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A 'DIAGNOSIS TOOL' FOR INNOVATION CREATED AND TESTED WITH THE AID OF DESIGN STUDENTS

Arthur O EGER[1] **and Ferry VERMEULEN**[2]
[1]Faculty of Engineering Technology, Section of Product Design, University of Twente, The Netherlands
[2]Section of Product Design, University of Twente and Design bureau Fever, Leiden, The Netherlands

ABSTRACT
Small and medium sized enterprises (SMEs) are generally considered as an important vehicle for new product development and innovation. However, SMEs inherently experience specific problems in their innovation processes, such as pursuing strategies that build the operational capabilities, which negatively influence their average innovative performance. Innovations from SMEs seem to be limited by the 'gap' between the generation of knowledge and the implementation of it: the so called innovation paradox. To increase the chance of success of an innovation generated by an SME, it would be best to choose step by step strategies. With the help of the theory of product phases it is possible to make overall predictions for the evolutionary development of a product after its market introduction and formulate low risk strategies. This theory was transformed into a 'diagnosis tool' which offers fresh starting points for innovation strategies by SMEs. The tool (a computer program) consists of a questionnaire that is used to analyse the present situation of a company and to give possible strategies for future development of the product. The tool has been developed in cooperation with several companies. The tool was tested by students participating in the course *Evolutionary Product Development* at the University of Twente.

Keywords: Design methodology, innovation, diagnosis tool

1 INTRODUCTION

In the past few decades, the necessity of permanent innovation in SMEs has been accentuated increasingly. Worldwide, SMEs have been accepted as the engine of economic growth and for promoting equitable development. Successful SMEs are recognised as being an important component in the industrial development [1]. Since the European Commission formulated their 'Lisbon'-strategy in 2000, in which the European Council aimed to develop the European Union to the most dynamic and competitive (knowledge-based) economies in 2010, national governments have paid more and more attention to innovation. Innovation is generally considered as a necessity for the creation of sustainable competitive advantage as an essential element in the survival strategy of a company. The economic product life cycle (EPLC) takes a central role in this consideration: after a short or long period, a product will disappear from the market because a better product fulfilling the same needs will be introduced or because consumer requirements have changed. The product has reached its top and is descending towards the 'end phase'. Quite often this is the result of product introductions by competitors and a loss of distinctive properties. Despite the chances innovation can offer companies, especially SMEs have specific problems in their innovation process, which negatively influence their overall innovation performance [2]. Innovations from SMEs seem to be limited by the 'gap' between the generation of knowledge and the implementation of this knowledge by the businesses: the so called innovation paradox. The innovation paradox is the inability or reluctance of manufacturing firms (especially SMEs) to pursue strategies that build the operational capabilities necessary for innovation that will provide both profitability and growth. There are several reasons given for this innovation paradox. Lack of resources to invest substantially on a permanent basis in R&D is given as the main reason [3,4]. For SMEs, non-successful innovations can bring great risks for the future development of a company. To increase the chance of success of complex problems – and innovation undoubtedly is a complex phenomenon – it would be best to choose step by step strategies.

2 PRODUCT PHASES

One way to formulate step by step innovation strategies is based on the theory of the product phases developed by Eger [5]. According to Eger, with the help of *product phases* it is possible to make overall predictions for the evolutionary development of a product after its market introduction. Is it possible to transform the theory of product phases into a tool and if so, does the tool offer fresh starting points for innovation strategies by SMEs? If possible, there will be several different perspectives for such a tool. First of all it will be possible to describe on a more qualitative manner the future development of the product in time. Second, innovation is characterized by trial and error, which makes an innovation process expensive. With the tool, the process could occur in a more structured (and more inexpensive) manner. Third, the attention of the government and institutions for innovation in SMEs is increasing rapidly. These institutions can use the tool for helping companies with their innovation challenges and strengthen their competitive position. (Their interest can be explained by the possibilities the tool offers for structured innovation. Innovation safeguards the existence of a company and in that way contributes to economic growth.) This paper emerges as part of a larger research into the possibilities to transform the theory of product phases into a useful tool. The purpose of the first part was to investigate whether it is possible for entrepreneurs and product managers to determine the product phase of their product with help of the statements as described in *Evolutionary Product Development*. The purpose of the second part is to investigate whether it is possible to use the collected data to formulate fresh and useful starting points for the future development of a product. To this end the research has also been split into two phases: a pilot and an extended research. The main purpose of the pilot was to explore the topic area. To test the feasibility the observations were described and analysed to improve the method for the extended research. This paper shortly describes the first phase and continues with an experiment that was executed with students of Industrial Design Engineering at the University of Twente. In *Evolutionary Product Development* [5] Eger describes six product phases which are related to the economic product life cycle. The six phases are placed in a chronological order. In general, products will follow these product phases in the same order. The product phases can be described by the so called *product characteristics*. By positioning a product, based on its product characteristics, into one of the product phases, predictions about the most probable innovation pattern can be made by adding the product characteristics of the next product phase. With the help of product phases, it is possible to analyse the relationships between ergonomics, marketing, construction and styling: the four different fields on which industrial design engineering is based. The six product phases are named performance, optimisation, itemisation, segmentation, individualisation, and awareness. According to a recent study [6] the last three phases frequently co-exist instead of being followed up (Figure 1).

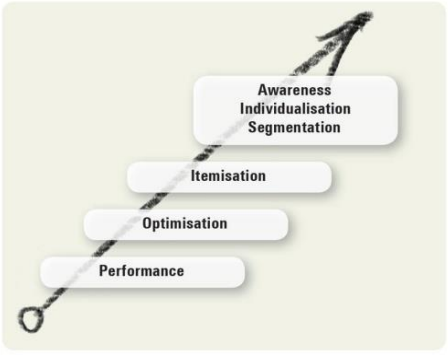

Figure 1. The Six Product Phases

The model states that each of the six product phases displays a typical pattern of product characteristics. Every company making money through the development, production or marketing of products will have to deal with this phenomenon. Managing it, requires skills with respect to both management of product development and design methodology, but also a sound awareness of design history. In practice, products in each phase can be found on the market and for every phase specific knowledge is required.

Generally speaking, the emphasis in the first phase – performance – is on new technologies. New product functions are developed for which the functional performance of the products is the main challenge at this point. In the second phase – optimisation – other knowledge is required. The market no longer accepts imperfections and other disciplines become important. Manufacturing technology and quality control become increasingly relevant. Product development is aimed at improving performance, better reliability, improvement of ergonomics and safety. In the third phase – itemisation – high quality and safety no longer suffice. Ergonomics and styling become important success factors. Research in the field of man-machine interfaces starts playing a role. Product development endeavours to develop extra features and accessories, including special editions of the product for different trade channels and target groups (segmentation). The last three phases co-exist. Product development is either aimed at target groups that become smaller and smaller (extended segmentation), or at mass customisation or co-creation, thus allowing the customer to influence the final result (individualisation). The ethical behaviour of the company or organisation behind the product is becoming more and more important to the customer (awareness).

3 RESEARCH QUESTIONS

The following research question is posed:

1. Is it possible to transform the theory of product phases into a useful tool which offers fresh starting points for innovation strategies?

The research questions of the first (1a) and second (1b) part of the research have been posed as follows:

1a. When the statements have been transformed into questions and are put into a questionnaire, is it possible for an entrepreneur to determine the product phase of a product?

1b. Can the collected data be used to formulate fresh and useful starting points for innovation strategies (by adding the product characteristics of the next product phase which will give the company a competitive edge)?

As the first goal of the research is to investigate whether it is possible for entrepreneurs and product managers to determine the product phase of their product, the unit of analysis is the entrepreneur or product manager. The participants are characterised by the fact that they have good knowledge of the companies' own products. They are involved daily in the development of the product and the strategies to be taken. To investigate whether it is possible for the entrepreneurs and product managers to determine the product phase of their product, a survey has been put together. Research was done by means of a questionnaire and a first pilot with five companies and their entrepreneurs or product managers has been set up. Because eventually the main goal is to evolve the product and to strengthen the competitive position of the company, the companies have been asked to point out two competitive products and answer the same questions for these products as well. The result is the determination of the product phase of the participating companies and the product phases of two competitive products. The second goal of the research is to investigate whether it is possible to use the results from the questionnaire to formulate fresh and useful starting points for the future development of a product. Therefore the answers of the questionnaires have been put in a product data sheet. With the answers and the knowledge of the product phases it was possible to formulate fresh and useful starting points.

4 THE SOFTWARE

For the pilot with the five companies a questionnaire was put together which consists of questions based on statements as described in *Evolutionary Product Development* [5]. These statements are useful for the questionnaire because in the theory of evolutionary product development they were formed to test whether the product characteristics and the product phases adequately describe what happens in reality. In earlier research it was shown that designers are able to develop the next generation of a product based on the model of product phases. Five companies have been approached with the questionnaire. The questionnaire appeared to be an adequate method to determine the product phase of a companies' product. However, several shortcomings have been found as well which should be avoided in future research. The participating companies have been asked to give comments on every starting point and to evaluate it. In general, all the participating companies were positive about the results and willing to follow some of the suggestions. During the time that the results were evaluated, two companies already continued innovating their products and used some of the formulated starting points (without knowing the results of the questionnaire).

Because of the perspectives of the research and with the pilot as useful input, the materials (a newly developed questionnaire and the data sheet) have been transformed into an online application. In this application, statements are given and the respondent is asked which statement best fits the companies' product and that of two of their most important competitors. Some examples of these statements are:

- The amount of parts is relatively high
- The amount of parts decreases
- The amount of parts is at its minimum

- The ergonomic demands and the way the product is being handled can be improved
- The product is easy to handle and meets the ergonomic demands

- The product's styling is of minor concern
- The styling of the parts of the product is good
- The product's styling is expressive
- The provider can distinguish himself by a good but simple and sober design

5 THE COURSE

In the first course of *Evolutionary Product Development* the history of a product is studied with the theory of product phases from Eger [5] in mind. The literature to be reviewed consists of professional and scientific publications and consumer guides. Copies of relevant articles from the Dutch Consumentengids are provided. In a second course a redesign is made for the product. This design has to be a feasible 'next logic step' (of course there are always several possibilities) based on the theory of product phases. This means that the design can never be a 'revolutionary concept', although it could contain new production methods, materials or other state-of-art features. The first course ends with a report about the history of the examined product. The analysis needs to include a mapping of the product characteristics in the six phases (text and table) and a description of how the product changed over time (in terms of dominant design, features, complexity, production methods, perception, legislation etc.).

An important deliverable of the course is a short comparison between one of the analysed products that is now on the market (free to choose) and two competitors. In very short descriptions (one sentence) suggestions for what the supplier (or designer) of the chosen product should do with regard to product development on each of the following 18 aspects: 1. Newness; 2. Functionality and reliability; 3. Technology; 4 Number of parts; 5. Ergonomics; 6. Safety; 7. Assortment/ is there much choice? 8. Adaptability to consumer wishes and ethics; 9. Product development ; 10. Styling; 11. Integration of form; 12. Number of competitors; 13. Price; 14. Production; 15. Assembly; 16. Promotion ; 17. Influence of the consumer on the final product; 18. Service organisation. After the students compared the product of their choice with two competitive products, and had given their 18 recommendations they were asked to use the software application.

6 RESULTS

The results of the application were compared with the student's 'manual' results. It proved that in most cases the results show similarities. The first results of the research will be explained by means of the work of one student. Figure 2 shows the manual determination of the product phase of coffee machines by this student. As can be seen, coffee machines are positioned in the segmentation phase. Next, the student used the 18 aspects that were described previously, to form innovation strategies for the future development of the coffee machine of his choice: the Siemens dip-brew. The following step was to choose two competitive products and to use the application. As can be seen in figure 3, all three products are positioned in the segmentation phase. The software automatically generates innovation strategies. The manually generated strategies and the strategies generated by the software were compared. Figure 4 shows both. It can be seen that most recommendations are similar.

Product charcteristics	Performance	Optimisation	Itemisation	Segmentation	Individualisation	Awareness
Newness	+	+	+/-	+	+	+
Functionality	+	+	+	+	+	+
Product development	+	+/-	+/-	+	+/-	-
Styling	+	+	+/-	+	+	+
Number of competitors	+	+/-	+	+	+/-	+/-
Pricing	?	?	+	+/-	+/-	+/-
Production	+/-	+	-	+	+	+
Promotion	+	+	+	+/-	-	-
Service	+	+	+	+	+	+
Ethics	+	+	+	+/-	+	-

Figure 2. Manual determination of the product phase of coffee machines; + = applies; - = does not apply; +/- = applies only partially; ? = unknown, uncertain

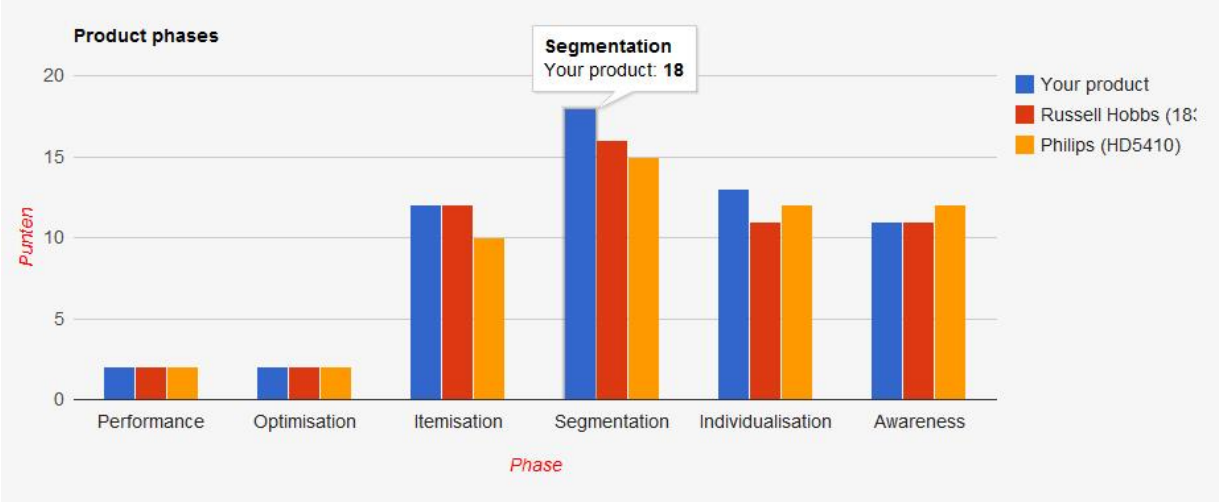

Figure 3. Determination of the product phases of three coffee machines with the aid of the software

	Software	Student
Newness	Almost everybody of the target group owns, knows or has heard of the product	Everyone is familiar with the product
Functionality	The product's functionality and reliability are good	The performance is good and the product is reliable
Technology	The product is not ensued from 'technology push'	*A microchip is the next technological step (smart coffee)*
Number of parts	The amount of parts has to be at its minimum	The number of parts should be kept to a minimum
Ergonomics	The product is easy to handle and meets the ergonomic demands	The device should be very easy to use
Safety	The product is safe	Safety should adhere to the highest standards
Assortment/ choice	The product offers many choices: the product line is broad	*Design can add value*
Adaptability/ ethics	The user might become more interested in the adjustment of the product to extend the life time of it	**Sub components are easily changed**
Product development	Product development should aim at creating possibilities for the user to affect the product's functionality by choosing from extra features or to compose his own product	**Development should focus on smarter features**
Styling	The provider should distinguish himself by a good but simple and sober design	**The styling should be expressive or meaningful**
Integration of form	The styling of the parts of the product (integration of form) is good	Form integration must be coherent
Number of competitors	There are many providers, competition is high	There are many competitors
Price	The unit price could become variable by adjustment of the product to the individual user	**Added value enables higher margins**
Production	Production of the product has been automated to a high level	The production is automated
Assembly	Assembly of the product is automated to a high level or has been outsourced to low labour countries	The assembly is mostly automated
Promotion	Promotion could occur through direct marketing	**Interactive media/virals are used to promote the product**
Influence of the consumer	Interactive media could be used to adjust the product to the individual user	**The consumer should be able to choose different features**
Service organisation	The product has a well-developed service organisation	Service should be exceptional. The user should feel involved

Figure 4. Manually generated strategies and the strategies generated by the software (Bold: Further development is needed. Regular: No development is needed (the software does not form strategies when no development is needed. The student however, has described all 18 aspects). Italic: The student formulated detailed concepts, this is something the application cannot do.

7 CONCLUSIONS AND RECOMMENDATIONS

For a first design the results are encouraging, although the software application certainly needs improvement. First of all, some descriptions the tool gives are not very clear, like 'The amount of parts has to be at its minimum'. This concerns the amount of parts which is necessary to fulfil the basic functionality. Extra features and accessories are excluded. (E.g. the first mobile telephone did have many parts which were all necessary for the function of calling. Current mobile phones still have many parts, but very few of those are necessary for the function of making phone calls). Second, the tool does not consider the recommendations, but gives suggestions that the students (or an expert) would leave out. For instance, during the pilot the tool gave the suggestion to a market leader in highly priced ladders to lower his prices. The product manager considered this a suggestion that the company most likely would not follow because of their A-status. The question remains if this really is a problem that has to be solved (e.g. by asking the company about their pricing strategy) or if it is better to let the entrepreneur make his own choices and rather use the suggestions of the application as a checklist (after all it is a possibility to lower the prices). After this first test we tend to the last solution: Give the user all possibilities and let him decide. Maybe with adding a warning that this is the application's strategy. The results of this first experiment are so promising that it is intended to repeat the experiment in next year's course. If it is possible to transform the theory of product phases into a application which offers fresh starting points for innovation strategies, there will be several different perspectives for such a application. First of all it might be possible to decrease the time to market. Second, it is very likely that, with help of the innovation strategies the tool offers, a product can be developed which will have more added value for the consumer than competitive products. Third, the tool provides insight into a complex process. Fourth, the tool can help in the decision making process of the designer or entrepreneur. At the moment of writing this paper we just started our evaluation. We expect to present more results during the conference.

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