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***ORIGINAL ARTICLE***

# Using a seismic sensor to improve PET scan imaging: A new product development case study

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***ABSTRACT***

A new product development (NPD) process consists of a sequence of events that create, model and implement an idea. All of these processes share some common stages necessary to ensure a successful new product launch. An interdisciplinary team was tasked with executing the initial phases of the NPD process for a start-up. This paper presents an exploratory case study following their journey of development of a novel application involving a MEMS accelerometer, typically used in seismic sensing, to improve PET scan imaging for medical diagnostics. Their work is interpreted with the theoretical stages mentioned in the literature and insights are drawn from the design thinking and validation methods used by this team. The effectiveness of these methods as perceived independently by each team member is also analysed. The criteria used for screening possible applications during the entire process are presented and an evaluation of their effectiveness and relevance is conducted.

*Keywords: MEMS accelerometer; medical imaging; new product development; screening criteria; open innovation; idea generation.*

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## INTRODUCTION

In today's age, there is a pressing need for companies and start-ups to constantly innovate and develop inventive applications around their technologies in order to dominate their markets (Cooper, 2008). Open innovation has taken centre stage as a lucrative option, prodding companies to look outside their own organizations for new product ideas (Chesbrough, 2003). While companies with simpler technologies and B2C products find this approach pliable, advanced-technology companies with complex products often resist the notion of seeking ideas from the outside world. Instead, these companies carry out idea capture internally which involves formally soliciting new product ideas from employees and a subsequent idea screening via some form of structured process. The effectiveness of this method, as is evident from the seminal work by Cooper and Edgett, is disappointing (Cooper and Edgett, 2008). Thus, employers are increasingly encouraging their R&D departments to source ideas from outside the firm to stimulate corporate open innovation. It has been demonstrated that openness during ideation leads to an increase in the performance in developing innovative ideas for the company since it raises the employees' awareness about technological opportunities and their individual alertness to the market opportunities (Salter, 2015).

This paper presents the case study of such an open innovation process followed by an advanced technology start-up named Innoseis. The company's low power, high sensitivity MEMS (Microelectromechanical systems) accelerometer was one of the many ground-breaking scientific innovations to come out of the Dutch nuclear research institute or Nikhef. The technology was originally fitted in the Einstein Telescope to remove minuscule low-frequency vibrations of the earth. The exceptionally high sensitivity of the accelerometer allowed for the extreme stabilization of the telescope's suspended mirrors by working as a digital geophone (SIMS 2019). Not surprisingly, the company found an application for this technology in the oil and gas industry where geophones are heavily used for seismic monitoring and analysis of the earth's structure (Aizawa, 2009; Ravindranath and Sharma, 2004). However, they sought alternative applications to diversify their product portfolio and outsourced the new product development process to an interdisciplinary team of engineers and designers. The team worked independently under the aegis of CERN IdeaSquare and carried out the following phases of new product development: idea generation, screening and business analysis. The development, testing and commercialization phases were not applicable under the context of the program and were not carried out. For the sake of being complete, the authors do briefly follow up with the start-up about the outcomes of these phases. This paper

presents the design thinking and validation methods used by this team which can be characterized as a flux of divergent and convergent steps while also presenting the effectiveness of these methods in the new product development process as perceived independently by each team member. The criteria used for screening possible applications during the entire process are also presented and an analysis of their effectiveness and relevance for the members of the team is conducted. Furthermore, this analysis of the screening criteria is extended to other multidisciplinary teams involved in similar new product development processes.

## THEORETICAL BACKGROUND

New product development is the process that includes all the activities carried out by companies and entrepreneurs when developing and launching new products into the market (Cooper, 1990). Since it is a process, it can be divided into a predetermined set of stages, and process-management methodologies can be applied (Cooper, 1990). Stage-gate systems are models that recognise this. They define the stages and establish gates in between each stage. There are many stage-gate systems that have been developed over the years. They have different names and may seem unique but there is a parallelism in the approaches adopted by all of them (Cooper, 1990). A very well know system is the one developed by Booz (Booz, 1982) and is the one used in this paper. This system consists of 7 stages: new product strategy development, idea generation, screening, business analysis, development, testing and commercialization and the description of each stage is summarized in Tab. 1 (Booz, 1982).

One of the best-known idea generation method is brainstorming, where ideas beyond the logical thinking are generated through a verbal discussion (Petersson, 2017). However, many studies have shown that an approach only based on brainstorming leads to redundant low-quality ideas (Petterson, 2017). To not lose the reported enhanced productivity when working in a group and to take advantages of the good obtained results when each person ideates on his/her own, an additional different method appeared (Petersson, 2017). Hybrid ideation is a type of technique that combines individual ideation and verbal interaction with teammates (Petersson, 2017). This category consists of methods such as brain dump, where each individual writes his/her ideas on post-it notes and later discusses them with the rest of his/her team; brainwriting, where each participant writes some ideas on a sheet of paper and passes the sheet to another teammate who has to read the previous ideas and contribute to them; and brain sketching, where each participant makes a sketch of his/her idea and later explains it to the others (Petersson, 2017; Dam and Teo, 2020).

**Tab. 1**. Stages in the model proposed by (Booz 1982) for an NPD process.

| Stage | Description |
|---|---|
| *1.New product strategy development* | The foundations of the NPD process are established here. The process is linked to the company objectives by clarifying the strategic requirements and providing a point of reference for the next stages. |
| *2. Idea generation* | A search for suitable product ideas starts in this phase. Ideas can be sought from any potential idea source. All the ideas should be initially considered as possible and welcomed. The goal is to produce a wealth of ideas. |
| *3. Screening* | Ideas should be evaluated and filtered according to their potential contribution. Ideas that do not match some criteria should be discarded from the next investigation stages. The goal is to focus only on the ideas with the greatest potential. |
| *4. Business analysis* | Hypothetical business plans are elaborated to determine the ideas' potential to become viable offerings. Barriers to enter, target markets, financial projections, product attributes, market growth information and so on, are identified. |
| *5. Development* | Ideas are transformed into products that are producible and demonstrable. During this stage, the previously conceptualized offerings may undergo modifications since in a real-word setting is much easier to see weak aspects of the stabilized hypothesis. |
| *6. Testing* | Business judgments are validated through a trial market entry to determine the suitability of the products. The generated feedback provides another opportunity to modify and refine more the new products before they enter the marketplace. |
| *7. Commercialization* | The new product is launched into the full-scale market. Special attention should be payed to customer's feedback and quickly remediate any unmet customer's expectation. Special attention should be payed to competitor's reaction. |

There are multiple ideation methods that have been explored in addition to the aforementioned ones but because of the focus of this paper, only two more are explained. Bodystroming, where the individuals act out their innovative ideas and storyboarding, where a story related to the problem is developed and its dynamics are explored (Dam and Teo, 2020).

The screening stage is a critical, complex and difficult process since there is very little information available about the investments needed, the market or the costs of the proposed ideas (Cooper, 1984). All the ideas need to be categorized, filtered with the appropriated criteria, polished and narrowed down in order to select the most promising ones (Cooper and de Brentani, 1984; Dam and Teo, 2020). For a quick and easy first visual inspection of the many generated ideas, the literature suggests using the

four categories method. Four main domains under which most of the ideas can be categorized are selected and the ideas that do not fit in any of them are filtered out. The how-wow-now matrix is another method that provides an easy-to-follow mechanism for the evaluation of the innovativeness and feasibility of the ideas (Dam and Teo, 2020). It consists of the generation of a two-axis matrix where all the ideas are classified. One of the axes indicates the difficulty of implementation and the other the degree of innovativeness (Dam and Teo, 2020). Finally, the ideas can be screened based on some criteria. (Cooper and de Bretani, 1984) identified 11 main criteria that drive this phase: product differential advantage, corporate synergy, technological and production synergy, project financing, financial potential, size of the market, diversification strategy, market maintenance strategy, product life, rational market and domestic market (Cooper and de Brentani, 1984).

There are many canvases studied in literature any one of which can be used to perform a hypothetical business analysis. One of these is the lean canvas model. It provides a method to study the possible costs incurred, the channels that are going to be used to market the new product, to select customer segments and to plan revenue streams. Furthermore, the unique value proposition would be defined which should clearly illustrate the value of the product and why it is better than other options on the market (Qastharin, 2015). Companies that successfully launch a new product have usually followed a formal NPD process which have involved the aforementioned stages. Skipping some of the stages or having a low-quality execution in some of the stages often leads to product failure (Cooper, 1990; Booz, 1982). Furthermore, recent studies have shown the benefits of performing, at least some of the stages of the NPD process within interdisciplinary groups (Petersson, 2017). These groups have a wider range of abilities and skills and thus, they will perform better than monodisciplinary groups or entrepreneurs working on their own, especially in the idea generation and screening phases (Petersson, 2017).

## METHODS

The authors follow the work done by a four-member interdisciplinary team who, under the context of an innovation programme at CERN IdeaSquare, were tasked with executing the initial phases of the new product development process for a start-up. The NPD framework developed by Booz (Booz, 1982) is used as a theoretical construct to analyse the different stages that took place throughout the course of the programme. The description of the team's experience and the rationale behind their decisions across multiple stages is based on an interview conducted with the team members. An emphasis is put in illustrating how the group behaved and reacted during the process, which NPD methods were applied individually, and which ones were performed collectively as well as how these methods can be associated with the early stages of a typical NPD process. Furthermore, the perceived relevance and effectiveness of the 11 well accepted screening criteria in an NPD process as proposed by (Cooper and de Brentani, 1984) was investigated through a survey. Each criterion was shortly explained to the participants who were then asked to rank them on a scale from 0 to 5 with 0 implying "I never used it" and 5 implying "I used it all the time". The aim of the survey was to find the relevance of these criteria for the team mainly how often each member used these to filter his or her ideas. They were to base their answers on own point of view and reflection of how they made decisions, independently, irrespective of the final decision made by their team. Additionally, the effectiveness that they attributed to each criterion in retrospect after having finished the summer programme was also evaluated. The participants could rank only the criteria that they had used on a scale from 1 meaning "I found it not effective at all" to 5 meaning "I found it very effective". The people that did not use a criterion ranked it 0 in effectiveness. The argument here is that non-users of a criterion do not possess sufficient experience with it to rate its effectiveness. This survey was also repeated with members of other teams also participating in the summer programme. In total, 20 people participated in the survey. The gender distribution was 6 females and 14 males, and the disciplinary distribution was 5 designers/architects and 15 engineers across multiple diverse fields. Finally, the authors interviewed the CEO of the start-up that developed the technology in order to follow-up the evolution of the contributions made by this team and to contrast his opinion on the relevance of the 11 screening criteria with the team's opinion.

## RESULTS

The NPD process started with the team taking the Myers-Briggs Type Indicator personality test (Myers, 2010) to accelerate mutual intra-team understanding, facilitate communication and build collective dynamics. After the test, the team sat together, and each member discussed the results, describing themselves and explaining their preferred working styles. This was perceived as key in setting the team dynamics for the whole process and provided room for the development of effective team dynamics.

The team skipped the new product strategy development stage which accorded the group with total freedom to dive into very diverse ideas in the next stage. The first group brainstorming session which kickstarted the idea generation phase was carried out without a very deep understanding of the technical aspects or limitations of the complex technology at hand. As a consequence, the prevalent feeling in the interdisciplinary group was that all team members possessed the same level of the understanding of the technology leading to a decrease in

the fear of criticism by fellow teammates. This resulted in an unencumbered divergence process generating *wild* ideas that went beyond logical thinking. This was in line with what is to be expected as described in the literature (Dam and Teo, 2020).

Next, the participants of the study case participated in an individual brain dump process where more out of the box ideas were created but this time giving each participant time to think individually about possible applications. After that, a comfortable team atmosphere was achieved, which became pivotal in boosting the performance of the team in the impending stages and in overcoming the inertia of getting started. Subsequently, the team felt it was time to dive deeper into the nitty-gritty technicalities of the technology. This was triggered by the anxiety the team felt about working on unrealistic ideas. The team attributed a lack of depth in understanding the core technology as a roadblock in the NPD process.

After spending time studying the technology, the team performed one more brain dump session which generated approximately 30 ideas. This is also where they felt they excelled as an interdisciplinary team. The team leveraged this by directing the member who with a more technical background in electronics to simplify the technology to the rest leading to a variety of ideas being generated which mirrored the diversity in domain and skills within the team. The following methods that the team adopted can be described best as a cycling process which swung between the expansive divergent nature of an idea generation phase and the constricting convergent nature of an idea screening phase. The first screening stage commenced with the four categories method, which was applied to the previously generated ideas. The team discovered categorizing their ideas into four principal domains easy. Having their minds more focused, the group proceeded to transition back to the idea generation stage through a brainwriting session. A modified version of the brainwriting method was performed with the caveat that only ideas which could be congruent with the 4 domain categories would be written down. They allowed repetition of previous ideas but the members accentuated new ideas. When they received the paper sheet from another teammate as part of the method, they also provided a brief opinion on their teammate's ideas in lieu of simply adding their own. In this way, an internal feedback loop was generated combining individual as well as collective idea generation. This combination of individual and group idea generation methods was vital in the group's success in the innovation process. This observation is made in conjunction with longstanding postulations found in literature which mention members being more productive when working in a group than working on their own while also reaffirming the findings of that individuals ideating (as opposed to verbally interactive groups) are pre-eminent in coming up with high quality non-redundant ideas (Petersson, 2017). Finding this fine balance was a crucial factor in the group's success.

An unexpected consequence of using this modified method was that it elicited a spontaneous complementary screening step through the discussion that followed. Next, a brain sketching session was done to further spark even more ideas. This session combined an individual idea generation mechanism, individual sketching, together with a group idea generation strategy by getting the participants to comment on the sketched ideas and further refining them based on the commentary received. In hindsight, a majority (75%) of the members rated the brain sketching session as not very efficacious for coming up with new ideas primarily due to their poor drawing skills which hindered their ability to quickly express their ideas through sketches. However, all members found it to be an effective tool for further refining old ideas by establishing links between ideas newly generated from this session with the past ones. To exemplify, one member used a train sketch which was drawn to hint at a potential application in locomotive motion detection to extend her already proposed application of human detection to the field of physical security and crowd control.

Following the brain sketching, the team used an open innovation approach to filter all generated ideas by inviting critique from members of other groups of the summer programme. The team used these insights to look at their ideas through different lenses and criteria. All existing application ideas were classified through a how-wow-now matrix for easy visualization of their innovativeness and feasibility. The insights gained from this step propelled the group into a deep screening phase of selecting the most promising ideas. Each member was allowed to pick and advocate for three applications with voting being used to decide the winning ideas. Their judgments were based on criteria that they felt all promising ideas should meet. The authors evaluated the relevance (Fig. 1) and effectiveness (Fig. 2) of Cooper's screening criteria as perceived by the team. It can be observed from that the three most used criteria were financial potential, product differential advantage and size of market. They scored an average of 4.5, 4.5 and 4.25 points, respectively. Furthermore, it can be seen that they also have the highest (perceived) effectiveness. The least used criteria were project financing used only by two of the team members and domestic market used only by one of the team members.

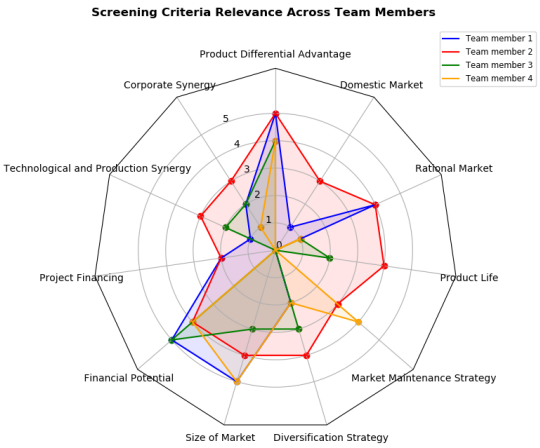


**Fig. 1**. Relevance of Cooper's eleven idea screening criteria for each of the four members of the case study.

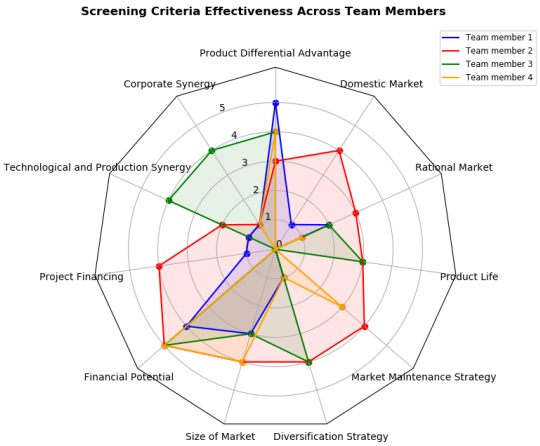


**Fig. 2**. Perceived effectiveness of Cooper's eleven idea screening criteria for each of the four members of the case study.

Figure 3 and Fig. 4 illustrate the average relevance and effectiveness of the eleven criteria for the team and the average of all the participants of the summer programme, respectively. The results are presented in a similar format as (Cooper and Edgett, 2008) for better interpretability. Fig. 3 and Fig. 4 show concordance in the criteria that appear in the top left quadrant of the graph which shows the most relevant and effective. It is also apparent that the team members considered project financing and corporate synergy to be much less significant as filtering factors than the other participants of the programme and they also rated these much lower in their effectiveness. Another criterion that shows a transition in between the quadrants of the graph is diversification strategy which was deemed more effective by the team members than by the rest of participants.

This careful filtering allowed the team to narrow down the four most promising ideas. These ideas were further refined through storyboarding and bodystorming. The participants reported that this helped them in developing a user-centric design and made their ideas more realistic by understanding the users with an emphasis on constructing an end user archetype. This also provided a nice segue for the team to start the fourth phase of the NPD process. A business analysis and business model formulation were carried out for four selected ideas. They used a lean canvas and market research to this end. The group refined their proposed revenue streams, clarifying and exalting their unique value preposition. They also used these methods to ponder over development and production requirements and in totality deciding the application that they considered showed the most promise. The application was to improve PET scans using an add on device which was fitted with the accelerometer technology. They then contacted potential end users and costumers to validate their assumptions and business plans. The feedback helped them improve the definition of their unique value preposition as well as their revenue stream. Finally, the team performed some additional validation of their solution and business analysis by building a prototype and delivering a start-up pitch to a panel of experts.

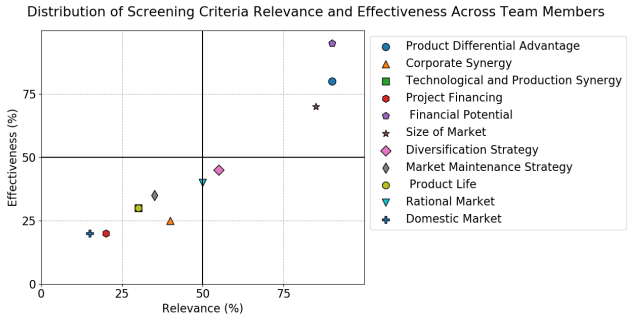


**Fig. 3**. Average effectiveness versus average relevance of the eleven screening criteria for the four membered team of the case study.

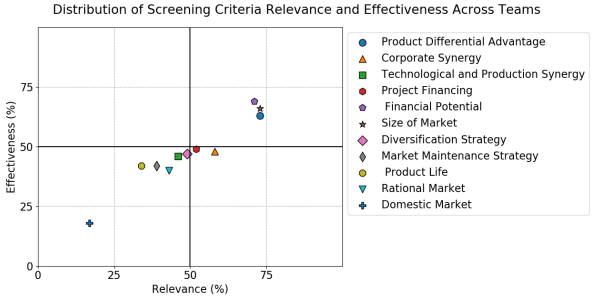


**Fig. 4**. Average effectiveness versus average relevance of the eleven screening criteria for all the participants of the summer programme.

In the interview we had with the CEO of the start-up, we found that the start-up chose not to commercialize the proposed idea due to a lack of a strong network required for developing the product. The start-up, however, did pick up another of the final four applications and is using

the team's efforts in the NPD process to develop it into a final product. As of writing, the start-up has applied for corporate funding to develop and commercialize the idea. The company never imagined the four applications that were presented to them and were grateful for the participant's approach to the whole innovation process. An interesting insight pointed out by the CEO was that when they were starting their NPD process for developing the geophone, the most relevant screening criteria for them were project financing, corporate synergy, size of market and product differential advantage.

## DISCUSSION AND CONCLUSIONS

The case study presents and analyses the work done by the team from the context of a new product development process. The first four stages of a typical NDP process are very well defined and all of the methods and techniques used by teams can be categorized as part of one of these phases. The initial idea generation sessions which were carried out without a deep technical understanding were vital in eradicating the fear of being criticized amongst the team members. This is primordial in order to ensure a nice flow of the idea generation stage (Dam & Teo 2020). The methods that were considered the most helpful in the generation of ideas were brain dump and brainwriting. Brain sketching was found to work better as a screening or refinement method instead of idea generation. The team immensely benefited by performing a brain sketching session after the four categories screening method as they found it easier to identify possible improvements for their ideas. We attribute this boost to be a direct consequence of following this sequence of methods as it prompts filtering of ideas based on feasibility. Furthermore, the team's efforts did not stem from a need to find a solution to an existing problem but instead were motivated by the need to find new applications for an existing technology. As a direct consequence, the storyboard and bodystorming techniques which are typically used to generate ideas by understanding customers' pains were found to be beneficial only in the later stages for the polishing of ideas. Another striking yet valuable difference that the team's process had with existing literature were the multiple oscillations between the idea generations and the idea screening stage. Instead of the more traditional linear transition from one phase to the next, the team's journey followed a cyclic procession which allowed them to find many new areas of applicability, dive deep into each of them and gain insights in the screening phase only to revisit the drawing board again but with new insights.

The three main screening criteria identified in this research when evaluated on the metrics of relevance and effectiveness are financial potential, product potential advantage and size of the market both for the studied team and for all the participants in the programme. However, a variability in the attributed relevance and effectiveness as perceived by the team and rest of the participants was overserved for the criteria of project financing, corporate synergy and diversification strategy criteria. This reinforces the benefits of conducting an interim open innovation step as by inviting external critique and input, the team gained insights which led the team to subconsciously also take into account these factors in the screening phase. Additionally, not carrying out the new product strategy development stage strongly influenced the outcomes of this programme. Cooper found that the top four screening criteria used by managers in companies are financial potential, corporate synergy, technological and production synergy and product differential advantage (Cooper, 1984). Not stablishing a link between the company objectives and the ideation process leads to the criteria involving synergy be considered as less relevant. However, in the end not carrying out this stage turned out to be highly beneficial for the company since the team explored radically new verticals and one of them is ended up being the idea that the company is now focused on developing.

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## REFERENCES

Aizawa, T., Kimura, T., Matsuoka, T., Takeda, T., & Asano, Y., 2009. Application of MEMS accelerometer to geophysics, International Journal of the JCRM, 4(2): pp. 33-36.

Attract, Seismic imaging & monitoring systems (SIMS), https://attract- eu.com/selected-projects/seismic-imaging monitoring-systems-sims/, Accessed: 10/08/2019.

Booz, Allen & Hamilton, 1982. New product management forthe 1980s, New York: Booz, Allen & Hamilton, Inc.

Cooper, R. G. & de Brentani, U., 1984, Criteria for screening new industrial products, Industrial Management Marketing, 13: pp. 149-156.

Chesbrough, H. W., 2003. Open innovation: The new imperative for creating and profiting from technology. Harvard Business Press, Boston, MA, USA.

Cooper, R. G., 1990, Stage-gate systems: a new tool for managing new products, Business Horizons, 33(3): pp. 44-54.

Cooper, R. G. & Edgett, S. J., 2008, Ideation for product innovation: what are the best methods? PDMA Visions Magazine, 32.

Dam, R. F. & Teo, Y. S., Introduction to the essential ideation techniques which are the heart of design thinking,

https://www.interaction-design.org/literature/article/introduction-to-the-essential-ideation-techniques-which-are-the-heart-of-design-thinking, Accessed: 15/05/2020.

McLuskie, P., 2017, Innovation and entrepreneurship, International Journal of Entrepreneurial Behaviour & Research, 23(1): pp. 159-162.

Myers, I. B., & Myers, P. B.,2010. Gifts differing: Understanding personality type. Nicholas Brealey.

Petersson, A. M., Lundberg, J. & Rantatalo, M., 2017, Ideation methods applied in a cross-functional inter-organizational group: an exploratory case study from the railway sector, Research in Engineering Design, 28: pp. 71-97.

Qastharin, A. R., 2015, Business model canvas for social enterprise, The 7th Indonesian International Conference on Innovation, Entrepreneurship and Small Business (IICIES 2015), 2015, Bandung.

Ravindranath K. & Sharma, B. D., 2004, MEMS – A New Technology for Digital Geophone Design, 5th Conference & Exposition on Petroleum Geophysics, Regional Electronics Laboratory, Hyderabad, 2001, pp. 886-889.

Salter, A., Ter Wal, A. L. J., Criscuolo, P., Alexy, O., 2015, Open for ideation: individual-level openness and idea generation in R&D, Journal of Innovation Management, 32(4): pp. 488-504.