



OPTIMIZING THE PROCESS OF PRODUCT DEVELOPMENT BY COLLABORATING & THINKING VISUALLY- CO-CREATION WITHIN HOWDEN

D. A. Grant, G. Russell, B. Wagner and N. Fain

Keywords: knowledge transfer partnerships, new product development, visual thinking, collaboration, co-creation

1. Introduction

Product Development is key to the growth of many established companies who operate in the global market with many having structured processes to allow product development to be carried out consistently and efficiently. When these processes are developed there is usually a top down and bottom up approach which includes consultation and interaction with all affected parties to reduce the amount of resistance to change. Traditionally this is achieved through formal and informal discussion using tools such as presentations, one to one interviews and group workshops.

When implementing any kind of change within a corporation there is always an element of resistance from the individuals who have to modify their working practices. This resistance to change is often driven by the fact that the individuals who have to change do not fully understand why the change is occurring or because they have not been consulted or involved in the development of the new way of working.

This paper will explore the potential of using visual thinking methodology to improve collaboration and manage resistance to change within a heavy-engineering product development environment. Visual tools are defined as “visualization-enabled mixed initiative systems that empower people in solving complex problems by engaging them in the entire resolution process, suggesting appropriate actions with visual cues, and reducing their cognitive load with visual representations of their tasks” [Pu and Lalanne 2002]. Although extensively used in product design, there is little evidence that they help explore the complexities of designing a product development process, specifically related to collaboration in heavy-engineering environments.

This paper explores the methodology used within a Knowledge Transfer Partnership (KTP) project between a Scottish University and a Scottish heavy-engineering company to show how a visual thinking methodology was used as the primary method for transferring knowledge related to the development of a product development procedure. The outcome of using this methodology was the co-creation of a bespoke new product development procedure which facilitates the company's growth through the development of commercially viable products which get to the market quicker.

The paper is structured as follows: first, the KTP as an approach to solving strategic problems for companies through external engagement with Universities and the Government is presented, along with the background to the case company and the KTP case project; second the theoretical underpinnings related to product development and visual thinking methodologies are presented to support the findings within the illustrative case. This case forms the core part of the paper, where the integration and co-

creation potential of visual thinking methodologies in New Product Development is discussed. The paper finishes with implications from the case relevant for both, practitioners and academics.

2. Context

2.1 Knowledge transfer partnerships

A knowledge transfer partnership is a three way collaboration between a company, university and the UK government. These collaborations are formed by creating projects that have benefits for all of the parties who take part in them. From an industry perspective, companies receive funding from the UK Government to establish a strategically important project which is supported by an academic institution. From an academic perspective the universities have an opportunity to increase their links within industry and see their theories applied to real life scenarios. From the government's perspective, the acceleration of innovation is realised within the economy through funding such projects. A KTP project involves hiring a recent graduate who is tasked with running and managing the project from inception to completion. The graduate receives a learning and development budget as part of the project to better their skills and increase their value to the three parties who are involved in the collaboration.

2.2 The company

Howden designs, engineers and supplies air and gas handling equipment, such as industrial fans, process gas compressors and rotary heat exchangers. Established over 150 years ago as an engineering company, Howden has grown to become a worldwide organisation with over 6,000 employees and companies in 26 countries. Howden's equipment may be found in various industries, for example in power generation, petrochemicals, mining, steel making and cement manufacturing. Due to increased competition and evolving technology within target markets, the company has developed a strategic plan to help develop and grow the business to reach its vision, "To be the world's leading applications engineer providing lifetime solutions in air and gas handling." Critical to achieving the strategic plan is the need to deliver competitive products to expand served markets, grow aftermarket business and provide new product offerings in key segments. This focus on product development highlighted a need to establish sustainable, repeatable and competitive product development procedures. To achieve this, the company partnered with University of Strathclyde, Department of Marketing in a KTP project.

2.3 The project

The KTP project aims to develop a sustainable new product development procedure that will ensure timely and cost-effective delivery of commercially viable products to the market. The project has been divided into the following stages: (1) Preliminary analysis of the current state of NPD activities within the company, (2) secondary research regarding best practices in order to develop a pilot model of a NPD procedure for the Howden fan business, (3) testing and pilot implementation of the new NPD procedure within selected projects, (4) model optimisation, and (5) full roll-out of the model and procedure documentation to the entire Howden business platform.

2.4 The approach

The chosen methodology for the purposes of this study was case study, where multiple qualitative research methods are applied within a systematic action research design [Kocher et al. 2011]. Action research aims at solving real life problems within a specific context, thus the objective of knowledge developed from action research is to "provide a better understanding in order to support and promote better managerial and organisational practices" ([Palshaugen 2009] cited in [Kocher et al. 2011]). This ultimately suggests that researchers and practitioners should design field-experiments in order to provide a novel solution to a specific problem the practitioners' organisation is facing [Fendt and Kaminska-Labbe 2011]. Since the key purpose of collaboration between the researchers and the case company is to develop a NPD best-practice framework, taking the systematic action research design was deemed appropriate.

3. Theoretical underpinnings

Different approaches to implementing product development procedures exist within the engineering and management literature, however companies still struggle with effective implementation of these processes into practice. Different methodologies are also proposed in literature that could help mitigate these challenges. For the purposes of this paper visual thinking will be presented and its potential for supporting NPD process implementation explored.

3.1 New product development

New Product Development can be defined as a process of conceiving, creating, and launching a product new to the company, a market or the world [Crawford 2003]. A product development process can be seen as the organisation and arrangement of specific tasks that are performed to design a product. The tasks start with the identification of a market opportunity or need and finish with the manufacture and sale of a product which fulfils that need [Ulrich and Eppinger 2012]. The main purpose of arranging the tasks in a structured manner is to help identify the key actions that are required to be completed during the development process including recognition that these tasks and their order must be modified to suit the type of product that is being developed [Pahl et al. 2007]. A typical engineering-based view of New Product Development divides the process into stages according to the department within the company where the development activities take place (Figure 1).



Figure 1. Department-based view of NPD [Bujis 2003]

It is noted that structuring product development activities in this functional manner creates roadblocks and issues [Cooper 1994]. To combat this a more cross functional, collaborative orientation, of new product development activities is required. One of the most widely adopted structures for developing products in this format is the Stage Gate model [Cooper 2009] which is structured in a generic five stage, five gate format. The stages are as follows:

- Scoping
- Build Business Case
- Development
- Testing and Validation
- Launch

This traditional method of new product development is applicable to most R&D establishments and has been used successfully by many large companies to create robust product designs that can be duplicated thousands of times [Cooper 2008]. It is noted that the stage gate methodology does have its limitations, mainly that a phased and staged planning approach to running project does not accommodate innovative projects which push the boundaries [Lenfle and Loch 2010] and that the process is too rigid to react to change within the project [Cooper 2014]. It is acknowledged that tailoring the traditional methodologies for product development to best suit the output of the product development process can be extremely beneficial [Salerno et al. 2014] and by doing so, many of the inherent problems with the stage gate methodology can be mitigated.

3.2 Challenges related to implementing NPD procedures within organisations

There are many challenges associated with implementing a new process or way of working into an organisation. With regards to a NPD procedure one of these challenges is the length of time it takes the company to roll out the procedure so that it has become standard practice within the company [Kiss and Barr 2014]. One way that this issue can be mitigated is to perform the roll out of the procedure concurrently with its development. Another observed challenge is that the NPD procedure will consist of new ways of working which will be unfamiliar to the stakeholders within the organisation. The processes and actions that are contained within the NPD procedure will need to be learned and worked through several times before the procedure becomes standard practice for the organisation [Bessant and

Francis 1997]. This issue will inhibit the organisation's ability to implement the NPD procedure but can be mitigated by involving stakeholders in its creation. It is also noted that if stakeholder involvement is not considered during the creation of the process resistance to change can increase with the resistance occurring through the "not invented here" syndrome. Another issue that is apparent when the implementation of a new process is considered concerns a lack of communication between staff and a lack of cross functional collaboration [Swink 1998]. It is noted that if these issues occur during the roll out of the procedure it will struggle to take hold within the company and employees will resort to their old ways of working and avoid the new procedure. It is noted that using a visual method of communication could pose a potentially novel solution to these issues.

3.3 Visual thinking

Visual thinking can be described as an instinctive mental process which can be used to visualise ideas and assist with solving problems, which is built on visual language (images, shapes, patterns, textures, symbols and colours) instead of a verbal language [Brumberger 2007]. In a psychological context visual thinking has been described as "the representation of knowledge in the form of structures in motion; it is the flow of images as pictures, diagrams, explanatory models, orchestrated paintings of immense ideas, and simple gestures" [John-Steiner 1997]. Visual thinking can therefore be seen as a method of communicating and interpreting a range of ideas, both large and small, through the process of seeing, drawing and imagining. It can also be noted that communicating visually, with participants observing pictures and line drawings, facilitates a greater understanding of abstract concepts when this method is compared to communicating the concepts vocally [Harris and Zha 2013]. Within the world of design visual thinking is used extensively by designers to create and analyse their ideas. It is also noted that many people use the medium of drawing to organise their thoughts during their day to day lives [Ware 2008]. Artists use many visual communication tools to construct their paintings. One of these tools relates to the palette of colour that is used to inform the mood of their painting. An example of this is a painting that consists of mainly cold colours like dark blues, purples and greens. The use of this colour palette displays a depressing, sullen or sad mood. Another visual tool that artists use is that of composition. An example of this is the golden ratio (Phi or 1.618). This ratio is used extensively by artists to add order and structure to their compositions. It is also noted that the use of the golden ratio in art subconsciously makes the paintings more appealing to the viewer. Industrial designers and user centred designers place great emphasis on drawing and sketching to allow them to iterate and work through their ideas and concepts. Drawings and sketches also allow them to illustrate ideas surrounding form and function to their peers in a fast and effective manner. The nature of drawing and sketching also allows the individual who is looking at the sketch to process a lot of information about it quickly. This is also apparent in the field of graphic design. An example of this would be the London Underground Map which uses a visual language (or a set of visual rules) to communicate information regarding types of train lines, stops where changes to different lines are available and the pricing structure of the underground to allow an individual using the underground to quickly make a decision on the fastest and cheapest route to get from one destination to the other. In electrical engineering, visual thinking or visual communication is also used to communicate across language and cultural barriers. This is illustrated by the standard symbols that are used to display types of components like resistors, capacitors and diodes within circuit diagrams. The use of visual language also extends to the components themselves, particularly resistors, which are painted with colour coded rings that allows engineers to easily work out the amount of resistance that a particular resistor applies. Another strong example of thinking visually is seen within transport. There are visual rules that control and manage how vehicles and people move around urbanised areas. This is done by applying visual rules to traffic lights, road signs and road markings therefore allowing the driver of the vehicle to think in a visual manner to comprehend and process information at speed. Visual language is also present within the vehicles themselves with each colour of light on the back of the vehicle communicating a different action by the vehicle. Within nature visual communication is used extensively to display danger. An example of this is an animal that is coloured aggressively like a wasp. The black and yellow colouring is used to warn other animals of its sting. These examples show the clear benefits of thinking and communicating visually and also highlight the fact that communicating and thinking visually can be used as a universal tool for transmitting and

processing information. The illustrative case describes the application of this methodology to the transfer of new product development best practice from academia into industry and identifies the key benefits of using this method of knowledge exchange.

4. Illustrative case

4.1 The visual methodology and employee engagement

Within the context of the KTP project, the development of a bespoke NPD procedure for Howden followed an extensive literature review and interviews with stakeholders within the company to identify what NPD processes already existed. It was identified that the Standard Operating Procedure (SOP) defining NPD as a set of stage-gates, as proposed by Cooper [2009], was available within the documentation, the interviews however showed that the employees were only aware of it, but not using it to its full potential. The interviews also revealed that standard NPD procedures, such as the stage-gate do not work for the company due to the bespoke nature of the products they manufacture. The interviewees suggested an adaptable, modular approach would be needed to (1) integrate all the relevant functions in NPD, (2) enable flexibility in relation to the nature of the development projects, and (3) provide a clear governance structure and KPIs to effectively manage accountability within different activities.



Figure 2. First iteration of the NPD procedure

Armed with this information the KTP associate employed the visual methodology to create the first iteration of the NPD procedure. Combining the knowledge gained from best-practice literature and interviews a first schematic of the fuzzy front end stages was drafted in order for the Associate to visualise the needed outcome (Figure 2). Like the methods of visual thinking that were described above, the visual methodology utilised a visual language that would make it easier for the associate and the stakeholders to comprehend and process the information that the drawing was communicating. Evidence of this is the fact that only three colours were used to draw the image and each colour was used for a specific purpose. Blue was used to describe actions, green was used to provide the rationale for the

actions and red was used for describing the review points that would be built into the process. Metaphor was also used within the visual methodology to reinforce the types of actions that were happening within the procedure. For example, the cloud metaphor was used as the drawing for the first part of the process, the funnel metaphor is used when describing the sorting and screening of ideas. These metaphors have been extensively used within the literature to describe the NPD procedures and were also identified as relevant to the employees of the company in the interviews. The visualisation of these metaphors enabled the stakeholders to understand what is happening at each stage in the process. The following comment was made by a Howden employee. "Funnels are popping up everywhere. Every process within Howden at the minute seems to involve a funnel when organisation and prioritisation are being discussed." This feedback was reviewed at a point when there was no formal discussion related to the NPD process development between the KTP Associate and the engineer who made the comment. The visual representation was positioned on a wall next to the kitchen, where the business unit's employees made coffee. This caused increased footfall past the initial representation and sparked interest by the employees, both the ones that are involved in NPD and the ones dealing with other operations within the company. Comments like the one mentioned above were used as feedback to improve the visualisation of the process.



Figure 3. The expanded visual process map

Further to the metaphors that were contained within the drawing, its very nature has been a powerful tool to facilitate the transfer knowledge. A sketch is defined as something that is rough or a work in progress and it can be noted that an individual is more inclined to comment honestly on something that they feel is a work in progress or is not finished [Buxton 2007]. The drawing that was created was intentionally very "sketchy" in nature and did not look polished or finished. This made commenting on it more socially acceptable for stakeholders within Howden and therefore increased levels of engagement with the KTP Project. This went some way to mitigating the risks that can be seen when attempting to implement an NPD Procedure within a company. On passing the drawing a senior stakeholder who worked in the HR department of the company commented: "This is brilliant! No one here does anything like this. People here are too scared to put their ideas on the wall like this." The fact

that she used the word "idea" to describe the drawing shows that she understood that the NPD procedure that was being created was still under development and that comments on the content of the drawing were being welcomed. This statement was backed up by an associate from the supply chain department who commented that "the majority of stuff here isn't sent out for comment or review until it's nearly finished or in a final draft form. This is different [from anything else that's done in Howden] because at an early stage people can contribute when a lot of the questions about what you're doing remain unanswered". This shows that he understood the value of the sketchy nature of the process map since he felt that it invites comment and critique. These comments go some way to proving that the nature of the drawing increased the levels of engagement within Howden which ultimately added value to the process that was under development and assisted with its roll out within Howden.

4.2 The growth of "the wall"

As stated previously one of the challenges that can be identified when implementing a NPD Procedure into a company is "not invented here syndrome". The visual methodology that was used went some way to overcoming this challenge. This is evidenced by the growth of the drawing seen in Figure 3. As the stakeholders within Howden engaged with it they would draw on it, amend it and help expand it. This meant that their ideas and thoughts were being incorporated into the procedure during the process of its development. This also facilitated the simultaneous creation and roll out of the NPD procedure since there was an element of learning and exposure to the new procedure whilst it was under creation. The visual representation thus facilitated co-creation processes, enabling implementation of different needs of stakeholders and extrapolation of more concrete solutions [Ali and Liem 2015]. Although the co-creation process does not substitute a formal roll out of the finished procedure it goes a long way to resolving the issue of "not invented here syndrome" since the stakeholders that will ultimately be using a procedure that they were involved in creating. This enables early buy-in to the procedure and concurrent integration into the company.

4.3 Analysis of engagement levels

As previously stated it was observed that there was an increased level of engagement within Howden due to the fact that the NPD procedure was being created using a visual method. Factors which improve engagement can be attributed to the size and scale of the drawing when it was on display, the fact that it was always on display and a high level of footfall past its location. This increased the range of Stakeholders that were exposed to the creation of the NPD procedure. Table 1 shows the planned engagement that would have happened if a visual methodology had not been employed.

Table 1. Stakeholders that would have engaged with the development of the NPD regardless of its method of creation

Business Unit	Job Title	Quantity
Howden Technology	Head of Howden Technology	1
Howden Technology	R&D project manager	1
Howden Technology	Engineering analysis manager	1
Howden Technology	Engineering software manager	2
Howden Technology	Manager of technology solutions	1
Howden Technology	Project coordinator	1
Howden Technology	Engineers	13
Howden UK	Product development manager	1
Howden UK	Product manager	2
Howden UK	Marketing manager	1
Howden UK	General manager - Engineering	1

These stakeholders were identified using the change management tool for stakeholder analysis and a plan was put in place to engage with them during the creation of the NPD procedure prior to the visual

method being used. Table 2 shows the additional stakeholders who engaged with the NPD procedure due to the nature of it being developed in a visual manner.

Table 2. Additional stakeholders who engaged with the development of the NPD process due to the method of creation

Business Unit	Job Title	Quantity
Global Supply Chain	Group head of supply chain	1
Global Supply Chain	Divisional supply chain sourcing project manager	1
Global Supply Chain	Divisional supply chain project manager	1
Global Supply Chain	Divisional category manager	1
Global Supply Chain	Platform category manager	1
Global HR	Internal communications manager	1
Global HR	HR manager	1
Global HR	Business systems integration and strategy manager	1
Global HR	Business solutions process director	1
Global HR	Programme Enterprise management office lead	1
Global HR	Process manager	1
UK IT	IT helpdesk Administrator	2

Examining the second table it can be seen that due to the visual nature of the NPD procedure a larger range of stakeholders engaged with its development. The diversity of roles presented in the table also shows that the visual method of communication allows interaction with stakeholders at different levels and disciplines within the organisation. The fact that these stakeholders engaged with the visual process map went a long way to ensuring that the NPD procedure that was created would be accepted and adopted by the business.

5. Conclusion / implications

The purpose of this paper was to show how thinking and communicating visually can mitigate many of the difficulties encountered when creating and implementing a tailored NPD procedure into a global engineering organisation. The case that was presented illustrated a Knowledge Transfer Partnership project that used a visual method to produce, engage and communicate a bespoke NPD procedure and the use of this visual methodology has had implications for the company. As the NPD process was being developed a senior manager recognised that there was increased communication and collaboration within the department because of the visual method of engagement that was being used to develop the NPD process. He asked some of the KTP associate's colleagues to try and adopt this methodology for working through some of their projects. While using the visual methodology during one of his projects, one of the engineers commented that "it's what engineers do. They draw things. They think in pictures. It's strange that you don't see it more often around here." This has a great implication for the company since it demonstrates a potential move towards using the visual methodology as standard practice for assisting with change initiatives. There were however drawbacks observed to using the visual methodology to create the NPD process. These included stakeholders becoming overly familiar with the visual process map which resulted in a drop in discussion and engagement, although this was addressed by constantly updating and changing the process map so that it was always new and interesting for stakeholders. With this in mind it is felt that a visual method of communication an effective tool for assisting with the development and implementation of a NPD procedure within a global environment. The implementation of visual methodology for developing processes is not new, but this paper shows how it can be used to facilitate engagement from different levels within the organisation. The use of tool was not intentional in terms of creating engagement, it was used for making sense of a vast amount of information gathered through in-depth literature review of best practice and interviews with the Howden employees. Its positioning on the wall next to the kitchen created an environment

where informal conversations were supported and thus allowed the key stakeholders as well as the wider employee base to engage and contribute to the development of a relevant NPD procedure.

The visual methodology thus helped to (1) engage the relevant functions in defining their role within the procedure, (2) clarify the key activities that need to happen within the procedure, and (3) establish relevant criteria for evaluation. Co-creation of these key parameters within the procedure ensured early buy-in and caused the employees to think about the way NPD should be run. The newly developed procedure is not dissimilar to the initial SOP within the company, it has however been created by a wider engagement and employees are now aware of their accountability within the process, as they helped formulate its visualisation.

This case thus shows that visualisation methodologies can be useful in defining, conceptualising and finalising process developments as complex as NPD procedures, as they enable co-creation and engagement at an informal level.

References

- Ali, A., Liem, A., "The use and value of different co-creation and tools in the desing process", *Proceeding of the 20th International Confrence on Engineering Design (ICED15)*, Webber, C., Husung, S., Cantamessa, M., Cascini, G., Marjanovic, D., Venkataraman, S. (Eds.), *Design Society, Milan, 2015*, pp. 279-288.
- Bessant, J., Francis, D., "Implementing the New Product Development Process", *Technovation, Vol.17, No.4, 1997*, pp. 189-197.
- Brumberger, E. R., "Making the Strange Familiar; A Pedagogical Exploration of Visual Thinking", *Journal of Business and Technical Communication, Vol.21, No.4, 2007*, pp. 376-401.
- Bujis, J., "Modelling Product Innovation Process, From Linear Logic to Circular Chaos", *Creativity and Innovation Management, Vol.34, No.1, 2003*, pp. 76-93.
- Buxton, B., "Sketching User Experiences: Getting the Design Right and the Right Design", *Morgan Kaufmann San Francisco, 2007*.
- Cooper, R. G., "Perspective; Third-Generation New Product Processes", *Product Innovation Management, Vol.11, No.1, 1994*, pp. 3-14.
- Cooper, R. G., "Perspective; The Stage Gate Idea-to-Launch Process - Update, What's New, and NexGen Systems", *The Journal of Product Innovation Management, Vol.25, No.1, 2008*, pp. 213-232.
- Cooper, R. G., "How Companies are Reinventing Their Idea-to-Launch Methodologies", *Research Technology Management, Vol.52, No.2, 2009*, pp. 47- 57.
- Cooper, R. G., "Invited Article: What's Next? After Stage-Gate", *Research Technology Management, Vol.57, No.1, 2014*, pp. 20-31.
- Crawford, C. M., "New Products Management", *McGraw-Hill New York, 2003*.
- Fendt, J., Kaminska-Labbe, R., "Relevance and creativity through design-driven action research: introducing pragmatic accuracy", *European Management Journal, Vol.29, 2011*, pp. 217-233.
- Harris, C., Zha, S., "Concept Mapping: A Critical Thinking Technique", *Education, Vol.134, No.2, 2013*, pp. 207-211.
- John-Steiner, V., "Notebooks of The Mind: Exploration of Thinking", *Oxford University Press United Kingdom, 1997*.
- Kiss, A. N., Barr, P. S., "New Product Development Strategy Implementation Duration and New Venture Performance A Contingency-Based Perspective", *Journal of Management, 2014*, pp. 1-26.
- Kocher, P., Kaudela-Baum, S., Wolf, P., "Enhancing organisational innovation capability through systematic action research: a case study of Swiss SME in food industry", *Sys Pract Action Res., Vol.24, 2011*, pp. 17-44.
- Lenfle, S., Loch, C., "Lost Roots: How Project Management Came to Emphasize Control Over Flexibility and Novelty", *Californial Management Reivew, Vol.53, No.1, 2010*, pp. 32-55.
- Pahl, G., Beitz, W., Feldhusen, J., Grote, K-H., "Engineering Design. A Systematic Approach", *Springer London, 2007*.
- Pu, P., Lalanne, D., "Design Visual Thinking Tools for Mized Initiative Systems", *Proceedings of the 7th international conference on Intelligent user interfaces, ACM, 2002*, pp. 119-126.

Salerno, M. S., de Vasconcelos Gomes, L. A., da Silva, D. O., Bagnom R. B., Freitas, S. L. T. U., "Innovation Processes: Which Process for Which Project?", *Technovation*, Vol.35, No.1, 2014, pp. 29-70.

Swink, M. L., "A Tutorial on Implementing Concurrent Engineering in New Product Development Programs", *Journal of Operations Management*, Vol.16, No.1, 1998, pp. 103-116.

Ulrich, K. T., Eppinger, S. D., "Product Design and Development", McGraw-Hill Singapore, 2012.

Ware, C., "Visual Thinking or Design", Morgan Kaufmann Amsterdam London, 2008.

David Alexander Grant, New Product Development Analyst
Howden, Howden Technology
Old Govan Road, PA4 8XJ Glasgow, United Kingdom
Email: david.grant@howden.com