given its value, margin, growth and risk (source: Freire, 1997)

Overall – combining the four variables – the Education market is potentially the more attractive, while the remaining two markets are quite similar. This is in line with Manuel Câmara's opinion that considers that the best option is to address very aggressively the Education sector, doing contracts with schools and developing specific kits. In his opinion, the Prototyping sector can be kept addressed by both companies – if Printoo becomes a spin-off – because if Ynvisible focuses on displays, it can still have interest in using Printoo as a prototyping kit for its customers to have a first contact with the displays. It can be a Marketing tool for Ynvisible. For Printoo, this can be a form of selling more sporadically but probably often in high volume. Thus, Printoo would address all three markets, while Ynvisible would also address the Prototyping market.⁶⁹

⁶⁹ Based on interviews with Inês Henriques, with Manuel Câmara and with Jani-Mikael Kuusisto. Based on an article from Wired with Inês Henriques - <http://www.wired.com/2014/05/using-paper-thin-electronics-to-create-physical-web-browsers/>, and on article from IQ Intel with Inês Henriques - <http://iq.intel.com/how-maker-friendly-tools-are-embedding-internet-connectivity-into-everyday-objects/>.

Finally, it is necessary to combine strength in profiting from innovation and the attractiveness of markets in order to make conclusions on future strategies. Competitive strength is based on result of previously used Teece model.

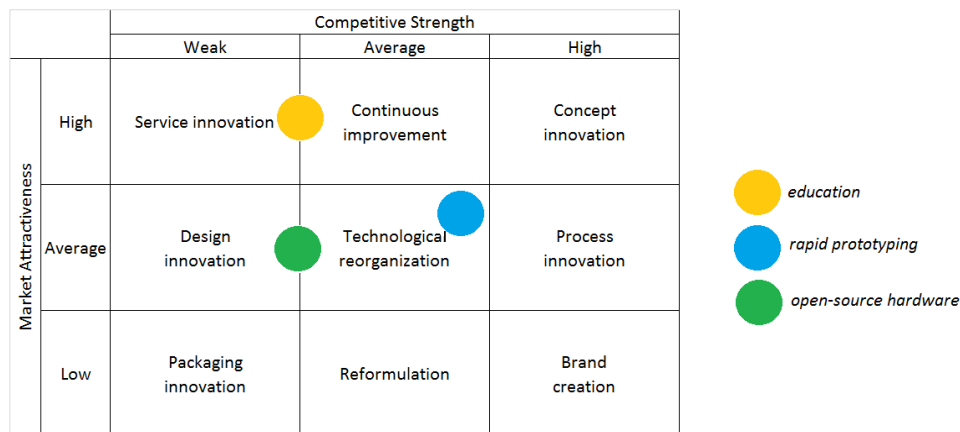


Figure 9 – Choice of Innovation: from a strategic perspective, companies should focus on innovation choices given the previously calculated market attractiveness and competitive strength (source: Freire, 2014)

In my opinion, given that Ynvisible will address the Education market only with Printoo – and its weak-to-average strength – the company should focus strategic innovation on continuous improvement for this market, as it actually intends to do. Ynvisible wants to launch new kits that allow new experiences for students. They also are actually doing service innovation, with their summer camps and workshops. For the Open-Source Hardware and its maker community, also with Printoo, the company should focus on design innovation and technological reorganization. For the Prototyping market, both Printoo and Ynvisible’s research projects are considered, hence a stronger position. In my opinion, the company seems to intend to invest in brand creation for these markets, what can probably not be the best alternative, as they should focus on reorganizing the technological base of Printoo.

These markets can be seen as ends or means. Inês Henriques stated that “*We believe that by getting these technologies out into the hands of a wider community of makers, there are huge opportunities for developing completely new types of products and services based on Printed Electronics*”. In my opinion, Ynvisible and Printoo can also try to claim such opportunities. For instance, the addition of software tools for design in Printed Electronics, as they are largely missing. Such software would help designers to simulate the usage of different components and to adjust the variables of those components. Moreover, it is expected that global IoT business will be larger in terms of software and services than in hardware along the following years.

In the opinion of Jani-Mikael Kuusisto, Senior Scientist at VTT – component supplier and future client of Printoo – Printoo will be a success. Kuusisto believes that it will also promote the success of Printed Electronics components’ suppliers and Printoo’s partners – such as VTT itself – and so stated: “*Going forward, we do hope to see that Printoo is a success because it will help us commercialize Printed*

*Electronics.*⁷⁰ In my opinion, that may be Printoo's main contribution, and Ynvisible can benefit from it on three forms: making profits from reselling components on Printoo kits; commercializing more Ynvisible displays; having more projects due to higher interest from clients on Printed Electronics.

7. Conclusions

Ynvisible needs to achieve sustainability, and for that the company is trying to have a product that can be produced and commercialized in high-volume, to achieve a stable cash inflow. The case illustrates how, in my opinion, the company should first focus on the Education market, which evidence shows is more valuable, more predictable and with less entry barriers for a product like Printoo. Inês Henriques and Manuel Câmara also validated this option and stated that Ynvisible intends to keep exploring the Education market with Printoo kits that combine traditional Electronics and Printed Electronics. In addition to this, the approach seems to be very adequate because it can create awareness for Printed Electronics technologies and applications, while being useful for the market for a broader purpose.

The focus on Prototyping is also important, but it seems to be secondary on the current situation. Higher competition and newness and uncertainty of its communities – namely the Makers – make it a higher risk approach, and Ynvisible apparently needs to show to potential investors it can scale up on the short-term, and not merely to deliver a fun recreational product.

As time will pass and Printoo and its brand may get more established, it should also continuously add new kits and components and improve them. Moreover, the company should enforce its strategic partnerships with component manufacturers and technology developers, in order to create entry barriers to similar products. These two aspects may be the key factors to actually be used in product design and rapid prototyping on the long-term.

If that is achieved, then it can be used by such product developers in applications that are related to the Internet of Things – and this is apparently the trigger for achieving a higher potential that currently no market seems to give

Finally, it would be interesting to study in the future several aspects. One of them is how Printoo performs in the markets, namely in the Education sector. As this market apparently demands different Printoo kits and additional services – as the interviewees considered – it would be interesting to evaluate if Ynvisible has the capability to adequately address both the Education and the Prototyping markets simultaneously. It would also be interesting to assess the impact of a probable division between Ynvisible and Printoo – if the latter becomes a spin-off company. As for the Internet of Things, I believe it will remain to be a fascinating topic to explore for years to come.

⁷⁰ Based on interviews with Inês Henriques, with Manuel Câmara and with Jani-Mikael Kuusisto. Based on an article from Wired with Inês Henriques - <http://www.wired.com/2014/05/using-paper-thin-electronics-to-create-physical-web-browsers/>, and on article from IQ Intel with Inês Henriques - <http://iq.intel.com/how-maker-friendly-tools-are-embedding-internet-connectivity-into-everyday-objects/>.

Appendices
Exhibits

Exhibit 1 Logos of Printoo, Ynvisible and YDreams



Exhibit 2 List of modular components existent in Printoo kits



What comes with Printoo?

Here you will find all the Printoo modules.

Please check out all the specifications in our website: www.ynvisible.com/printoo



01 CORE MODULE
Category: Board
ATmega328 microcontroller



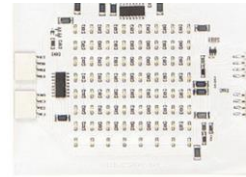
02 YNVISIBLE DISPLAY DRIVER
Category: Board
Drives up to 8 segments at once.



03 PRINTED BATTERY CONNECTOR
Category: Board
Pads to hold two 1.5V printed batteries.



04 COIN BATTERY HOLDER
Category: Board
Holds CR2016/CR2032 batteries.



09 LED MATRIX (8X8)
Category: Board
64 red LEDs.



10 CONDUCTIVE INK ADAPTER
Category: Board
Pads for conductive ink.



05 SENSOR MODULE
Category: Board
• Accelerometer – 3-axis analog output
• Light Sensor (Phototransistor)
• Temperature sensor (NTC)



06 DC MOTORS DRIVERS
Category: Board
Drives two DC motors.



07 SOLAR CELL CONNECTOR
Category: Board
Connects to the solar cell and rechargeable battery.



08 CAPACITIVE SENSING KEYS
Category: Board
Holds five touch buttons.



11 BLUETOOTH 4.0 MODULE
Category: Board
HM-10 BLE module.



12 YNVISIBLE ELECTROCHROMIC DISPLAY
Category: Component
Electrochromic segmented displays. Driving voltage: 1.5V.



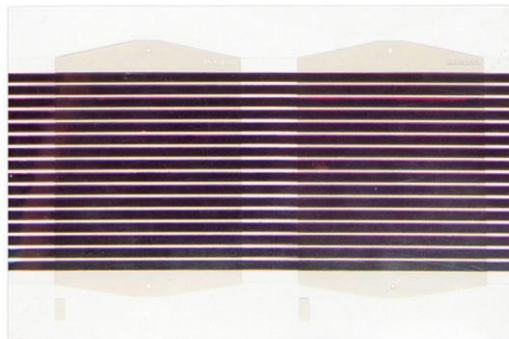
13 BLUE SPARK ULTRA-THIN BATTERY
Category: Component
• Voltage: 1.5 V
• Capacity: 20 mAh
• Thickness: 500 µm



14 ENFUCELL SOFT BATTERY
Category: Component
• Voltage: 1.5 V
• Capacity: 90 mAh
• Thickness: 700 µm



15 ISORG SLIDER
Category: Component
Six Organic Photodetectors.



16 MEKOPRINT POLYMER SOLAR CELL
Category: Component
Power: 60mW nominal at full sun.
Thin, flexible and can be cut in half!



Category: COMPONENT
YNVISIBLE DISPLAY



17 VTT LED STRIP
Category: Component
Red LED die chips on transparent PET:
• 350 microns thick
• Flexible

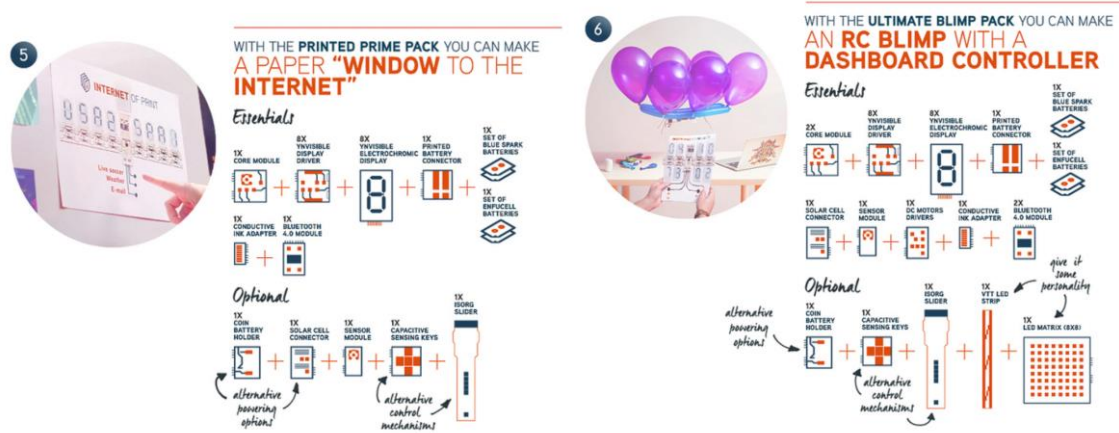


Exhibit 4 Ynvisible's team



Exhibit 5 YD YNVISIBLE, S.A.'s Income Statements, Balance Sheets and Cash Flow Statements of 2012, 2011 and 2010 (in €)

INCOME STATEMENT BY NATURE			
INCOME AND EXPENSES	2012	2011	2010
Sales and services rendered	68.035,06	9.664,43	
Operating subsidies	145.411,83	109.452,27	25.143,89
Gains / losses charged to subsidiaries and joint ventures			
Variation in production inventories			
Work for the entity itself			
Cost of sales			
Suppliers and external services	419.893,00	376.277,89	191.521,68
Staff costs	542.494,81	494.892,89	64.571,20
Impairment of inventories (losses/reversals)			
Impairment of receivables (losses/reversals)			
Provisions			
Impairment of non-depreciable/amortizable investments (losses/reversals)			

Other Impairment (losses/reversals)			
Increases/Decreases in the fair value			
Other incomes and profits	15.415,24	774,60	919,02
Other expenses and losses	38.222,49	13.476,67	843,95
Profit before depreciation, financing costs and taxes	-771.748,17	-764.756,15	-230.873,92
Expenses/reversals of depreciation and amortization	10.116,12	3.480,15	8,20
Impairment of depreciable/amortizable investments (losses/reversals)			
Operating profit	-781.864,29	-768.236,30	-230.882,12
Interest and similar income received		6.255,71	
Interest and similar expenses paid	2.952,13		
Profit before tax	-784.816,42	-761.980,59	-230.882,12
Income tax for the period	-182.824,29	-186.986,32	-58.793,05
Net profit	-601.992,13	-574.994,27	-172.089,07

BALANCE SHEET			
ASSETS	2012	2011	2010
Non-current assets			
Tangible fixed assets	36.947,36	39.721,52	237,80
Investment properties			
Goodwill			
Intangible assets	1.171,31	2.108,27	
Biological assets			
Financial investments - equity method			
Financial investments - other methods			
Shareholders/partners		435.020,32	
Other financial assets			
Deferred tax assets	384.740,05	251.624,85	58.832,40
SUM	422.858,72	728.474,96	59.070,20
Current assets			
Inventories			
Biological assets			
Clients		10.879,95	
Advances to suppliers	4.928,89	3.492,95	11.550,00
State and other public entities	77.961,15	86.135,01	25.849,46
Shareholders/partners			
Other accounts receivables	290.066,70	62.712,21	29.525,65
Deferrals	3.885,34	6.328,08	8.000,00
Financial assets held for trading			
Other financial assets			
Non-current assets held for sale			
Other current assets			
Cash and bank deposits	84.911,03	4.521,64	418.336,08
SUM	461.753,11	174.069,84	493.261,19
TOTAL ASSETS	884.611,83	902.544,80	552.331,39
EQUITY AND LIABILITIES			

EQUITY			
Paid-up capital	1.087.545,00	1.087.545,00	300.000,00
Own shares			
Other equity instruments			
Share premium	344.555,00	344.555,00	256.650,00
Legal reserves			
Other reserves			
Transited results	-805.915,54	-172.089,07	0,00
Adjustments on financial assets			
Revaluation surplus			
Other equity variations			80.000,00
SUM	626.184,46	1.260.010,93	636.650,00
Net profit	-601.992,13	-574.994,27	-172.089,07
Interim dividends			
TOTAL EQUITY	24.192,33	685.016,66	464.560,93
LIABILITIES			
Non-current liabilities			
Provisions			
Financing obtained			
Liabilities for post-employment benefits			
Deferred tax liabilities			
Other accounts payable			
SUM	0,00	0,00	0,00
Current liabilities			
Suppliers	90.561,93	47.242,77	34.685,28
Advances from customers			
State and other public entities	80.546,30	37.029,26	8.203,19
Shareholders/partners			
Financing obtained	33.427,10		
Other accounts payable	655.884,17	133.256,11	44.881,99
Deferrals			
Financial liabilities held for trade			
Other financial liabilities			
Financial liabilities held for sale			
Other current liabilities			
SUM	860.419,50	217.528,14	87.770,46
TOTAL LIABILITIES	860.419,50	217.528,14	87.770,46
TOTAL EQUITY AND LIABILITIES	884.611,83	902.544,80	552.331,39

CASH-FLOW STATEMENT			
ACCOUNTS	2012	2011	2010
CASH FLOWS FROM OPERATING ACTIVITIES			
Accounts receivable from customers	86.169,28	145,50	
Accounts payable to suppliers	472.125,43	470.672,79	184.283,03
Accounts payable to employees	518.142,76	249.723,33	26.269,37
Cash generated from operations	-904.098,91	-720.250,62	-210.552,40

Payment/receipt of income tax	-5.521,10	-1.167,26	
Other receivables/payables	561.271,51	-151.131,94	-7.761,54
CASH FLOWS FROM OPERATING ACTIVITIES (A)	-348.348,50	-872.549,82	-218.313,94
CASH FLOW FROM INVESTING ACTIVITIES			
Payments for:			
Tangible fixed assets			
Intangible assets			
Financial investments			
Other assets		425.143,30	
Receipts from:			
Tangible fixed assets			
Intangible assets			
Financial investments			
Other assets	435.020,32		
Investment subsidies			
Interest and similar income		6.236,20	
Dividends			
CASH FLOW FROM INVESTING ACTIVITIES (B)	435.020,32	-418.907,10	0,00
CASH FLOW FROM FINANCING ACTIVITIES			
Receipts from:			
Financing obtained	176.000,00		
Paid-up capital and other equity instruments		795.450,00	556.650,00
Coverage of losses			
Grants			
Other financing operations		82.196,60	80.000,00
Payments for:			
Financing obtained	176.000,00		
Interest and similar expenses	6.282,43	4,12	
Dividends			
Capital reductions and other equity instruments			
Other financing operations			
CASH FLOW FROM FINANCING ACTIVITIES (C)	-6.282,43	877.642,48	636.650,00
Change in cash and cash equivalents (A+B+C)	80.389,39	-413.814,44	418.336,06
Effect of exchange differences			
Cash and cash equivalents at beginning of period	4.521,64	418.336,08	
Cash and cash equivalents at end of period	84.911,03	4.521,64	418.336,08

Exhibit 6 YDREAMS - INFORMÁTICA, S.A.'s Income Statements, Balance Sheets and Cash Flow Statements of 2012, 2011 and 2010 (in €)

INCOME STATEMENT BY NATURE			
INCOME AND EXPENSES	2012	2011	2010
Sales and services rendered	3.099.017,62	3.489.005,53	2.591.191,66
Operating subsidies	174.614,25	221.552,25	547.538,14
Gains / losses charged to subsidiaries and joint ventures	-604.017,52	293.385,03	343.191,12
Variation in production inventories			

Work for the entity itself	25.125,49	314.985,63	285.700,25
Cost of sales			
Suppliers and external services	1.399.897,59	1.547.189,28	1.582.946,99
Staff costs	2.322.769,16	3.739.591,19	4.232.098,46
Impairment of inventories (losses/reversals)			
Impairment of receivables (losses/reversals)	1.259,40	-7.834,84	111.447,33
Provisions			
Impairment of non-depreciable/amortizable investments (losses/reversals)			
Other Impairment (losses/reversals)			
Increases/Decreases in the fair value			
Other incomes and profits	294.689,14	139.910,21	256.643,29
Other expenses and losses	521.207,96	206.519,41	106.978,42
Profit before depreciation, financing costs and taxes	-1.255.705,13	-1.026.626,39	-2.009.206,74
Expenses/reversals of depreciation and amortization	460.598,62	617.983,57	631.458,52
Impairment of depreciable/amortizable investments (losses/reversals)			
Operating profit	-1.716.303,75	-1.644.609,96	-2.640.665,26
Interest and similar income received	2.753,73	5.668,73	0,00
Interest and similar expenses paid	568.294,59	516.964,82	390.166,69
Net profit before interest and tax	-2.281.844,61	-2.155.906,05	-3.030.831,95
Income tax for the period	-261.322,95	-533.952,39	-913.428,37
Net profit	-2.020.521,66	-1.621.953,66	-2.117.403,58

BALANCE SHEET			
ASSETS	2012	2011	2010
Non-current assets			
Tangible fixed assets	1.676.541,14	2.090.274,84	2.246.650,82
Investment properties			
Goodwill			
Intangible assets	70.723,85	77.953,27	195.863,80
Biological assets			
Financial investments - equity method	145.115,30	607.242,35	438.291,12
Financial investments - other methods	20.000,00	20.000,00	15.000,00
Shareholders/partners			
Other financial assets	361.893,51	200.963,53	687.964,33
Deferred tax assets	3.827.063,68	4.921.156,43	4.488.268,67
SUM	6.101.337,48	7.917.590,42	8.072.038,74
Current assets			
Inventories			
Biological assets			
Clients	1.589.742,54	1.322.455,93	773.092,31
Advances to suppliers			2.075,67
State and other public entities	70.517,00	47.083,32	35.559,21
Shareholders/partners			
Other accounts receivables	843.833,73	1.330.080,49	1.194.119,98


Deferrals		63.104,34	116.367,24	165.216,57
Financial assets held for trading				
Other financial assets				
Non-current assets held for sale				
Other current assets				
Cash and bank deposits		58.475,37	1.933,41	15.871,19
	SUM	2.625.672,98	2.817.920,39	2.185.934,93
TOTAL ASSETS		8.727.010,46	10.735.510,81	10.257.973,67
EQUITY AND LIABILITIES				
EQUITY				
Paid-up capital		1.537.632,72	1.537.632,72	604.717,81
Own shares				
Other equity instruments				
Share premium		10.442.320,12	10.442.320,12	8.272.706,99
Legal reserves		7.095,43	7.095,43	7.095,43
Other reserves				
Transited results		-15.568.852,30	-12.557.644,72	-10.301.456,04
Adjustments on financial assets		-156.619,65	-251.960,62	-251.960,62
Revaluation surplus				
Other equity variations				
	SUM	-3.738.423,68	-822.557,07	-1.668.896,43
Net profit		-2.020.521,66	-1.621.953,66	-2.117.403,58
Interim dividends				
TOTAL EQUITY		-5.758.945,34	-2.444.510,73	-3.786.300,01
LIABILITIES				
Non-current liabilities				
Provisions				
Financing obtained		6.624.393,79	5.590.176,11	8.966.328,12
Liabilities for post-employment benefits				
Deferred tax liabilities				
Other accounts payable		259.086,99	214.143,92	
	SUM	6.883.480,78	5.804.320,03	8.966.328,12
Current liabilities				
Suppliers		697.629,76	587.012,49	709.143,10
Advances from customers				
State and other public entities		902.204,15	559.425,21	309.559,29
Shareholders/partners				
Financing obtained		4.237.212,79	3.378.037,94	1.989.583,73
Other accounts payable		1.656.373,77	2.581.417,89	1.768.877,68
Deferrals		109.054,55	269.807,98	300.781,76
Financial liabilities held for trade				
Other financial liabilities				
Financial liabilities held for sale				
Other current liabilities				
	SUM	7.602.475,02	7.375.701,51	5.077.945,56
TOTAL LIABILITIES		14.485.955,80	13.180.021,54	14.044.273,68

TOTAL EQUITY AND LIABILITIES	8.727.010,46	10.735.510,81	10.257.973,67
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CASH-FLOW STATEMENT			
ACCOUNTS	2012	2011	2010
CASH FLOWS FROM OPERATING ACTIVITIES			
Accounts receivable from customers	2.995.499,02	3.144.852,56	3.307.665,10
Accounts payable to suppliers	1.717.012,20	1.887.255,83	1.723.464,84
Accounts payable to employees	2.432.156,88	1.631.533,36	2.651.468,87
Cash generated from operations	-1.153.670,06	-373.936,63	-1.067.268,61
Payment/receipt of income tax	-1.690,60	-18.307,59	-35.549,84
Other receivables/payables	-201.259,87	-356.061,60	-789.026,66
CASH FLOWS FROM OPERATING ACTIVITIES (A)	-1.356.620,53	-748.305,82	-1.891.845,11
CASH FLOW FROM INVESTING ACTIVITIES			
Payments for:			
Tangible fixed assets		21.745,56	116.477,59
Intangible assets		8.215,64	121.636,30
Financial investments	440.107,99	149.833,83	227.400,00
Other assets			
Receipts from:			
Tangible fixed assets			
Intangible assets	203.400,64		
Financial investments		267.853,50	64.259,13
Other assets			
Investment subsidies			
Interest and similar income			
Dividends			
CASH FLOW FROM INVESTING ACTIVITIES (B)	-236.707,35	88.058,47	-401.254,76
CASH FLOW FROM FINANCING ACTIVITIES			
Receipts from:			
Financing obtained	2.559.882,96	1.118.143,30	4.800.000,00
Paid-up capital and other equity instruments			
Coverage of losses			
Grants			
Other financing operations	2.833,05		1.876,93
Payments for:			
Financing obtained	343.437,85	132.900,00	1.945.613,92
Interest and similar expenses	511.155,98	13.630,25	343.935,32
Dividends			
Capital reductions and other equity instruments			
Other financing operations		453.394,91	275.296,24
CASH FLOW FROM FINANCING ACTIVITIES (C)	1.708.122,18	518.218,14	2.237.031,45
Change in cash and cash equivalents (A+B+C)	114.794,30	-142.029,21	-56.068,42
Effect of exchange differences	0,00		
Cash and cash equivalents at beginning of period	-126.158,02	15.871,19	71.939,61
Cash and cash equivalents at end of period	-11.363,72	-126.158,02	15.871,19

Exhibit 7 Printoo Kickstarter campaign webpage and videos

Printoo: Paper-Thin, Flexible Arduino™-Compatible modules!



PRINTOO™
AN ARDUINO™-COMPATIBLE PLATFORM
TO BRING EVERYDAY OBJECTS TO LIFE.

The image shows a central printed circuit board (PCB) with a microcontroller, surrounded by several white, rectangular, paper-thin modules connected to it. The entire assembly is mounted on a light-colored, flexible substrate.

Printoo is an Arduino-based platform of paper-thin, low-power boards and modules that gives makers new levels of creative flexibility

Created by  Ynvisible

560 backers pledged \$80,336 to help bring this project to life.



Exhibit 8 Printoo's reach in news providers and social media in 2014

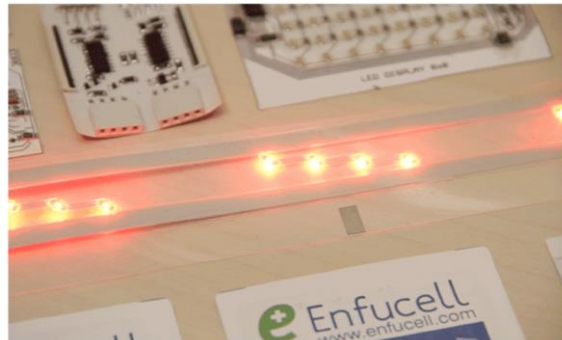


Exhibit 9 Printoo developments timeline and application examples on Kickstarter campaign

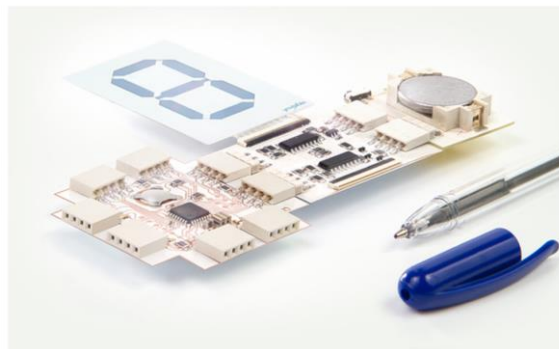
Printoo development timeline



Thin and flexible polymer solar cell. You can cut it into the shape you want!



Ultra-thin LED strip!



Paper-Thin Electrochromic Screen

Exhibit 10 Websites and online shops of Ynvisible and Printoo

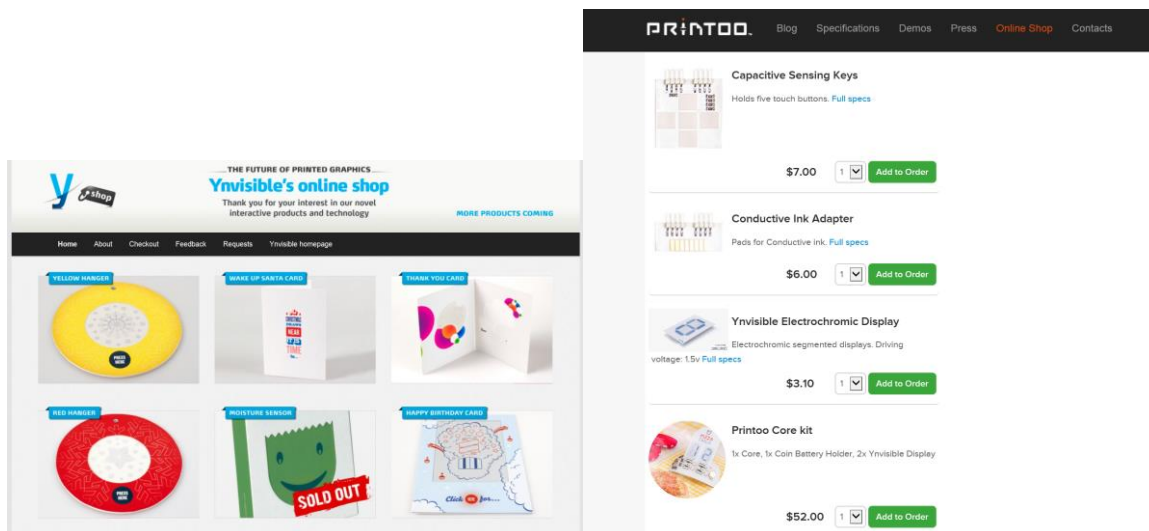


Exhibit 11 Prototyping and Education market sizes

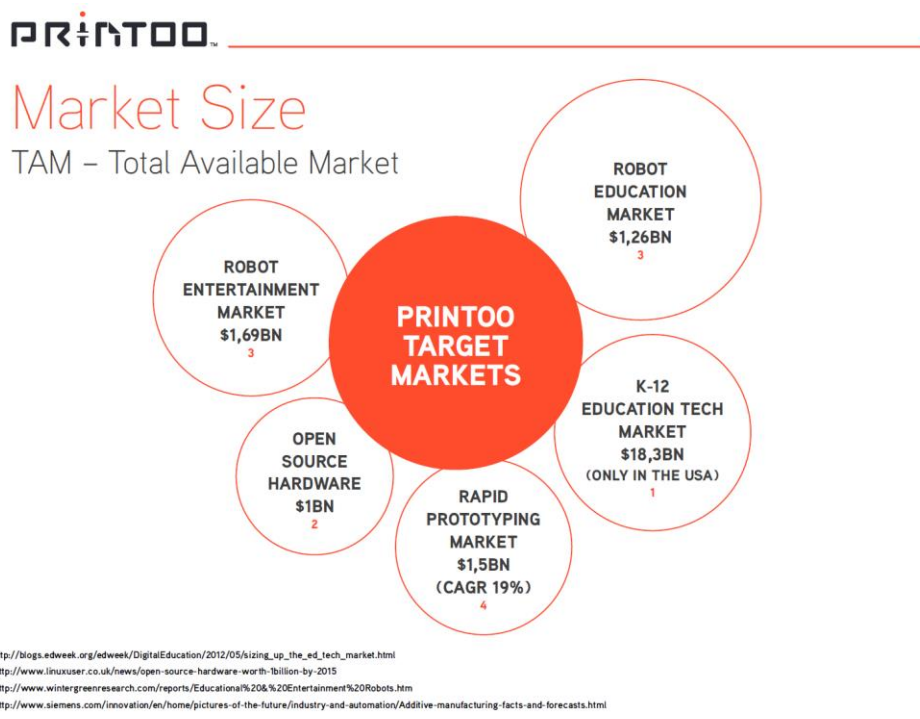
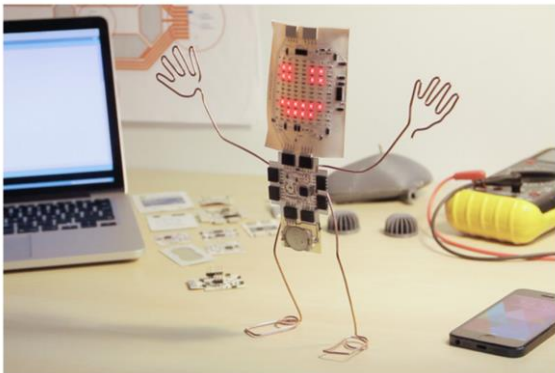
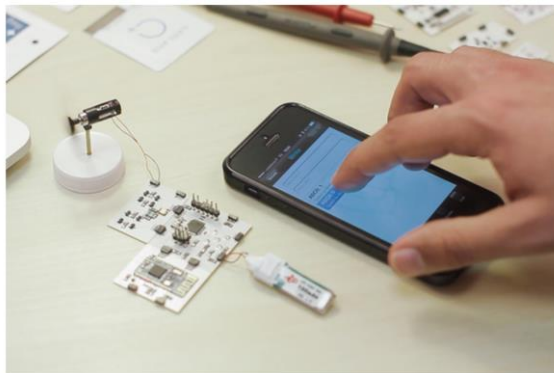


Exhibit 12 Examples of prototypes designed with Printoo kits and components, from Printoo’s website

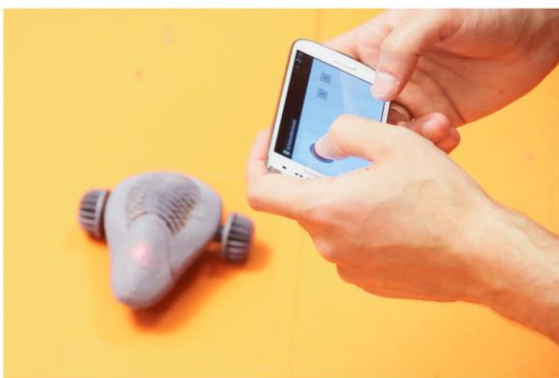
We can't wait to see what you do with Printoo!



Printoo Man!



Build it, power it, motorize it, connect it!



Take your 3D printed objects to the next level!



3D printed watercraft with motors and smartphone controls. (Yep, that's a little Ziphius!)

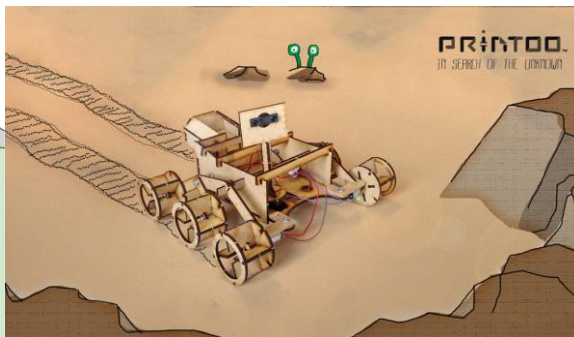
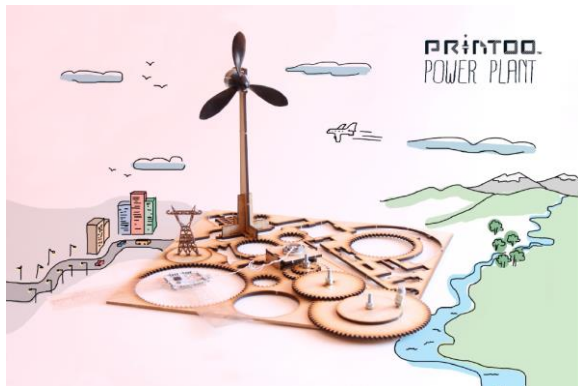


Solar powered 3D printed hovercraft!



The Goal Can will celebrate soccer goals live this Summer!

Exhibit 13 Examples of new Printoo kits, to target mainly the Education sector



History of YDreams

YDreams is a Portuguese company founded in 2000. Its purpose was to redefine the concept of interactivity, with a special focus on the field of Augmented Reality⁷¹. Since its inception, the company combined technology, art and design, conceiving innovative products and full-scale interactive environments – from retail spaces and museums to urban experiences. The company developed projects for global brands such as Adidas, Vodafone, Nokia, TMN, Barclays, Coca-Cola, Santander, BBC, JCDecaux, Ideo and LEGO. YDreams was also referenced in hundreds of articles in renowned news providers, and received several awards⁷². The company CEO is António Câmara – a university Professor, Scientist and Entrepreneur that won several awards, including the prestigious Pessoa Award in 2006.

YDreams carved a successful pathway – one that made it the banner for a new generation of entrepreneurs and technological companies of the country – and yet with greater expectations of the steps ahead. Such expectations can be exemplified as a statement made by António Câmara in 2012, predicting that YDreams was aiming to deliver a product capable of replacing the Apple iPhone.⁷³

Despite the success of YDreams, in 2011 – and after financial performance problems since 2006 – rumors of more severe financial problems affecting the payment of salaries started spreading. After years of struggling, in early 2015 the company made a special revitalization request to the Portuguese State in order to evade insolvency. Innovation was accomplished, but other business aspects might have been overlooked, as CEO António Câmara admitted: *“I didn’t have the sufficient management knowledge to convert the technological superiority in market results”*. The company also considered that the failure of reaching expectations was also induced by the financial crisis that stroke Portugal.⁷⁴

In January 2010, YDreams created its first spin-out company, Ynvisible – a company that would focus on the development of technologies in Printed Electronics. Besides Ynvisible, other spin-outs were created: YVision, YDreams Robotics, Audience Entertainment and Azorean⁷⁵.

⁷¹ YDreams’s purpose can be seen at <http://www.ynvisible.com/>. Augmented Reality is a technology that allows to give to a user the composite view of both the user’s view of the real world plus a placement of computer-generated images.

⁷² YDreams’ list of clients can be seen at <http://company.ydreams.com/#/en/projects/>.

⁷³ Based on an article from Exame Informática about YDreams situation - <http://exameinformatica.sapo.pt/noticias/mercados/2015-03-12-Ydreams-Dividas-de-18-milhoes-e-nomeacao-de-administrador-judicial>.

⁷⁴ Based on an article from Rádio Renascença about YDreams situation and interview with António Câmara - http://rr.sapo.pt/informacao_detalhe.aspx?did=182107.

⁷⁵ Azorean, was founded in 2011 with the aim to become a world leading company in marine robotics by providing a new generation of tools for ocean exploration.

Interviews

Interview with Luís Dias, Manager at Science4you, July 16th 2015:

[José Duarte] What do you seek for in educational products? How do you design and develop them, and integrate the scientific knowledge for children?

[Luís Dias] We have a team of developers, with people of several sectors – from Physics, to Chemistry and to Biology – that research for the topics. All our products are aligned with the educational programs of the schools of our national educational system, and so when we develop a toy for eight-to-ten year's old children, we know that those children are learning those exact topics at school. Thus, our objective is to focus our help – focus to give our “plus” in the end of the day – in making children learn. But always topics that they are getting familiar with at school, because that way they can get more interested.

With our products, they can make experiences and practice, which often they don't have the conditions to at school. And we develop these experiences along with the schools – and some are our partners.

But children can also try the experiences by themselves at home. And that's when they really understand how they work – because one thing is seeing something in a book, and another thing is seeing how it functions in a scale model.

[JD] Do you have any products that use and allow programming?

[ND] We have mobile4you. It's a smartphone with several apps that we developed. On this case, parents can pre-program it, to establish the way children can use the smartphone.

[JD] Do you already have any products that use Printed Electronics components?

[ND] Not yet. But maybe in the future.

[JD] I suspect it's still a new type of technology and knowledge also for adults, not only for children. And it gets complicated to explain how the technology works, moreover because there aren't many applications of that technology yet.

[ND] Whenever there is a technological shock, one never knows what exactly will be done with the technology. Also, when there are new applications of a given technology, we adults often have difficulties to adapt to them. For children that is much easier, and so, who knows?

Nevertheless, adapting that specific technology to a toy for children doesn't seem easy for me. We can certainly have applications for it, but I'm not seeing a kid being able to have the knowledge for it, as I only see them as users.

[JD] What role have other technologies – others that you also use in your products and that are also complex – in the diffusion of technology? Your main target is children, but do you affect a larger ecosystem? I mean, do your products help promote the adoption of new technologies?

[ND] The effect that we think we have is the dissemination of technologies that are already being commercialized. As for knowledge, we also help to disseminate it, but more basic knowledge, appropriated for children.

We have some more technological products in the Portuguese market, such as smartphones and tablets.

[JD] Can you assess the impact of such dissemination of technological products?

[ND] It's not easy to assess such impact. We can only assess if our products were well accepted by the market, as were tablets. But a potentially broader area of influence is difficult for us to assess.

[JD] Do you have any products that allow to establish communication among them?

[ND] Not yet, but we intend to have simple drones in the future.

We need to have this balance... this sort of toys starts to have a higher price, and are not considered as toys then. Thus, the market niche gets smaller, and we would only get to a few hundreds of children in this country. A parent probably wouldn't spend what a drone currently costs... maybe for himself or herself. But in the future, the several droned being made by companies will get cheaper, and then it will make sense.

But all related publishing that are trying to preview that the future is that. That is, that more and more toys with interaction – being it among toys or with smartphones and other devices – will appear.

[JD] You have one project that seeks to promote Entrepreneurship in children – for them to create their own toys. What are the results of that project? Would drones – in the sense of giving “life” to different objects – be a good example of what they would like to create?

[ND] Our objective is not to make things that already exist but with different objects or materials. The ideas that normally come from children are ideas for new board games.

[JD] What advice would you give to a company such as Ynvisible? One that made an innovative, disruptive product, still “strange” to the market, and that might address the education sector?

[ND] The first step is to understand what problems and needs that product addresses to. And to work on the product – to evolve and adapt it – to answer with different solutions, for problems and sectors not yet addressed.

[JD] How valuable are your partnerships? Namely Universities. When you started, how did you position in your ecosystem, and what type of partnerships did you seek?

[ND] Our first partnership was with the Faculty of Sciences of the University of Lisbon (Faculdade de Ciências da Universidade de Lisboa). Being scientific toys, we had to be associated to a recognized institution, one that could positive judgements relatively to the products we would put on the market.

After that, we also tried to associate ourselves with other brands and institutions that also have that component and recognition. For instance, in England we partner with the Oxford University, and in Spain with the Autonomous University of Madrid (Universidad Autónoma de Madrid). We also partner with Discovery – that is very recognizable and is a company of that created content related to science.

The value of these partnerships is intangible, and maybe we will never quite assess how high that value is. We never tried to market our products without the Faculty of Sciences' "stamp", for instance. But we certainly know that this partnerships' value is big – if Oxford put their "stamp" on our products, it surely is because they believe they have something different and interesting.

Interview with Jani-Mikael Kuusisto, Senior Scientist at VTT, July 27th 2015:

[Jani-Mikael Kuusisto] The father of the idea (behind Printoo) was Manuel (Manuel Câmara from Ynvisible). It's an initiative that we gave to him to take forward and that resolved in a successful Kickstarter campaign. At least from the money raising perspective. They have not yet delivered the actual units to their backers.

I was there at Ynvisible during those months when we were planning and carrying the Kickstarter campaign, and I came back to Finland last year around this time, so I've been away from Portugal roughly one year.

[JMK] About your questions: I have to say that VTT is not pure play costumer. So, first of all, to describe who VTT is. We are a research institute. I believe we are the second or third biggest research institute in Europe. We are a public entity – we are a company but we are fully owned by the government of Finland.

We had some layoffs in the past couple of years... I was in VTT before I joined Ynvisible and now I've returned to VTT. We are about 2500 people.

We have had developments in Printed Electronics since the late 1990s. We are not organized around Printed Electronics alone, we have one business unit that has 85 people working full-time in Printed Electronics. But for instance, the part of the organization I'm in is Digital Systems and Services, and while we work a lot with these technologies, it doesn't say Printed Electronics anywhere in our business division. So I'd say that in terms of our organization, there are multiple different units that could be involved with Printoo.

But I am jumping ahead, so let me just briefly explain VTT's background. We were established, I believe, around the 1940s. And the brief history is that VTT was established to help the Finnish industry, in developing new products. We had lost a war, in the WW2 we fought the Soviet Union twice and the Germans once, and as we lost a war to the Soviet Union, we had to pay back in industrial goods. We were a very agriculture-oriented country, back then, so to help our companies grow and develop new products, VTT was established by the Finnish government to provide R&D help and services to Finnish companies. And essentially that's still a big part of what we do, as we work with Finnish companies helping them adopt technologies from research into business.

However we are a much more international institute now, as we have a lot of partners and clients outside of Finland, but I'd say that Finland is still where our main business is.

This Printed Electronics, like I said, started in the 1990s. The two main industries in Finland in the 1990s were Electronics and the Forest industry. And both of those industries are going through huge structural changes. And, as a result, the economy in Finland has suffered because Electronics jobs have moved to Asia, and paper consumption has declined. So, why we started in Printed Electronics development in the late 1990s was in one part to use conventional printing and paper making processes to produce more intelligent objects and on the other side was to find a way in which we

could be a cost-effective manufacturer of electronics, in a world where we are very expensive labor. So that's why we started dealing with these very high-volume Printed Electronics technologies.

I think that what was important in our connection to Printoo was that we are specialized in a lot of these technologies on a component level, and maybe on system level. But as a research institute, we're not very good at developing products. It's our customers who come with product ideas. And Ynvisible on the other side is very skilled in product development, helping companies – big consumer companies, for example – to take advantage of this emerging technologies. So, from our perspective, and now I'm speaking on behalf of VTT, what Ynvisible is doing, and what Printoo is, is very interesting to us because it provides the product developers and the product designers a tool, with which to start using Printed Electronics. So we know how to develop the components and the systems and scale them to production, but we need these people that know how to design actual products based on these components.

So when Manuel Câmara had the idea and Ynvisible was seeking partners for this Kickstarter campaign, and at that time I was at Ynvisible, VTT was one of the first parties that we contacted to join in, because we knew that VTT was needing something like this. So VTT was a partner on the Kickstarter campaign, we had a few people on organization backing this project, and going forward we do hope to see that Printoo is a success because it will help us commercialize Printed Electronics.

[José Duarte] What are the needs that you think that your customers have, that get satisfied with Printoo?

[JMK] I'd say that, and this does not apply to all companies, but most companies, most product designers, have no understanding of Printed Flexible Electronics. They may have experience with more conventional electronic components, but with these printed items less so. And if you have experience with conventional electronics, these Printed Electronics can actually be quite disappointing. If we take a new flexible component, and a conventional component, and expect it to perform in a similar fashion, today the technology in flexible and Printed Electronics is at a state that can be disappointing, for someone that expects it to deliver in the same type of performance.

Therefore, for these people that are more familiar with working with electronics, we need to provide them with a more complete set of components, not just individual ones. Because if you just give them the individual, they will compare it one on one with the older existing one, but if you actually provide a broader set of technologies and components and they can combine those and build new devices and products, then it becomes more interesting for them. They are no longer comparing pears to apples, as they are on an individual component level.

Meanwhile, we have this hacker movement, we have more and more people that are starting to explore electronics and do-it-yourself pretty much everything, who might not be so familiar with conventional electronics. I think that they are a very exciting community for us, because they are more open to radically think what we can do with electronics when it's shaped in a new form. It's a bigger field, it's a wide range of different things. And for them, they certainly need more than just the

components. So, if they were to contact VTT today, and they were interested in some of the components, say solar cells or printed LED strips, sure we can provide them with those, but there's not too much they can do with just those components, so they need something, a kind of "glue", a smart way of bringing these pieces together. And that's where something like Printoo is certainly needed.

[JD] Do you see VTT selling directly to those enthusiasts and makers?

[JMK] No, actually I don't see VTT, as VTT, actively selling or reselling Printoo. So, we are a government-owned research institute. Our job is to sell research projects, and when we develop intellectual property, our job is to license that. However, Printoo is an important tool for us to communicate these technologies and these possibilities, so I see ourselves more as a customer buying some units of Printoo, showing those to our clients, to show how it can be used, so actually is more helping to promote.

At the same time, however, VTT is involved in different organizations and groups networks, where one is called PrintoCent, and PrintoCent has a lot of members within it, we have a budget for PrintoCent, and we have partner organizations in PrintoCent who can buy Printoo and resell Printoo, under the PrintoCent name. So we VTT are a driving force for the PrintoCent network and I think that within this PrintoCent network, we may want to buy and then resell these units. But that money would not come into VTT's bank account, but to some other entity.

[JD] If you want mainly to promote this type of product so that people ultimately buy more of your components, in which industries do you preview or already know that you can it promote more?

[JMK] I would say a very wide range. Currently we have on an annual level 100 to 125 person-years of research in Printed Electronics and we serve a broad range of customers. So the industries that we're dealing with, the spectrum is very wide. It's actually somewhat challenging for me to even highlight focus points because in some regards when you're in a R&D organization, a lot of our customer relationships are built throughout the years. Our Marketing is somewhat reactive, so we don't have a business strategy and say let's take the Medical sector and put our focus and efforts there. Our strategy is more like our customers come, they ask for things, and we help.

So, I wouldn't say that we have one particular industry in mind with Printoo. However, having said all this earlier, there are a lot of interesting developments on the wearables sector, in the healthcare sector, more broadly, and also certainly in consumer packaged goods. Electronics can come to everyday home appliances as well, and the car industry. So I would say that those are five industries that stood out the most.

[JD] What type of applications do you preview for the car industry?

[JMK] The LED strip was originally developed after an Italian car company came into us and asked that the future car should be as light and disposable as possible, and demonstrated that we could replace existing lighting solutions with these thin films with LED lights. And in fact the reason why that

film has red lights is that it was a demonstrator for a car back lights. So that's just one example. There's a lot of companies in that sector that are trying to replace wiring in the car and bringing other elements that can be brought by a film, that are molded in plastic molds into the car. So, in this industry, lighter weight is one driver.

[JD] What about in packaging? It seems really interesting to use it in packaging, but what about the costs? Are there a lot of companies already applying it?

[JMK] I would say that there is more interest than real intent. So, the problem with this, is that when we look at really high-volume package consumer goods is that they are usually produced very inexpensively, and in high-volumes you have the disposability and recyclability issues. But then again, at the same time, I'd like to highlight that it's not in the package necessarily alone, but if you look at electric toothbrushes – this is a consumer package good, that comes in a package, and is electronic – you start to have this kind of added intelligent functionality in products, and Printed Electronics offers a lot of possibilities beyond the electronic toothbrush, and then the question becomes: is that the electronics in the package or the product itself or a combination of these both. So I wouldn't say that there's a huge immediate opportunity, but it's an emerging opportunity, within the next 3 to 5 years. You will start to see new types of consumer products that were based on Printed Electronics.

[JD] Do you know any other competitors? And how did VTT know about Printoo?

[JMK] In this case there was this connection, we belong to the same network. Ynvisible is a member of PrintoCent. And the nice thing in PrintoCent is that the companies share ideas and actively communicate what they are doing. And I think that Manuel may have somehow, when he had this idea, look at things within PrintoCent and seen that there is also an opportunity, a need there.

So, it was through this network and through this connection that Ynvisible was able very early to cast the idea and ask these companies if they were interested in joining the idea. Of course I was in Ynvisible then, and I've been doing this through the years, along fifteen years now, I have a fairly broad network of contacts around the world, so it was also easy to use those contacts to just call around.

But then, if there are competing solutions, I would say that – again as a research institute – we have to know as much as possible about new emerging things. I don't know if my colleagues follow crowdfunding campaigns as they should – as a lot of new things are communicated there – but they certainly go to a lot of industry conferences, scientific conferences, when these things are emerging. So we have within VTT a huge database of technology intelligence and also our experts are often our researchers are known industry experts in their fields. So they tend to know the people and what's happening on those sectors. But of course, in modern times, with the Internet, we will always have surprises. You have clever things pop up.

In terms of competitors and potentially having competition to Printoo, I don't see immediate competition right now. We have not recognized anything that is exactly like Printoo. But I could say

that Printoo is not too difficult to copy. The closest thing to Printoo that has come previously is the OE-a – Organic Electronics Association – prototyping kit. Ynvisible is also a member in OE-a, and knows very well that that organization compiles these different components and gives those kits out to a small number of users every year. It's just that they didn't have "glue" to that, as it's more like buying or receiving a package with all these little pieces, and then being left to your own devices to actually do something with them. So that was the closest thing prior to Printoo.

Of course when at Printoo using Arduino working with Flexible Electronics, there are a lot of players in that field. And the best way that Printoo can retain competitive advantage is to continue to network with companies that have components to offer to Printoo, and the other is to develop a very strong brand name – and everything that is required to have a strong brand name. So, a well-functioning product and create a kind of design standard – if they can create Printoo as a kind of a defacto standard, that everyone wants their components to work with Printoo – then they can reach a strong competitive position.

[JD] How do you envision the progress of Printoo? Do you think it is going to be a "big success"? And what exactly would a "big success" be?

[JMK] I believe it will be a big success. I think I may have a different definition of "big success" than what a venture capitalist might have. So I'm not sure whether Printoo as we now know it now is "VC-packable", but I believe it can be a significant business. I believe it can easily reach volumes of tens if not hundreds of millions of euros revenues annually. In its current form, I don't even see a threat of it exhausting the market, if it continues to supply new components, and new improved versions of that core.

So I do believe that it can be a serious business. The challenge is finding the investors who have "deep enough pockets" and believe that it can happen. Some companies with strategic interest in the electronics field might be interesting owners for Printoo.

[JD] After Printoo – even if it evolves and gets more and updated components – what can happen? What other products can appear due to Printoo?

[JMK] There are some many different directions that Printoo could go in the future. What I would see as an unaddressed market opportunity is that the software tools for design in Printed Electronics are largely missing. So, when we think of a product designer today, they often times have different software's which they use in designing the product. And I think that now with the hardware side, and some software programming of the core itself, is made available, one interesting direction would be to design more advanced software for the designers, and that they can take different components, adjust the variables of those components, combine them with another one. That would be a very interesting add-on to what Printoo is. To make it really a product design tool for these type of electronic components.

[JD] You are referring to a software for the model creation and the simulation of electronic creations?

[JMK] Yes, exactly. And that is a topic where I don't see any players all that active at this point. But this is just one direction to grow in, but I think it's a very natural one, that people want not just the hardware. Because working with hardware, the iteration rounds are so slow, they want to virtualize that, they want the software to do that. But that's a big step.

Let's say you have a Printoo kit, and there is certain type of electrochromic display, and then you get a printed solar cell, and you want to combine those, and you can do it and see how they perform together. But as a product designer, what if you want a different sized electrochromic display, and that maybe performs slightly differently than the one in the kit. What if you still want to use solar power into it, and you want to know how big the solar power should be. So, having the ability to test these variables without calling the component supplier and then the Electrochromics supplier to ask them which components to use. So these are the type of slow iteration rounds that the designer will then run into in the next age. This is still a big opportunity for someone who provides those design services. But I think for this field to really take off, the more the hacker or the product designer can do a design with a software, the better.

[JD] What are the key success factors for Ynvisible, regarding Printoo? I believe you already mentioned at least two: that they have to be in a tight partnership with component makers, to get the new components and use them smartly on new kits, and you also mentioned that the brand has to be really strong – to be the defacto solution. Do you see any other critical factor?

[JMK] It takes money to make money. As simple as it sounds, I think that it is, in our field, largely overlooked. We have in our space a lot of companies with too small resources that are attempting to do something bigger than what they actually can, with those resources. And therefore I think that for Printoo to be a success, it not only has to sell well, but it has to also have that financing to be a step ahead. It's just critical. This is not the software business, where you set up a server in your house and are instantly global. This is going to take somewhat deep pockets.

[JD] Which role do you think that Printoo can have on the adoption of new, complex technologies – all these technologies we have been talking about? Printoo, and also other similar products.

[JMK] Time will tell. I think it can, if it's well run and properly supported, I think it can become something truly unique. By the way it can also be managed completely open-sourced, with the main responsibility is then given to the component suppliers, and anyone who wants to develop open software for this.

So I think it can also become a bit of a movement on itself. I do think that it can have a significant role. It depends on how this all is managed, and Printoo having a relatively clear idea of what model it wants to use to go forward. Does it attempt to do as much as possible by itself? Does it go to the open source? Or something in-between. I think that means to be figures out by Printoo itself, and if successful I think it will be one of the key points for the success of Flexible Electronics.

[JD] How do you see the Internet of Things, and what could be the role of Printoo, and all Printed Electronics, in the coming of the Internet of Things? And, by the way, what could be the role of VTT and other researchers?

[JMK] VTT's role is to develop new technologies, technological know-how, selling services and intellectual property to companies.

In terms of the Internet of Things, it's an all-encompassing word, but I do see that Printed Electronics is one of the technological key enablers for realizing the Internet of Things. I think it's a means to embed electronic type functionality in almost anything. So when we are looking at these truly large area, high-volume modular cells that can be designed so that they can blend into the rest of the product, and you have these sensors that can be embedded into anything around us, I think Printed Electronics is one of the key enablers.

And the role for Printoo in that is to enable to design these new products. I am not sure if Printoo will be embedded into everything, in itself. I think that to go into more industrial production you may want to optimize the system where you don't need as much intelligence as in the Printoo itself. But that's one other direction that Printoo can take, to be a sort of "Intel inside" – to be a key core component done in everything.

Printoo – and countering what I said earlier – also has the ability to demonstrate how more conventional electronics work in combination with Printed Electronics. So called hybrid systems. Printoo can play a role, where product designers could test a very wide range of components, both rigid and flexible. And that's really critical in early stages of rapid prototyping. Many times, to prototype something, you want to do it quick, and with the Internet of Things there are a lot of people with ideas and go and do fancy YouTube videos, but doing that prototype that really works is actually a fairly expensive exercise. So now Printoo enables pretty much anyone to do prototyping at a relatively low cost.

[JD] If you had to decide the strategy of Ynvisible, would one of your first focus be the Education market?

[JMK] I know Ynvisible is interested in the Education market, and I think that for their purpose it fits nicely. Most of what I said are business, industrial things, because we as VTT work in that domain. But stepping out of VTT's domain, I do believe as a parent that the Education market is also significant. Because as a parent, you want your children to have access to the know-how in these new types of tools and technologies. You want them to explore. I don't say that everyone wants this, but anyone that is somehow connected to technology and wants their children to learn will, not necessarily want to own – but will want to see their children to have access to these through school or fablabs or libraries.

Interview with Inês Henriques, CEO at Ynvisible, July 28th 2015:

[José Duarte] How would you define Ynvisible's culture? And how important is that culture of innovation?

[Inês Henriques] Ynvisible was created, not around a technology, but around a vision. Our vision was to expand interaction in everyday's objects. To add information, actions and reactions in products and things that didn't have them, and would be improved if they did.

Ynvisible is a spin-out of YDreams, and as so, the innovative and disruption-seeking culture was already there even before the company was created. As Inês Henriques said, "It was already on their DNA".

[JD] What is the structure of Ynvisible?

[IH] Ynvisible's number of workers has changed along the last three years, between ten and twenty, and at this moment we are twelve. We do not have rigid departments, as we are a very cohesive and flexible team. Our clearest division is between those doing research on our laboratory – developing Printed Electronics technology – and those responsible for the management, design and marketing of our projects and products. We do not have people specifically allocated to Printoo versus to our other projects with clients, but our researchers are less allocated to Printoo – except in the case of the production of the electrochromic display components in Printoo.

[JD] Who are your strategic partners, and how important is that network?

[IH] Our first partner, as we started focusing in developing Printed Electronics technologies, was FCT UNL (Faculty of Science and Technology of the New University of Lisbon) – specially its Chemistry unit. Recently, we also started a partnership with FEUP (Faculty of Engineering of the University of Porto). Besides those, our partners are some of the companies that have the components that we use in Printoo, such as Enfucell, BlueSpark, and VTT. Our most important partner might have been a printing company that was our supplier since our first projects, even before Printoo.

[JD] What was the purpose of the creation of Printoo, and what needs of customers will it satisfy?

[IH] Before Printoo, as we were developing, implementing on projects, and selling our components with our Printed Electronics technologies, we always had a lot of interest and curiosity regarding how did the technology work. By then, we had our online shop, which we created to show some simple applications of our electrochromic displays such as postcards that would change their appearance according to some given interactions. Often, we realized that customers would dismantle our components, to actually see how they worked, and they would contact us very with high interest.

Also, as we assessed the Printed Electronics industry, we didn't see any products that someone could use without nothing else – there were only single, isolated, components. And a lot of profiles of people that could use those components to design the products they wanted, didn't have the sufficient expertise to join such components, or didn't have access to them, or weren't aware of the possibilities

of combination with other components. And it was clear that if we could simplify the technologies by offering a set of components, customers' effort in applying those technologies would be smaller.

[JD] What was the result, feedback and impact of the Kickstarter campaign?

[IH] Before the Kickstarter campaign, and from the feedback of both our projects with companies and our online shop customer, we thought that our target would be composed of two groups.

First, the makers, the enthusiasts, the “geeks”. Those who wanted to create, and didn't quite have access to these technologies, as they were expensive, and the components weren't sold combined, in a manner that was very difficult to someone with this profile to have access to them all.

Second, the people from research and development departments in companies. These people wanted such a set to be able to rapidly prototype and to design products, using Printed and Flexible Electronics.

The Kickstarter gave us two major lessons. The first one is that the number of makers and developers was even bigger than anticipated, and that alone would have made the campaign a success.

And the other one was that the Education sector really got interested in Printoo. We had numerous contacts and feedback from University and High School professors from various countries telling us that they would really like to use Printoo in their classes and projects. They saw a real potential in the product – which it would allow to engage students, to both be interested in learning about these technologies, and to be interested in experimenting and making inventive projects. Some even volunteered to try Printoo on their classrooms right away, in order to help to test its acceptance.

[JD] Which previous projects by Ynvisible led to the creation of Printoo? Are there any you can disclose?

[IH] We had, and still have, many projects in Ynvisible, although most of them cannot be disclosed. We had some prototyping projects that made us aware that giving similar, but simpler, tools to our customers would benefit them in understanding even more what do these technologies allow. So we had several, from the Healthcare sector – with wearables, used by each patient, that allow medical staff to control their treatments – to the Consumer Goods Packaging sector – with physical interfaces built on the packages, that allow customers to say they “like” that product, and also to have real-time information about the product inside.

[JD] Your strategy is to address Printoo to which markets and industries?

[IH] The main market we will address with Printoo is going to be the Education sector. We will address also the researchers in companies and institutes and the makers, but Education is going to be our main target, as the Kickstarter campaign showed us it so should be.

To be able to do that, first of all we will continue the process of producing the units for our Kickstarter backers, and then receive feedback from all those customers and improve the product, and then carry on to address the market.

[JD] How do you intend to with the product offer, and its pricing and communication?

[IH] Printoo has several kits, and their prices are quite different, according to the specific components each one has. Nonetheless, we intend to, as we start getting feedback from customers, create new kits according to their needs, as well as we will continue improving each kit, by replacing components with better and less expensive ones.

[JD] In terms of production, integration and assembly of Printoo, how much is done by Ynvisible and what is outsourced?

[IH] Our Printoo production model is mainly outsourced, exception made to our own technologies, mainly the electrochromic displays. These are produced in our laboratory, by our researchers.

[JD] How will Ynvisible evolve with Printoo?

[IH] When Printoo starts being produced, we will continue evaluating our strategy, but maybe the most probable scenario is for Printoo to become a spin-off company – dedicated only to the product – and Ynvisible to keep focused in developing technologies and doing research projects, in Printed and Flexible Electronics, as it was before the creation of Printoo.

[JD] What are the key success factors for Ynvisible, regarding Printoo?

[IH] The critical factors for Printoo's success are going to be our capacity to understand users' needs and evolve and adapt the product to them, as well as our capacity to efficiently educate people about our technologies and promote what they can allow people to do. Also, we must be capable of showing investors and/or distributors that what we are doing is highly interesting for them.

[JD] Do you think that, with Printoo, you can completely jump away from YDreams and get to a level of success that they didn't reach – to get a high consumption product? Will Printoo be the product they never had?

[IH] I do think that Printoo can take us further than YDreams. If this project gets the results we anticipate and hope, we can have a big leap.

Interview with Manuel Câmara, New Products Manager at Ynvisible, July 30th 2015:

[JD] What is the structure of Ynvisible? How many employees does it have, and how did it change over time?

[MC] We had always between ten and fifteen, maybe with a peak of eighteen. Now we have around ten. It has to do with resources available.

[JD] What strategic partners do you have?

[MC] FCT-UNL was a strategic partner since the beginning. Upon the creation of Ynvisible, even before it was established as company, it also had collaboration with CENIMAT. Meanwhile, it has had some other collaborations with research institutions, such as FEUP or CENTI.

Corporate partners wise, we have had some companies that produce Printed Electronics components that on some projects are complementary to Ynvisible. These include BlueSpark, Enfucell, Mekoprint, Pragmatic and ISORG. Since we hired Jani-Mikael Kuusisto (that is not with us anymore) in 2011, we also started collaborating with Finland's VTT, and associated with PrintoCent. There was also a collaboration with Xenia in 2011, to formulate inks, but with results that were not positive.

[JD] How do the structure and the culture of the company contribute for its success, as an innovative company?

[MC] On the scientific side there is a high number of PhD's (four counting with António Câmara). On the product development side there is a mixture of designers and engineers, and freedom to think about projects. Innovation comes from necessity – as we have a new technology, with no established market, we needed to start imagining new products to integrate it.

[JD] What part of the company, and of its effort, is dedicated to Printoo, comparing to the other projects?

[MC] Today it should be between 80-90% for Printoo.

[JD] How would you describe Printoo, as a product and as a set of technologies that it constitutes?

[MC] Printoo is a prototyping kit that brings along Printed Electronics technologies that were not accessible to the public in general, and that corresponds to a new paradigm of prototyping with electronics. Until now, electronics prototyping was focusing on the technologies themselves, and Printoo's objective is to make that electronics the most invisible possible in the design of new products.

[JD] What was the purpose of the creation of Printoo?

[MC] The main motivation comes from the fact that only a few product designers and engineers know the technology of electrochromic displays. Who knows LCD's and e-ink, when designing a new product that requires a display, will use one of those technologies. If one doesn't know electrochromic

displays, one will never use them. Thus, it was necessary to place those displays on the hands of those people, in a way that prototyping would be made easier for them.

[JD] What are the client needs that Printoo will satisfy?

[MC] Our clients need to: a) Prototype with electronics in an easy way – not worrying much with breadboards and others aspects; b) Know all available technologies; c) Prototype with designs that are the closest possible to the final model – and Flexible Electronics allows more options than the rigid one, on that sense.

[JD] What was the result and impact of the Kickstarter campaign, and what was the feedback from each sector?

[MC] The companies with whom we work in particular have a much closed environment. They close their Intellectual Property a lot. A lot of them didn't know Kickstarter. So, inside these companies there was a new knowledge, and some of the engineers from those companies got very enthusiastic with the project, and there was a bit of openness. Because this thing of Makers and of Open Source is really a very different way of doing things on a corporate level, that was not very present mostly on more scientific companies, in which intellectual property is protected, and one works in secret basically. So on that area there was that impact.

As for the campaign itself, we had no idea how many people would be interested. We didn't expect it to be a flop, but we did not know how much would we do on the campaign. But yes, we knew more or less what the target was. The Education sector was, in fact, a surprise, because we did not expect it. Also, from other groups, we had several backers that are from companies that bought a lot of materials for the more expensive kits, and we were able to assess they were from companies.

It also happened that – as Printed Electronics components are something that we do for long – we noticed that for the majority of people, these technologies were something new. They had never thought of objects on that way, never had seen that they could be used in prototyping, and so I think that the campaign had a big impact on people, more than on us.

[JD] What previous projects led to the creation of Printoo? Is there any project you can disclose?

[MC] This one is tough. Actually, there was an internal project previously to Printoo that consisted in an Arduino shield where we connected Ynvisible displays and control them with a computer.

[JD] What is the strategy designed for Printoo, and which markets and sectors will it address? And which specific applications of use for each sector?

[MC] The short-term objective is to deliver Printoo to the Kickstarter backers, and see how people react to it – how they interact with the product. And so that is what we are going to see between September and October. Then, we divide the strategy in mainly two markets.

The first one is the market of Early-adopters, enthusiasts of everything that is original and technological – and then we will try to search for third-parties, and we have several research institutes and universities that are already interested in doing modules for the Printoo. Because if a university has a new sensor or solar panel or OLED module and wants to give a sample to people for them to try out the technology... or even if you have a start-up with a new sensor and wants large electronics companies to test that sensor – that engineers from those companies test them – maybe the easiest way will be to make, from that sensor, a new module for Printoo and allow people to test with Printoo. And so we have had some universities in Spain, the United States, Finland, and even Germany, that showed interest in making new modules for the Printoo.

The second one is the Education market, in which we are now starting an initiative called “The Inventors’ Club” (“O Clube dos Inventores”) that was born when we started realizing that Education was a good market, and so we wanted to know that market. So we started going to several schools near us to propose to do workshops, and own of those schools suggested that we should give classes all year. Since we didn’t have Printoo’s for the classes, we thought of giving classes about Electronics in general, and so it started to be called “The Inventors’ Club”. And that is being transformed and now we have something called “The Inventors”, in which, although it was born from Printoo, we give classes around Electronics, and we are creating kits around Printoo and probably with other boards that are not flexible, to address that market. And the products that we will do are a sort of Science4you, in which we assemble different pieces, but with a price level that is much higher and a level of complexity and value that is also much higher. One example is this (a Mars Rover replica made of cardboard), in which the idea is that we place the board and control it with the smartphone. We are creating some of these kits and we will explore the sector this way. But on this sector the product is actually a slightly different product, where the objective is not to show new Printed Electronics technologies – because Printed Electronics are probably not interesting for children – but to keep the original best features of the product and apply them to a product more focused to Education, and built really to be more appropriate for these experiences.

Actually, this summer we are giving several Summer Camps and we will have a few more, and we are also discussing with some schools to plan these Summer Camps in several schools for next year. For now, we have been hiring teachers and we go to schools, but at some point we will have only the kits – kits prepared for Education, with manuals to give the classes – and so we scale the model this way. But first we have to test what works and what doesn’t. We are making questionnaires to kids to know which experiences they liked.

[JD] Besides the Education market, what strategies are being formed, in terms of evolution and adaptation of the product? More kits and modules?

[MC] More modules and keeping the improvement of each module. On a distribution level, we want to see who has interest in reselling Printoo kits. But for the more professional market, a more niche market, we think we can control using our site.

We have had interest shown from universities that have courses on Printed Electronics, e from some Printed Electronics clusters, and for example in India there is an university with a lot of students, which can mean that Printoo can sell a few thousands of units at once. It's something more opportunistic and with a more complex scalability than selling units to the Education market, which is gigantic and easy to address.

[JD] Besides kits, what other type of offer can Printoo turn into, namely on a company level? And what new business opportunities can it bring, besides Printoo itself?

[MC] For Education we will have the kits to build specific things, and on other side we will have the prototyping, but we don't have any other type of application thought.

[JD] In terms of communication and price, will you maintain a similar strategy when you start producing in a larger scale?

[MC] We won't be able to reduce costs unless volume would increase exponentially. But we don't think we will be able to reduce costs in a way to reduce prices. What can happen is that certain companies as Disney or Bosch, that have big R&D sectors, would be willing to spend a few thousands of euros for a kit with a very wide range of modules, then we could think of something more focused on that type of consumer.

In the Education market, if we start mixing rigid boards and more volume, it is expectable that we can start to have cheaper products.

[JD] Your production model consist in producing your electrochromic displays, while the remaining components are produced by your partner companies? Will this model continue the same?

[MC] The components come from companies from Europe – except one type of batteries that comes from the United States – and the assembly is made here in Portugal. The only thing that comes from outside the European Union is the flexible circuits, which are made in China. It is probable that in the future the assembly starts being made in China as well, because it will eventually be cheaper.

[JD] But regarding your displays that you produce and will continue to produce at Ynvisible, will they be made by own staff?

[MC] Yes.

[JD] What other companies and products do you consider as competitors, and how do you see them? Arduino, Raspberry Pi, Little Bits, LEGO Mindstorms?

[MC] We are in two markets: prototyping and Education. One thing that both have in common is that they are not monopolist markets at all, and thus are markets with many small niches and segments that are possible to be occupied.

And so in prototyping we have much more than Arduino and Raspberry Pi. We have a lot of people making different type of boards for prototyping. And in fact there is a lot of competition, but on the other side there are a lot of different needs that consumers have.

In Education, Little Bits is good for children from until ten or twelve years old. Mindstorms is good for children from ten to sixteen that want to do robotics. But in Education we have many geographical zones, year ranges, subjects and different learning needs.

So we don't see them as a threat. Because this is not like creating a social network or a high-volume consumer good, in which we are competing with big companies. Mostly in the Education market, that is an exponentially increasing market regarding the adoption of technology, there is no leader. I mean, there are leaders, but not leaders who block the entry of new companies. We don't see them as big threats, and to some extent they are even increasing the market. Little Bits, for example, has grown and having hype because it is introducing in schools what is necessary to teach about technology, e and so they target younger ages, leaving older ages with the need for other types of kits and products.

In the case of specific competitors, Raspberry Pi is something more open than will not produce kits for Education. People buy Raspberry Pi and then they build something on top of it. Arduino, right now, is basically two companies that are not functioning very well, and they kept a bit stopped on their innovation. Little Bits works the market better, and LEGO Mindstorms... LEGO is a huge company that is very well established, but that product also stopped innovating. Mindstorms was born in 1998, and it didn't change much since then.

So there is a big opportunity to enter, mainly in the Education market. In the prototyping one, in fact there is a lot of competition, and it is harder to present something new. We were able to show something new, but in this market, what is new turns to be old after two years, because it is a market always looking for new stuff.

[JD] Does it make sense to think only of Education, or also of the toy market?

[MC] It's something mixed. When we speak of Education, we are not thinking of selling only to schools, but also for parents that want their kids to be intelligent. That think that this toy is better that, for example, a videogame.

[JD] What progress do you anticipate for Printoo? And what do you anticipate for Ynvisible, in the post-Printoo phase?

[MC] What is probable for Ynvisible is that it focuses on the display technology that it has. Printoo appeared in a moment when Ynvisible had an acquisition offer – that was almost concluded, but eventually it got cancelled – and after that we needed to redefine our strategy and that made the company more prone to accept “crazier” ideas. There was more openness to explore our own products. In the future, it is expectable that Ynvisible focuses on the opportunities that it has, of selling its displays, in ongoing development projects.

What is expected for Printoo is that, to be a viable company, it needs to have a recurring cash-flow every month. The way that seems more direct to me until now is... well, we have had the European Union SME Instrument phase 1 fund, and we are going to candidate to the phase 2 fund, but this is to assure our short-term sustainability. On the other side, we have to start to sell kits and to do contracts with schools – and that's what we are doing. So, at this moments we are going very aggressively to the Education sector, hoping that it will sustain us, in a way.

The prototyping part can maybe be kept in both companies, because if Ynvisible focuses on displays, it can continue to have interest in having Printoo as a prototyping kit for its customers to have a first contact with the displays. It can be a Marketing tool for Ynvisible. And for Printoo, it can continue to be a form of selling more sporadically but probably often in high volume.

If I had to summarize it, I would say that Printoo company will dedicate itself 80% to Education and that Ynvisible company will dedicate itself almost 100%, or 90%, to the display technologies and to the client projects it has.

[JD] What are the Key Success Factors for Ynvisible, regarding Printoo? In other interviews I made there were mentioned three: a) A strong brand, with Printoo establishing itself as the reference product within the genre, through communication and strategic partnerships; b) A constant evolution of the product, adapting constantly the kits to client needs and updating the components, for them to be newer, more capable, cheaper and lighter; c) And to be able to get the necessary capital to advance to higher volume production. Do you agree with all three, and do you think there are others?

[MC] Whether the three key factors are marketing, innovation and financing... yes, I agree that's it. But maybe we should consider that distribution is also critical. Because one can have good marketing and innovation, and everything else working, and still be hard to establish the distribution channels to reach everywhere. In the case of Science4you, their main point is not product innovation nor marketing, but the way they created those distribution channels, and that took several years to reach, and still they are not giants in the toy sector.

For hardware companies, distribution is one of the main entry barriers. Because established companies are already in the store and it's much easier for them, because they already deliver a high volume of products, allowing them to have higher scale and better margins, than to small companies that don't have that distribution.

But Internet makes things easier. When one sells via the Internet, one keeps all margins. But if we want to reach higher volumes, we need to enter in big retailers, and that is a long process. So I would say that distribution, if it fits in this category, is maybe one of our challenges to come.

[JD] Do you think that, with Printoo, Ynvisible will surpass the success that YDreams had over time?

[MC] I think that both are very different and we cannot compare them. I don't know which variable we are comparing. When YDreams focused on products, it was on mobile phone videogames, but the biggest part of its history was made doing projects. In this case (Printoo) we are talking of a company

that makes products, and so in the sense of creating a product that generates a cash-flow that allows to sustain the company through those sales, maybe, if that is the level of comparison. But we aren't interested in comparing...

In the case of Ynvisible what will make the company reach the next level will be more related its displays. And on that sense I see that it makes sense to divide Ynvisible and Printoo in two different parts. When we talk about Ynvisible, what I think it is more probable that will make Ynvisible a successful company will be the integration of its display technology on other products. In the case of Printoo, it can be a kit for Education and for prototyping that is successful. So it's something very different than for the rest of Ynvisible or for YDreams. Moreover because Printoo, one year ago, was something, and now we are looking at Education and it is a very different product, and let's see what comes out from this.

[JD] What role can Printoo have in the adoption of new technologies?

[MC] Something that was thrilling, and that I already mentioned before, is that hardware companies – not as software companies, in which you try to have the most users possible using your platform, because they live from network economies – don't necessarily benefit from network economies. And because it doesn't necessarily apply, the way hardware companies have been maintaining their value is through patents and intellectual property. Since the patent and intellectual property system sometimes doesn't work very well, they keep everything secret. In hardware, we do something and we need to sign a non-disclosure agreement, and that happened with us also and each would take long to negotiate. And Printoo is the idea that what matters for those companies is not to protect their intellectual property, but rather to make product designers adopt their technologies. And to adopt their technologies, these have to be open and available to them. So it was a very different way to operate – it was a paradigm shift, to get more open. But actually we had a recent case in which we got a request for us to sell printed batteries, and I suggested to put them in direct contact with the battery supplier, but the person didn't want and wanted to buy from us instead, which we thought was weird. We then realized it was a company that wanted the batteries to copy them, and so there existed this abuse – an attempt of stealing intellectual property – originated by our effort to try to open the market. And this is exactly what we do not want to happen, because it gives strength to the idea that the best way to operate in hardware is the closed and secret way. This risk exists.

There is also the fact that, in electronics, the boards and components that exist in the market are the rigid ones, and what we are here making available is something new that people don't know yet.

[JD] How do you see the Internet of Things coming, and what role can Printed Electronics and Printoo – or other similar product – have?

[MC] Maybe two years ago we were in a state in which the Internet of Things was an intelligent toaster and an intelligent car, and we are still in the process of developing that intelligent car. A big part of what we talk about, when we talk about the Internet of Things, is to turn make these large objects intelligent and communicating among themselves.

The Internet of Things that Printed Electronics allows is at a much smaller object level. And for that to happen, we need it to be possible to integrate all these Printed Electronics technologies in a way that allows high volume, low cost production. And there was still no one able to make it. There are some median cases, like the case of a battery company that created a band aid that measures body temperature and sends those signals to the smartphone – TempTrack – and that was a success. But there are still very few that are able to do Printed Electronics products that are integrated and produced in low volume. Thin Film company is one that promises to do that. When that becomes possible and standard, Printed Electronics will allow to embed intelligence everywhere – all types of packaging, logistics, etc. And that will allow the general economy to have efficiencies in areas that are not so visible, such as the ability to understand if goods transport can damage the goods or not. It can also have an impact in medicine, in which there are a lot of people talking about diagnosis devices, for example if you blow to a piece of paper and you get a hepatitis diagnosis. A lot of these applications are being developed today, with sensors for everything and something else, that when integrated in an electric circuit, they allow to perform diagnosis. If that type of sensors are something that you have not only at your doctor's, but be so cheap that you have it everywhere, than a big impact is sure – due to make able to detect several conditions quickly. If these devices get spread all over the place, being produced in high volume and with a low price, it will be important, because such applications are not possible with traditional electronics.

[JD] Besides the wearables, consumer goods packaging, healthcare and auto industries, which other industry is there with significant Printed Electronics applications?

[MC] In Ynvisible we had, for instance, projects for toys, to make card games and interactive board games. We had projects in many areas since these technologies are sort of horizontal and thus it's possible to apply them to many fields, just like it happens with traditional electronics.

But the ones that have more bets on are those. And also intelligent cards, which initially was an area where lots of people were investing, and they needed for instance to place PINs in cards, and so electrochromic display technologies' investments were being focused on displays for credit cards, for example.

[MC] Relatively to existing products from other companies that can be made after projects done by Ynvisible, we don't have those yet, because these technologies are still getting more mature – which always takes some years – and only after that can products be made, with fully tested technologies, and that are ready for a life cycle of five years without problems after their launch.

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