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Editorial Preface

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Analyzing Target User Group's Preferences and Product Form Design Specification Through Web-Based 2-Dimensinoal Design Decision Tool

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Abstract

In the modern market where consumerism is running higher and the product life span is getting shorter, it is one of the challenges for the marketing and design departments in enterprises to know how to get a thorough grasp of the consumer's preference and potential target user group. With the wide spread and growth of the internet, a web-based survey is not influenced by time and space factors, making it easier for designers to have an in-depth understanding of the consumer's preferences towards products. Based upon the 2-dimensional image scale, 120 college students from Taiwan and Japan were invited to evaluate 27 pencil sharpener samples in terms of their preferences and intention of purchase. From the survey, competitive portable pencil sharpeners were identified for the references of new product design and development. The results indicated that such a web-based 2-dimensional image survey system could offer real time help in product segmentation and the selection of competition products as well as the target user group with the output systematic diagrams and tables. Furthermore, morphological analysis for product form elements and quantification type I analysis could help designers and marketing managers set up proper policies for product form design for the target user groups in the design and marketing of new product development.

Keywords: Design Decision Tool, Market Segmentation, Target User Group Analysis

1. INTRODUCTION

The development of the internet has made the web an efficient channel for communication. As a result, many scholars construct image analytic tools based upon the internet technology to help designers control the consumer's feelings of product form so as to develop products that meet the consumer's preferences and needs. In their systems, data obtained from the survey were used for product image analysis by statistical analyses such as factor analysis or Multidimensional Scaling Analysis (MDS). Because of the variation of consumer behaviors in the market place nowadays, different user groups may vary in their preferences toward products. It causes the segmentation of the market place of the same products. In light of this, it is necessary that

designers consider the market segmentation and preferences of special user groups in the design and development of new products. From this point of view, product design and development is closely related to market segmentation and preferences of the target user group.

The web-based design decision tool proposed in this study was mainly based upon the 2-dimensional image scale frequently used in design departments in enterprises. It is a goal-oriented analytic system that could meet the enterprise's needs in doing specific product image survey. In this study, the distribution patterns of product samples in four quadrants could be specified for market segmentation. The design decision tool proposed in the present study applied SWF for multiple product views, Active Server Pages (ASP), 2-dimensional interactive Flash, and Access for the website survey. The main purpose of this image survey system is to explore the target user groups' preferences toward product form. Such an image analytical system can efficiently generate graphic output for market segmentation for competition products, preference analysis of target user groups, and quantitative analysis of product form, serving as references for new product design and marketing in enterprises.

Through the web-based analytic system proposed by the authors, college students from Huafan University, Taiwan and Kyushu Tokai University Japan were asked to evaluate 27 current portable pencil sharpener samples in terms of their preferences toward product form of portable pencil sharpeners. In this system, the user group's survey data can be updated in real time and further analyzed in graphics and tables to help researchers investigate product preferences and target user groups. With diagrams and tables from the system, such quantitative data can help designers identify the target user group of the competition product and the proper direction for new product design.

2. LITERATURE REVIEW

Viewpoints and methods regarding product image analysis, web image survey system, consumer behavior and market segmentation were reviewed in this study.

In product image analysis, Nagamichi started the so-called emotion engineering or Kansei engineering where consumer's feeling and image perception were transformed into product design elements in the 1970s. These design elements are the product attributes that meet the consumer's needs and they are aimed to help reach a harmonic situation of the psychological and physical status when the product is used. Furthermore, the concept of Kansei Engineering System in which a design-oriented database was constructed is based on the consumer survey for designers to control the consumer's emotional needs and further develop products that meet the requirements in the market [1]. For modern products, products should be endowed with added value (in most cases, this indicates the symbolic values) in addition to their concrete functions. And in the consumerism era, the amount of image and meaning a product can transmit is closely related to its value.

In terms of product image, a product could communicate with its users through the form attributes of a product such as lines, color, texture structure and the outer context [2]. And these messages sent out from a product should be based from the consumer's points of view. In other words, images are the product appearance or verbally imagery designers consider suitable from the user's needs or feelings. The image of a product might be separated from its functional aspect. Similarly, Tsai and Ho asserted that designers use some sorts of form language to reshape a product image and send out messages to the user, forming an automatic communication model [3]. In such situations, it is due to the designer's ability in transforming the image in the design course. Differently put, product form elements are the essence to keep the message of an image, enabling users to have the same feelings and understand the designers' intention as well as how to operate the product. From the above studies, it is clear that product form can transmit image message and that it is an important factor for a successful product whether a designer can grasp the image to transmit and bring users' needs and feelings into control.

For a designer to get the picture of the image to transmit in a product and control the user's needs and feelings, the semantic differential method (SD) is a frequently used technique [4]. It is an experimental method specially used for the measurement of the meaning of objects. SD is composed of the concept to measure, the semantic scale, and the subject. The object, image, and subject form a 3-dimension database and the subject can express their feelings toward different stimuli in a more complete way. Moreover, Zeisel maintained that based upon the relationships between design attributes of a product and the user's perceptions, it is an easy way for subjects to make their choice and show the differences among different products along the scale if some verbal descriptions, i.e., the image word pair, is offered [5]. With the affective factors to product design, systematic data could be generated to help designers grasp the images they endowed in the product [6]. Moreover, the preference or perceptual evaluation of product samples with varying attributes can help designers deal with much uncertain information. With the data obtained, principal factors of the consumers' abstract emotions or preference can be extracted and feed-backed to conceptual design. This is a widespread application in the design field. Many researchers in product form image domain have used the SD method to explore product images; for example, new product development based on the consumer-oriented techniques [1], the differences of perceptions between real products and photographic images [7], the main dimensions for the evaluation of product form [8]. In the above product image studies, researchers need to collect the subject's data through SD method and then log in the data for further statistical analyses such as factor analysis, cluster analysis, and MDS. However, it takes training to conduct statistical analysis and the interpretation of the output diagrams and tables. For this reason, such studies are frequently seen in theoretical domain rather than industries and design houses.

Besides, to simplify the above emotional survey and statistical analysis and to meet the specific goals in new product design or marketing survey, the semantic differential method was incorporated with the 2-dimensional design decision tool. The frequently used 2-dimensional image scale was proposed by Kobayashi in Nippon Color & Design Research Institute [9]. Since then, it has been a design analytic method frequently used in product development and promotion by the industry and design houses. The titles along X and Y axes can be changed according to the design purposes. It uses a visualized and systematic diagram to reach consensus among participants of a design team and avoid the designer to go astray in the idea development process. Furthermore, the image analysis is the most popular method used in the design houses in Taiwan. From a case study of 70 companies, he found that from the 66 companies that used image scale, 36 companies (54.5%) adopted the 2-dimensional structure [10]. This demonstrates that the 2-dimensional analytic tool is so important that it has been widely used in the product design process.

According to the importance of 2-dimensional image scale in product design, it is easy to see discrepancy between the real market and the design team because most of such studies are conducted in the design department or R&D team. It is, therefore, essential that we need a 2-dimensional image survey system that is objective and suitable for quantitative analysis in enterprises, design houses, and academic units.

In terms of web-based image survey, Roy and Kodkani integrated database and WWW and made it possible for each designer in a team to access the survey data through authorized password [11]. Through a web-based product and process data modeling in concurrent design, the design process can be efficiently integrated to make decisions on line [12]. In recent year, many studies have used the web technique to improve the shortcomings of traditional image scale survey. For example, in a study of the production of Multidimensional Scaling questionnaire, Tu and Chen adopted the world-wide web platform to construct the survey. From the WWW platform, it is possible for designers to generate website questionnaire and conduct the survey on line and automatically collect the data they need in the format of Java Apple or dynamic HTML [13]. In addition, Ikudame and Harada proposed a survey system for image data by Hypercard 2.2. Such a system can be set to compare product images according to some specific images and gather

statistical data like the subject's basic profile and the raw data of the perception evaluation [14]. Furthermore, a CAKE (Computer Aided Kansei Engineering) system was made to help designers proceed such product image analysis tasks. Through data retrieval technique, CAKE could show the product image samples in a random order and save the subject's data. On the computer screen, the subject could mark the degrees of styling images regarding all the product samples [15]. More importantly, after the semantic differential test, the image samples could be further tuned to show their differences, bringing forth a more precise image database. Furthermore, it was expanded to offer more functions for designers' references through the website, including (1) experimental design and survey system, (2) data processing and analysis, (3) database integration and searching system [16]. The above researchers conducted product image analyses through web technique to help designers grasp consumers' preferences toward product styling images. But the experimental material was limited to single photograph of a fixed perspective angle or the front view; some details of product sample images may not totally be presented, which may affect the subject's evaluation of the sample images. Besides, although the 2-dimensional image scale is frequently used by the industry and design houses, it is a problem annoying designers how to extend few designers' subjective data to the major consumers for the objective image database. For these reasons, the authors proposed a web-based 2-dimensional design decision tool that could solve the problems of the presentation of detailed features of product samples and further statistical analyses. Such kind of systems can meet the requirements of designers in their image analysis procedure. Based upon the characteristics of materials studied in web-based image scale system and the interpretation of the output data, the authors proposed an image survey system suitable for designers during the stage of new product design and development.

Consumer behavior is an integrated science covering social science, psychology, economics, marketing, and the like domain. Many scholars define consumer behavior from different perspectives. For example, a cognitive and interactive procedure people have in response to different consumption situations and environments in their life and commercial exchange [17], a serial decision-making procedure individual uses money or money substitute to exchange commercial goods or services, including all decisions before or after an action [18]. Schiffman and Kanuk assert that purchasing behavior is a performance an individual has towards the search of products, services, and ideas or the acquisition, evaluation, and disposal of information so as to satisfy his or her needs [19]. Moreover, consumer behavior consists of the activities people have in selection, purchasing, and using products, including mental and contextual process and physical actions to satisfy their needs and desires [20]. It is a way people obtain, consume, and dispose products, services, and ideas [21]. A more in-depth understanding of consumer behaviors will let us realize other rules in the activities. Other researchers think that consumer behavior relates to all sorts of activities people acquire, consume, and dispose products or services [22]. It is a dynamic decision-making procedure where people need to make decisions for the needs recognition, data retrieval, information processing, purchasing action, and evaluation before and after purchasing a product. As we know, a market is composed of consumers and there exist differences in consumers' behaviors. Therefore, it is necessary that an enterprise is able to separate the differences in consumers and develop a proper marketing policy for specific market sectors so as to reach their goal in new product design and marketing. As a result, in this study, the degree of consumer's intention of purchasing was adopted as an important index in the marketing survey and analysis.

Market segmentation is an important issue in the consumerism era nowadays. It divides a potential market place into several subclasses in each of which the consumers are common in their needs or characteristics; then one or a few subclasses will be selected for the target markets for an enterprise [19]. For an effective marketing planning, a proper section between the extreme segmentation and mass production should be adopted [22]. The purpose of market segmentation is to take consumer's behaviors into consideration and classify the individuals into user groups so that the differences in the same group are minimal and the differences among different segments are maximal. Furthermore, market segmentation is the clear sections of the market according to the consumers' needs for products or marketing combination and description of the contour of

each section [23]. In other words, market segmentation is the procedure in which a big market is divided into small groups of consumers [24, 25, 26, 27, 28]. For the marketing of all sorts of business, market segmentation is a important strategic domain [29, 30]. Consumers in the same market sector will have similar consumer behavior and purchasing habit [31]. For strategy makers, the information of market segmentation makes it possible for them to bring the characteristics of each user group under control in the early stage of marketing. More importantly, the result of market segmentation can be efficiently applied to the competitive strategies [32]. When an enterprise faces multiple market sectors, marketing managers need to figure out the characteristics of each segment so as to apply appropriate strategies [33]. Using coffee shops as an example, he divided the market place into four quadrants based on the product usage frequency and preferences for market analysis. From the above studies of consumer behavior and market segmentation, it is clear that for design and marketing, an in-depth understanding of the characteristics and preferences of the target user group can help an enterprise or design house achieve maximum results in the competitive market.

From the overview of related studies, it is evident that 2-dimensional image analysis is frequently used by enterprises in and product image analysis at product development stage. In such analyses, the distribution of test samples in four quadrants and the segmented market sectors only by team members may be too subjective or limited. On the contrary, through the combination of web technique and 2-dimensional image analytic tool, the perceptions and preferences of consumers rather than the design team members or marketing personnel can offer an objective views and quantitative references. To enhance the competition ability in the market, the understanding of market needs is a must for an enterprise. However, literature regarding web-based 2-dimensional design decision tool is rare and more attention should be paid attention to such kind of 2-dimensional design decision tool

3. RESEARCH METHOD-The web-based design decision tool

From the above discussion, it is clear that 2-dimensional image scale has been frequently used by the industry and design houses. It is an important issue for designers to know how to extend from the few subjective views of personnel in R&D department to an objective image data of the consumers in the market. In a study of the product development of the motorcycle backpack, Huang applied image analytic tool in which a product sample could be placed in some locations on an image scale by many subjects to reflect their perceptions and preferences toward the product form [34]. The subjects' views could then be analyzed in an objective way from the calculation of the gravitation of all subjects' coordinates. In this way, the problem frequently seen in traditional image scale was solved. The average coordinates of the product samples in the design decision tool is based on the gravitation center of the locations subjects move the sample image along the axes [35]. Considering the needs of researcher and subjects in using the 2-dimensional design decision tool, an objective and efficient way to present the survey output has been introduced in the proposal system. The digital data of the coordinate subjects have for each product sample and the gravitation centers of product samples in four quadrants can be obtained for the interpretation of the output data for further statistical analysis.

Lin, Chang, and Huang combined FLASH, ASP, HTML, and database techniques to extend the function of the web-based 2-dimensional design decision tool for the collection of image data of product form [36]. Firstly, in their model, the subject profile as well as coordinates of the positions subjects place the image sample on the image scale can be obtained. Secondly, the calculation of gravitation is automatically generated and downloaded for the quantitative analysis. Thirdly, the output of statistical analysis can be visually presented for market segmentation from the distribution of the gravitation centers of the test samples. Finally, the distribution pattern for each product sample can be generated in a separated graphic to specify the potential target user groups (gender, profession, or demographic area). When the subjects enter the 2-dimensional design decision tool, they need to fill in personal data for the analysis of target user group in terms of demographic variables. Subjects key in or chose items from pull-down menu to fill in the form. When there are one or more columns left blank, they will be informed to complete the data

before they enter the 2-dimensional image scale test page. In the 2-dimensional design decision tool, the interface of the web-based 2-dimensional analytic tool can be divided into three parts as can be seen in Figure 1. Area 1 on the upper left part shows the dynamic product sample window where different views and texts regarding product features are offered; Area 2 on the lower left part contains the control buttons of the multiple dynamic views of the product samples for the download of the sample image to test; Area 3 in the right side is the test area of the analytic tool where different image words and multiple choices of image analytic tables can be provided for the evaluation according to the design goal or marketing survey. In the evaluation, the subjects are asked to place product sample images on four quadrants of the image scale. And they can remove and adjust the sample images onto the 2-dimensional image scale according to the differences of product images and their relative positions in four quadrants.

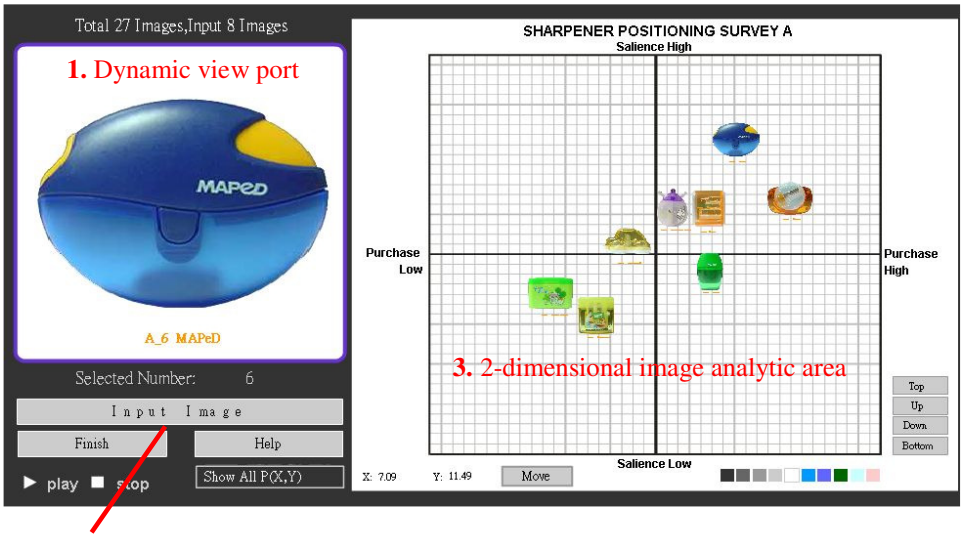


FIGURE 1: The test page of the image analytic image system

After the subjects enter their personal data and evaluate the product samples, the basic profile and coordinate data can be downloaded. In addition, the design decision tool offers a function for researchers to choose and calculate the group center. As can be seen in Figure 2, items to analyze can be selected from the checker buttons in the left side and the popup columns in the central part for the target user groups. In Figure 7, gender and test area are chosen for the cross tab analysis. It also allows the researcher to choose the specific items of a single target user group for the output data. For example, the gender and demographic items are chosen. Then the pull down menu can be used for the target user group. After the selection of demographic conditions, the researcher can choose to analyze the distribution patterns of all product samples or one specific product sample by clicking at the buttons in the lower part.

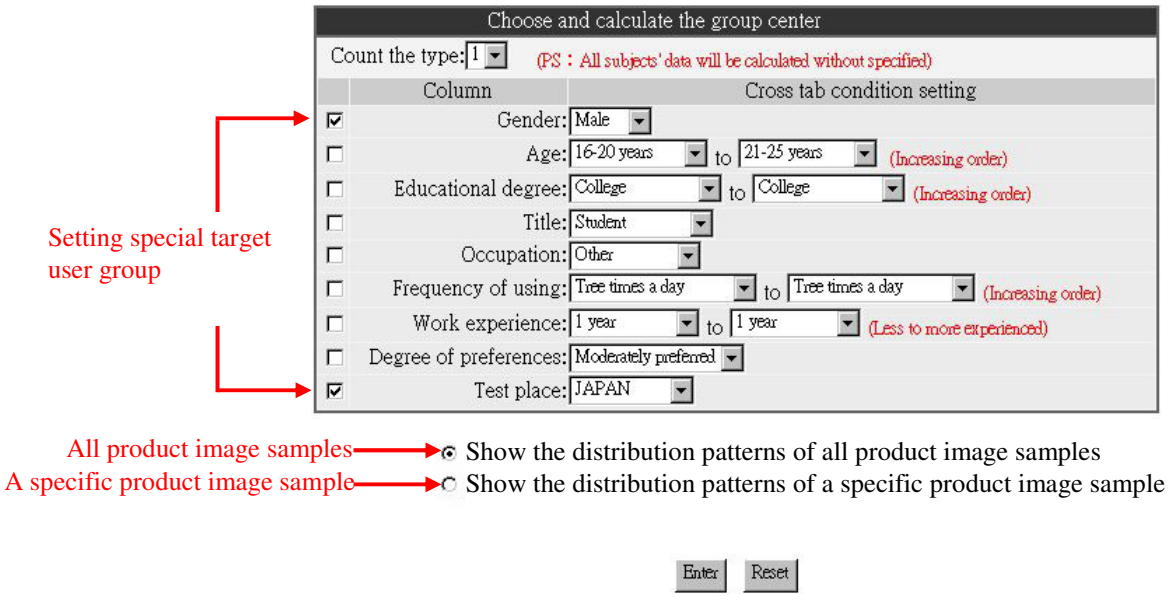


FIGURE 2: Focus of Visual Design in Packaging

For the convenience of statistical analyses, the design decision tool offer two formats of output data and the number of items can be adjusted according to the purposes of survey. From the setting of subject profile, the basic data of the subject, including the subject's name, gender, age, educational degree, company, title, work experience, frequency of product usage, product preferences, test area, telephone number, E-mail, and the like personal data, can be generated in HTML or EXCEL format. The number of items can be adjusted according to the researcher's needs. For the output data of the coordinates of the product samples, the average coordinates of a specific product sample can be generated in addition to the coordinates for each subject and can be downloaded in either HTML or EXCEL format.

In terms of the distribution pattern of product samples, the researcher can choose to generate distribution diagram of special conditions in Figure 2. For example, Figure 3a illustrates the average distribution view of portable pencil sharpeners of all subjects. This will make it easy for researchers to process market segmentation based upon the coordinates of competition product samples by checking whether there exist significant differences in varying market sectors through multi-variant analysis.

Besides, the design decision tool can offer the distribution pattern of all subjects for a single product sample to demonstrate the concentration degree of the distribution pattern or the degree of preference subjects have toward a specific product. This is shown in Figure 3b. A product highly preferred by subjects, Sample S27 is located in first quadrant with (8.42, 5.72) its gravitation center.

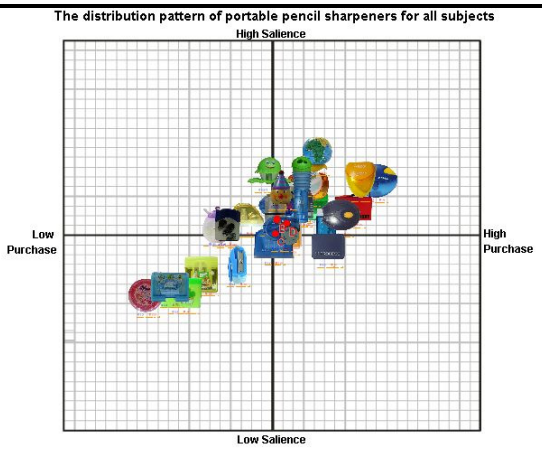


FIGURE 3a: The distribution pattern of portable pencil sharpeners for all subjects

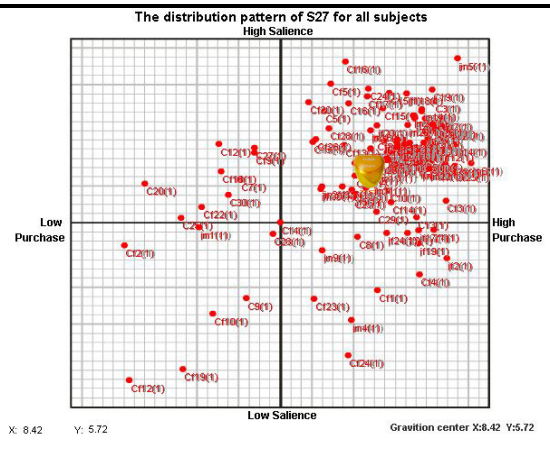


FIGURE 3b: The distribution pattern of S27 for all subjects

Moreover, the researcher can choose to generate the distribution pattern of a special target user group to understand the gravitation center and preferences of a special user group. With the coordinates of a specific product sample and the subject demographic data, the preferences of the target user group toward one certain product sample can be verified. In addition, with the gravitation center data and the morphological data of product image samples, the effects of product form elements have on product form preference can be clarified for designer's references through quantification type I analysis, a multiple regression analysis between user's preferences and product form elements.

Morphological analysis is a method frequently used for the analysis of product form, from which new product forms can be formed from the elements of the product samples. Morphological analysis can be applied in the following four steps: (1) divide the subject into several independent factors, (2) find different patterns for each individual factor, (3) reorganize the different patterns, and (4) evaluate the feasible combination modules [37]. From Quantification Type I analysis, a reference model can be obtained for the product form specification of new product. In this study, the average gravitation coordinates and form factors and categories were used for quantification type I analysis to offer references for new product form design.

In processing the web-based image analysis, the researcher should first build up the dynamic views for product samples, set up the survey topics (image words) and columns for subject profile. On the other hand, the subject can process the image evaluation through the tutorial in the Internet or be instructed face-to-face by the researcher. When the subject enters the design decision tool, they need to fill in personal data before they start the image evaluation. After the test, the subject's data will be transmitted to the database for further calculation through ASP.

After the subjects finish the evaluation, the researcher can download the data and distribution patterns on the server. First of all, the research can download the subject profile in the format of Excel or Html. With such data, the target user groups for some specific product samples can be made. In addition, through the coordinates of all subjects and the average coordinates, the preferences and product form analyses can be processed. More importantly, through the selection buttons and target user groups, special distribution patterns for competition product samples or single product sample can be generated (see Figure 4). From this the representative product samples and their form features can be selected for the references for new product design and development. The combination of quantitative data and diagrams makes it more objective to interpret the output of survey. Figure 4 illustrates the conceptual diagram of the web-based design decision tool.

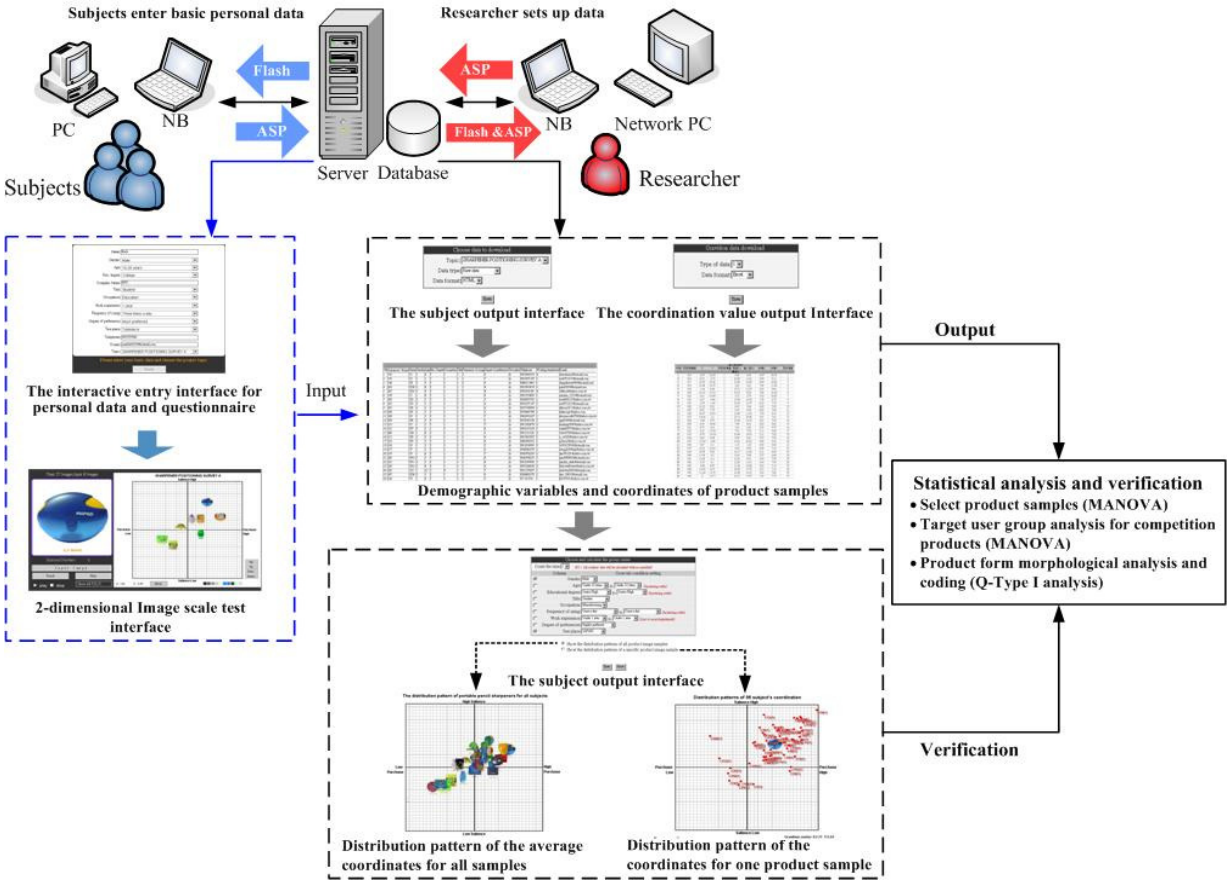


FIGURE 4: The conceptual diagram of the web-based design decision tool

Through the web-based design decision tool, the subjects' preferences toward product samples and major target user groups can be determined. For the design department, market segmentation policies and product form patterns can be offered for product design strategy through the distribution patterns of product samples in four quadrants from the target user group or all of the subjects.

4. RESEARCH RESULTS AND ANALYSIS—A PRACTICAL APPLICATION OF THE WEB-BASED DESIGN DECISION TOOL

4.1 Selecting product samples and criteria for X and Y axes

In this study, 27 portable pencil sharpeners made in Taiwan, Japan, France, and Germany were provided by the client for the web-based image evaluation. The product form images and selling prices are shown in Table 3. The image words along the evaluation axes were decided by the client and related studies. Customers in different user groups will vary in their consumer behaviors and preferences towards products [38, 39]. For example, in a study of mineral water bottle design, salience of product form and intention of purchase were chosen as evaluation criteria for the product form and marketing research. Compared with typical semantic differential experiments where many image words are used, the smaller number of image words would save a lot of time and energy of the survey and further statistical analyses [40].

For this reason, salience of product form and intention of purchase were also chosen in this study. The four quadrants constructed by these two axes, therefore, have their special strategic implications.

								
Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9
Taiwan NT:35	France NT:20	Taiwan NT:30	Taiwan NT:15	Taiwan NT:25	France NT:20	Taiwan NT:20	Japan NT:50	Japan NT:60
								
Sample 10	Sample 11	Sample 12	Sample 13	Sample 14	Sample 15	Sample 16	Sample 17	Sample 18
France NT:20	France NT:19	Japan NT:20	Japan NT:60	China NT:35	France NT:25	Japan NT:60	Japan NT:32	Japan NT:48
								
Sample 19	Sample 20	Sample 21	Sample 22	Sample 23	Sample 24	Sample 25	Sample 26	Sample 27
Japan NT:60	Japan NT:54	France NT:20	Germany NT:90	Japan NT:40	Taiwan NT:20	Taiwan NT:15	Germany NT:150	France NT:13

TABLE 3: 27 samples of portable pencil sharpeners used in the experiment

4.2 Product image analysis of the portable pencil sharpener

Through the web-based 2-dimensional analytic tool, 120 college students from Taiwan and Japan were invited to enter their perceptions of the 27 portable pencil sharpeners.

In this study, the first quadrant is chosen as the major competition area in that the subjects' intention of purchase and product form salience are of higher values. They can set to be the target area for product design appeal in the future. The second quadrant is defined as the product form competition area. Product samples in this area feature attractive product form but unacceptable price range. As a result, it's a special market area where product prices are to be adjusted. The third quadrant is considered as the rejection area in that the degrees of product form salience and price acceptability are much lower. At last, the fourth quadrant is a competition area for product prices because the samples have acceptable prices but lower salience of product form. Therefore, this area can be a section for product form to be improved.

4.2.1 Selecting product samples in terms of subjects' preferences

From the analytic system, a graphic output for the average coordination of portable pencil samples could be obtained in 10 work days. This is illustrated in Figure 5.

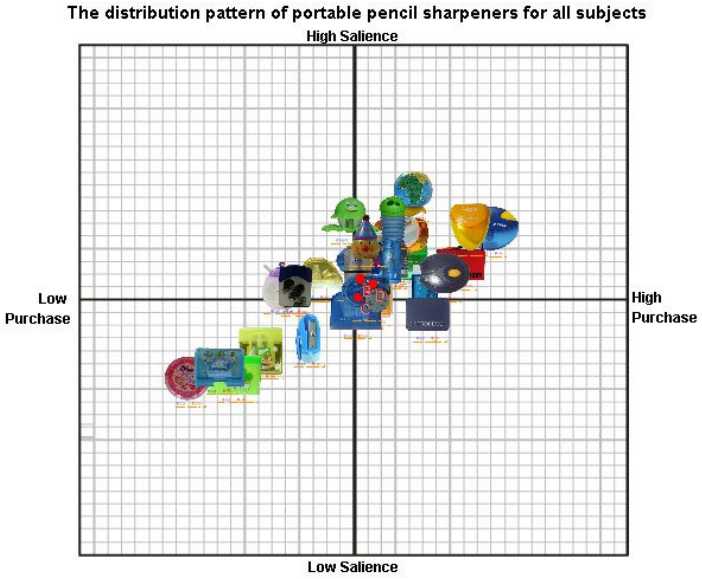
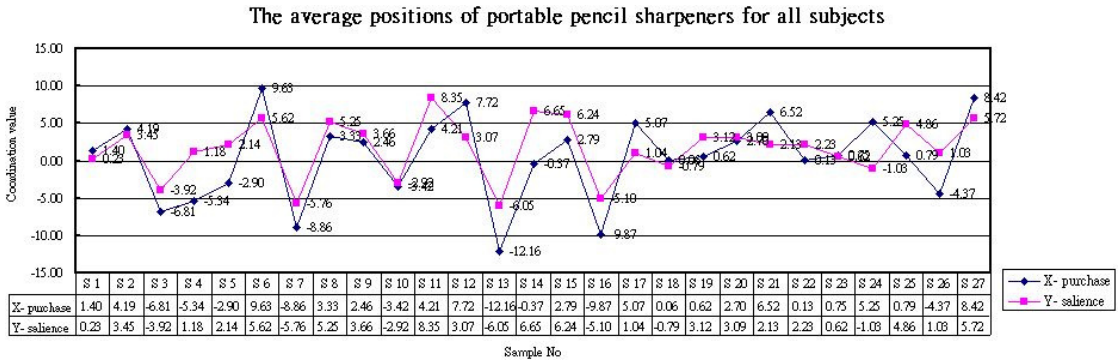


FIGURE 5: The distribution pattern of portable pencil sharpeners for all subjects

As mentioned above, the four quadrants of the view of purchase intention and product form salience vary in their strategic implications. In terms of market segmentation, product samples in first quadrant are the important ones to consider for the purpose of highly salient product form design and high purchase intention. They included 16 samples, S1, S2, S6, S8, S9, S11, S12, S15, S17, S19, S20, S21, S22, S23, S25, and S27. Among these 16 samples, 7 of them are from Japan; 6 from France, 2 from Taiwan, and 1 from Germany. These samples are the target for further analyses. The average positions of portable pencil sharpeners for all 120 subjects could be obtained from the system. It is shown in Figure 6.



	S 1	S 2	S 3	S 4	S 5	S 6	S 7	S 8	S 9	S 10	S 11	S 12	S 13	S 14	S 15	S 16	S 17	S 18	S 19	S 20	S 21	S 22	S 23	S 24	S 25	S 26	S 27
X- purchase	1.40	4.19	-6.81	-5.34	-2.90	9.63	-8.86	3.33	2.46	-3.42	4.21	7.72	-12.16	-0.37	2.79	-9.87	5.07	0.06	0.62	2.70	6.52	0.13	0.75	5.25	0.79	-4.37	8.42
Y- salience	0.23	3.45	-3.92	1.18	2.14	5.62	-5.76	5.25	3.66	-2.92	8.35	3.07	-6.05	6.65	6.24	-5.10	1.04	-0.79	3.12	3.09	2.13	2.23	0.62	-1.08	4.86	1.08	5.72

FIGURE 6: The average positions of 27 portable pencil sharpeners in terms of purchase intention and product form salience

To examine whether there existed significant differences among the above 16 competition product samples in first quadrant, a one-way Manova was conducted. Hypotheses for the Manova were H0 : $\alpha ip=0$, for all (i,p); H1 : $\alpha ip\neq 0$, for some (i,p), in which p is the number of responding variables; i is the number of single factors. The result of Manova indicated that Wilks' Lambda p value<.0001<0.05, meaning that there existed significant differences among 16 competition samples in first quadrant. Moreover, through marginal tests, it was found that these 16 samples were significantly different along X and Y axes (p value <0.0001<0.05). Furthermore, from Sheffe post hoc test, five competitive samples along X axis, the intention of purchase, were identified. In a descending order, they were S6, S27, S12, S21, S17, significantly higher than the

other eleven samples in intention of purchase. Their product selling prices fall between NT$13 and NT$32, belonging to fair price products. Among them, samples S6, S12, and S21 only sell for NT$20 and can serve as references for the policy of price setting in the future. In terms of Y axis, the product form salience, six representative portable pencil sharpeners, Samples S11, S15, S27, S6, S8, S25, were significantly more salient than the other ten samples. Among them, samples S11, S15, S27, S6, and S25 are of biomorphic styles and can serve as references for styling specification. From the competition analysis along X and Y axes, samples S6 and S27 were more preferred by the subjects. They were made in France and of the selling price of NT$20 and NT$13 respectively. Both of them feature the transparent pencil shaving case and biomorphic form. The oval shape of S6 and iMac-like feature of S27 could serve as references for new product form design.

4.2.2 Target market analysis of the test products

From literature review, it is clear that customers in different user groups vary in their preferences and purchasing behaviors. In light of this, an in-depth understanding of the target user group will help with the development of new products. In this study, Sample S6 was used as an example for the preference analysis of target user group because it performed well along both product form salience and purchase intention axes. Through the user interface as shown in Figure 2, gender and geomorphic variables were selected for the potential target user group among male Taiwanese, female Taiwanese, male Japanese and female Japanese students. A click of the lower round button can generate the output distribution graphic of a single product sample and the average coordinates of the target user group.

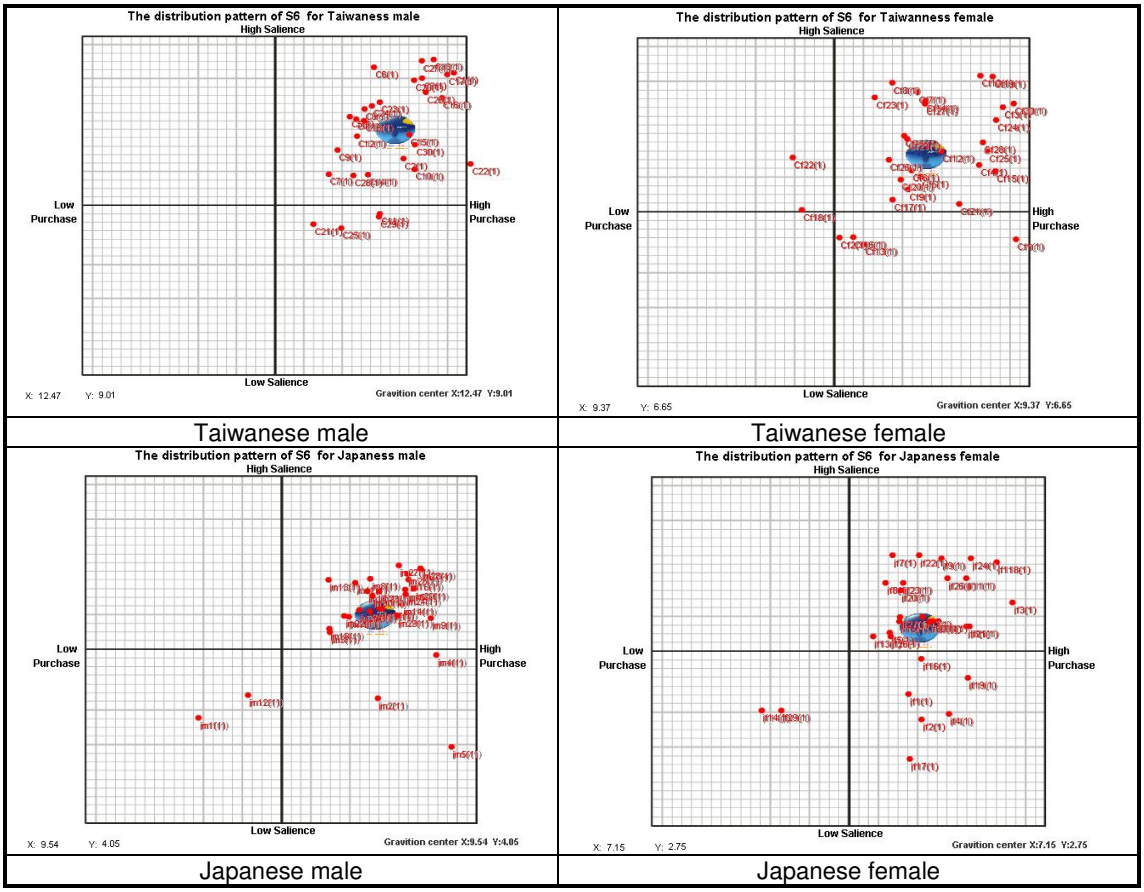


FIGURE 7: The distribution pattern of S6 for 4 target groups

Figure 7 illustrates the distribution pattern and the final average coordinate for Sample S6, (12.47, 9.01) for the degrees of purchase intention and product form salience, from the viewpoints of male Taiwanese students; (9.37, 6.65) from the viewpoints of female Taiwanese students; (9.54, 4.05) from the viewpoints of male Japanese students; and (7.15, 2.75) from the viewpoints of female Japanese students. From the above output diagrams for different target user groups, it is clear that male Taiwanese can be set as the target user group for Sample S6, of the highest coordinate (12.47, 9.01) while female Japanese group has the lowest coordinate (7.15, 2.75). Through the distribution pattern and coordinate values of single product sample, we can generate the preference conditions different user groups have toward the single product sample (S6) efficiently. This is helpful for the analysis of design and marketing.

To explore whether there existed significant differences among these target user groups, the coordinates of the subjects of four potential user groups in terms of product form salience and purchase intention of sample S6 were used for one-way Manova. The result showed that in the total test, Wilks' Lambda p value=0.0006<0.05, indicating that there existed significant differences among four potential user groups along product form salience and purchase intention. Moreover, marginal tests also showed significant differences among four potential user groups along purchase intention axis (p value=0.0040) as well as product form salience axis (p value=0.0003). Moreover, post hoc of Sheffe demonstrated that male Taiwanese students could be selected as the representative target user group. Therefore, it's reasonable for us to choose male Taiwanese students as the target user groups for a portable pencil sharpener like Sample S6. For other competition product samples, the similar methods can be used to explore whether there exist significant differences in potential consumer groups.

4.3 Morphological analysis of product form of portable pencil sharpeners

The patterns or levels of design factors of a product form represent the form treatments of a product. At the same time, it is also a systematic expression way of the design attributes of a product. Through morphological analysis, the major design factors of portable pencil sharpeners include total form, product texture, cutter, hole of sharpener, connecting structure of the pencil shaving case and the body, tip adjustment structure, broken tip retreating device, and the finish. The detailed classification for these design factors of portable pencil sharpeners are shown in Table 4.

Design factors	Design factor levels of portable pencil sharpener				
A. Total form	a1.geometric	a2.biomorphic	a3.special		
B. Product texture	b1.transparent	b2.opaque	b3.Combining transparent and opaque		
C. Cutter	c1.Clear	c2.Hidden			
D. Hole of sharpener	d1.Sliding	d2.With cover	d3.Rotating	d4. None	
E Connecting structure of the	e1.Integral	e2.Separated	e3.Without pencil shaving		
F. Tip adjustment structure	f1.Spiral	f2.Cam	f3.Sliding	f4.Dividing into parts	f5.None
G. Broken tip retreating device	g1. With retreating device		g2. Without retreating		
H. Finish	h1.Majorly texts	h2.Majorly	graphics	h3. None	

TABLE 4: Design factors and their levels of portable pencil sharpener

4.3.1 The influence of product form elements upon evaluation criteria

In this section, the purchase intention data were used to explore the influences of product form elements in students of Taiwan and Japan. To do this, the average coordinates were first standardized from the manipulation of z scores. With the standardized scores of purchase intention and codes of morphological analysis of product form of portable pencil sharpeners, a

quantification type I, a kind of regression analysis, was conducted. From this, the influences design factors and design factor levels of portable pencil sharpeners upon subjects' purchase intention were explored, from which the differences of students of two countries had on the form treatments, the design factor levels were examined.

With the output interface of the web-based 2-dimensioal analytical tool, the average coordinates of students from Taiwan and Japan can be obtained for 27 pencil sharpeners. From the above analysis, the subjects from different countries will have different distribution patterns in terms of the average coordinates of 27 pencil sharpeners. The results of Q-type I analysis for the purchase intention (X axis) of Taiwanese students indicate a multiple correlation coefficient (r)= 0.941, the determination power (r2) =0.884, and constant -0.003. For the purchase intention of Japanese students, a multiple correlation coefficient (r)= 0.968, the determination power (r2) =0.937, and constant 0.000.

Design factors	Partial correlation Taiwan	Rank order	Partial correlation Japan	Rank order
A. Total form	0.512	5	0.892	3
B. Product texture	0.486		0.858	4
C. Cutter	0.007		0.704	7
D. Hole of sharpener	0.685	3	0.809	5
E. Connecting structure of the pencil shaving case and the body	0.612	4	0.905	2
F. Tip adjustment structure	0.715	2	0.777	6
G. Broken tip retreating device	0.184		0.127	
H. Finish	0.909	1	0.949	1

TABLE 5: Partial correlations design factors of portable pencil sharpeners have on the purchase intention of Taiwanese and Japanese students

From Q-type I analysis, different design elements (design factors) would cast different influences on the subject's purchase intention of portable pencil sharpeners. This is shown by the value of partial correlation coefficients, which reflect the degree of relative importance of design factors or the product form elements. The partial correlations and rank orders of design factors of portable pencil sharpeners have on purchase intention of Taiwanese and Japanese students are shown in Table 5. In this study, the design factors whose partial correlation coefficients were bigger than 0.5 were chosen as important design factors. The rank order of form element's relative importance on Taiwanese students' purchase intention of portable pencil sharpeners was Finish (0.909)>Tip adjustment structure (0.715)>Hole of sharpener (0.685)>Connecting structure of the pencil shaving case and the body (0.612)>Total form (0.512). For Japanese students, the rank order of form element's relative importance on their purchase intention of portable pencil sharpeners was Finish (0.949)>Connecting structure of the pencil shaving case and the body (0.905)>Total form (0.892)>Product texture (0.858)>Hole of sharpener (0.809)>Tip adjustment structure (0.777)>Cutter (0.704). The results of the rank order of relative importance of form elements on subject's purchase intention demonstrated that there existed differences between Japanese and Taiwanese students.

From the viewpoint of marketing, the design elements of the product form of portable pencil sharpeners would cast different degrees of influence upon the subject's intention of purchase, which is shown in the category scores in Table 6. In terms of total form of pencil sharpeners, special form (a1) is highly suggested and samples S8(0.73), S9(1.61), S10(0.09) can be the

major competition products for references, whereas biomorphic form (a2) is most preferred by Japanese students. Samples S11(10.59), S14(6.38), S15(5.36), S25(2.37),and S27(11.35) can be the major competition products. For the sharpener hole design, Taiwanese students would prefer one with cover (d2) and S1(1.13), S17(4.18), S22(2.39), S24(4.29) can serve as references, while Japanese students would like to have a rotating hole design (d3) and samples S8(5.93) and S20(5.15) can be the major competition products for references. As far as connecting structure, tip adjustment structure and finish of pencil sharpeners, Japanese and Taiwanese students have the same preference in these design factors. For the connecting structure of pencil shaving case and the body, a separated (e2) style is suggested and samples S6, S11, S27 can be referred. For the tip adjustment structure design, sliding style (f3) and sample S6 cab be considered. For the finish design, text labeling (h1) can be the major medium and samples S6, S12, S17, S21, S24, S27 can serve as references for designers. For the purpose of highest intention of purchase, the strategy of product form design should be different for the student market places in Taiwan and Japan.

Taiwanese students		Design factor levels of portable pencil sharpeners	Japanese students	
Design factors	category scores		category scores	Design factors
A. Total form	a1. -0.230	a1. Geometric	a1. -0.334	A. Total form
	a2. 0.030	a2. Biomorphic	a2. 0.915	
	a3. 0.868	a3. Special form	a3. -0.264	
B. Product texture	b1. -0.223	b1. Transparent	b1. -0.325	B. Product texture
	b2. 0.398	b2. Opaque	b2. 0.879	
	b3. -0.238	b3.Combining transparent and opaque	b3. -0.597	
C. Cutter	c1. 0.003	c1. Clear	c1. 0.324	C. Cutter
	c2. -0.005	c2. Hidden	c2. -0.472	
D. Hole of sharpener	d1. -0.755	d1. Sliding	d1. -0.683	D. Hole of sharpener
	d2. 0.195	d2. With cover	d2. 0.378	
	d3. 0.125	d3. Rotating	d3. 0.489	
	d4. 0.100	d4. None	d4. -0.064	
E. Connecting structure of the pencil shaving case and the body	e1. 0.058	e1. Integral	e1. -0.156	E. Connecting structure of the pencil shaving case and the body
	e2. 0.101	e2. Separated	e2. 0.436	
	e3. -2.015	e3.Without pencil shaving case	e3. -3.041	
F. Tip adjustment structure	f1. -0.429	f1. Spiral	f1. 0.466	F. Tip adjustment structure
	f2. -1.441	f2. Cam	f2. 0.003	
	f3. 1.301	f3. Sliding	f3. 1.394	
	f4. -0.007	f4. Dividing into parts	f4. -0.348	
	f5. 0.092	f5. None	f5. -0.073	
G. Broken tip retreating device	g1. 0.131	g1. With retreating device	g1. 0.076	G. Broken tip retreating device
	g2. -0.046	g2. Without retreating device	g2. -0.027	
H. Finish	h1. 0.785	h1. Majorly texts	h1. 0.796	H. Finish
	h2. -0.898	h2. Majorly graphics	h2. -0.854	
	h3. -1.230	h3. None	h3. -1.418	

TABLE 6: The category scores of design factor levels of portable pencil sharpeners on the purchase intention of Taiwanese and Japanese students

5. CONCLUSION AND SUGGESTION

In order to specify the most competitive products from the website survey from the viewpoints of Taiwanese and Japanese college students, portable pencil sharpeners were used as an example to explore the potential user's preferences and perception of product form salience through a web-based design decision tool. The results indicated that, in ten days of survey, the web-based analytic system could largely reduce the questionnaire survey and data logging of product samples. Furthermore, human errors in data logging could also be avoided.

Product market segmentation can be made by the web-based 2-dimensional image analytical system. 16 portable pencil sharpeners in first quadrant could be selected as competition products. And from multivariate analyses of variance, major competition products along intention of purchase (X axis) and product form salience (Y axis) could be identified. As far as the product form features are concerned, there existed some remarkable differences between Taiwan and Japan in terms of their intension of purchase to the combinations of product form elements. Designers therefore, should pay attention to such differences and deal with them subtly.
At last, the authors reached the following conclusions:

(a) In addition, the application of image scale analysis of products is executed by experts or designers, which is more subjective. In the analytical tool proposed in this study, the survey is conducted directly by consumers and can reflect the preferences and viewpoints of the target user group in the market. The results of the marketing survey are, therefore, more objective.
(b) The web-based survey can serve as an analytical tool for the policy of market segmentation from competition analysis of the major competition products. From multivariate analyses of variance, there were five major competition products along intention of purchase, with the price range between NT$13 to 32. Among these five competitive products, three of them, Samples S6, S12, S21 only sold for NT$20 and could serve as references for the setting of product prices. In terms of purchase intention, samples S11, S15, S27, S6, S8, and S25 were six major competition products. Among them, samples S11, S15, S27, S6, S25 have biomorphic form features. This analytical tool can help designers and marketing personnel in enterprises take hold of consumer's preferences and set a proper policy for further product development.
(c) The output diagrams and tables provided in the image analytical system are helpful for the target user group's preferences. And from the distribution of target user group's preferences toward a single product, the preferences of different target user groups can be identified. From the study, it is clear that sample S6 is the favorite pencil sharpener for male Taiwanese students. In the proposed analytical system, further analyses can be conducted from the setting of the target user group so as to download the tables and graphics in real time; thus designers or researchers can keep preferences of different target user groups in control.
(d) In enterprises or design consultants, image scale analysis is generally applied for product classification and market segmentation. In this study, its function is extended to the morphological analysis of product form. With the average coordinate data and morphological charts for product form analysis, product form design specifications can be made through quantification type I analysis. It has been found that Taiwanese and Japanese students are different in their preferences toward different combination of product form patterns, which serves as references for the new product form development.

Due to the limitation of time and energy, only portable pencil sharpeners were explored in this study. In the future, more criteria can be surveyed in the 2-dimensional analytic system. Other important demographic variables can be added for the emotional and marketing purposes. Based upon the requirements of survey or goals in product design or marketing analysis, other criteria or concepts can be added in the analytical system. Finally, more life style variables can be used as criteria or put in the AIOs questionnaire survey for market segmentation in new product design and development

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Manager's Preferences Modeling Within Multi-Criteria Flowshop Scheduling Problem: A Metaheuristic Approach

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Abstract

This paper proposes a metaheuristic to solve the permutation flow shop scheduling problem where several criteria are to be considered, i.e., the makespan, total flowtime and total tardiness of jobs. The proposed metaheuristic is based on tabu search algorithm. The Compromise Programming model and the concept of satisfaction functions are utilized to integrate explicitly the manager's preferences. The proposed approach has been tested through a computational experiment. This approach can be useful for large scale scheduling problems and the manager can consider additional scheduling criteria.

Keywords: Permutation Flowshop, Multi-Criteria Scheduling, Compromise Programming, Satisfaction Functions, manager's Preferences.

1. INTRODUCTION

The aim of the scheduling theory is the allocation of a set of limited resources to process a given number of jobs (MacCarthy and Liu,[20]). More specifically, a scheduling problem consists of finding the sequence of a set of jobs (tasks) to be processed on different machines, so that technological constraints are satisfied and one or several performance criteria are optimized (T'kindt and Billaut, [23]). The scheduling literature reveals that several criteria should be considered to present more realistic solutions to the production manager. However, it is generally impossible to find a sequence that optimizes simultaneously different conflicting scheduling criteria. Thus, the manager must consider the sequence of the best compromise. Hence, the manager needs to make some trade-offs between the scheduling criteria. Thus, the obtained solution will be a satisfactory solution.

Several approaches and models are proposed to solve the scheduling problem, namely discrete variable mathematical programming, simulation techniques and network analysis. Specific algorithms and heuristics have been utilized to deal with the scheduling problem. The choice of an appropriate approach depends on the complexity of the problem, the number of the jobs to be scheduled, the configuration of the machines, the production system and the nature of the job arrivals (static or dynamic). For example, Gangadhran and Rajendran [10] have applied the Simulated Annealing technique to minimize the makespan and the total flow time (ΣC_i). Kondakci *et al*. [17] have utilized the shortest processing time and the earliest due date rules to minimize the total flow time and the maximum tardiness penalties. We also notice many other algorithms have been developed to deal with multi-criteria scheduling problems.

Gupta *et al*. [16] have proposed some heuristics to solve a bi-criteria scheduling problem. Arroyo and Armentano [5] have proposed a partial enumeration heuristic for multi-objective flowshop scheduling problem where they provide the manager with approximate Pareto optimal solutions.

Their heuristic offers a set of feasible solutions and the manager's preferences are partially considered according to *a posteriori* articulation.

Armentano and Arroyo [4] have proposed a new tabu search algorithm for multi-objective combinatorial problems with the aim of obtaining a good approximation of the Pareto-optimal or efficient solutions. A nice feature of this multi-objective algorithm is that it introduces only one additional parameter, namely, the number of paths. This algorithm is applied to the permutation flowshop scheduling problem in order to minimize the criteria of makespan and maximum tardiness. For instances involving two machines, the performance of the algorithm is tested against the Branch-and-Bound enumeration algorithm, and for more than two machines it is compared with that of a tabu search algorithm and a genetic local search algorithm, both from the literature. Computational results show that the heuristic proposed by Armentano and Arroyo [4] yields to a better approximation than these algorithms.

Allahverdi [1] was interested in a machine flowshop problem with the objective of minimizing a weighted sum of makespan and maximum tardiness. Varadharajan and Rajendran [26] presented a multi-objective simulated annealing algorithm (MOSA) for permutation flowshop scheduling to minimise the makespan and total flowtime for jobs. The MOSA seeks to obtain non-dominated solutions through the implementation of a simple probability function that attempts to generate solutions on the Pareto-optimal front. Framinan and Leisten [7] tackle the problem of total flowtime and makespan minimisation in a permutation flowshop. The authors have introduced a multi-criteria iterated greedy search algorithm. Their algorithm iterates over a multi-criteria constructive heuristic approach to yield a set of Pareto-efficient solutions.

Loukil *et al*. [19] have adapted the MOSA to solve a multi-criteria flowshop scheduling problem. Lemesre *et al*. [18] proposed an exact method to solve a bi-criteria scheduling problem named the parallel partitioning method. This method allows the generation of efficient solutions. According to Lemesre *et al* [18], their method requires less CPU time comparatively to the two phases method of Ulungu and Teghem [25]. In their book, T'kindt and Billaut [23] present a quite complete literature review regarding multi-criteria scheduling theory.

Gagné *et al.* [9] have proposed a generic approach to finding compromise solutions for multiple-objective scheduling problems using metaheuristics. As an illustration, they present a new hybrid *Tabu Search/Variable Neighbourhood Search* (*Tabu-VNS*) application of this approach for the solution of a bi-objective scheduling problem. Through numerical experiments they demonstrate its efficiency and effectiveness. They have confirmed that compromise programming with the *Tabu-VNS* metaheuristic generates solutions that approach those of the known reference sets. Gagné *et al.* [8] presented an adjustment of an Ant Colony Optimization for an eventual use in a generic research procedure of compromise solutions for single machine scheduling problem.

Our literature review of multi-criteria scheduling problems shows that a large number of the proposed approaches to solve the flow shop scheduling problems do not take into account explicitly the manager's preferences. However, Aouni *et al.* [3] and Allouche *et al.* [2] have developed an aggregation procedure that considers three different criteria to obtain the best sequence in a flowshop production environment. The authors utilize the compromise programming model and the concept of satisfaction functions to integrate explicitly the manager's preferences. The satisfaction functions measure the intensity of preference regarding the deviations between the achievement and the aspiration levels of the following criteria: makespan, total flow time and total tardiness. Their procedure is easy to apply and it requires few parameters (thresholds) to be provided by the manager. The satisfaction functions thresholds have a specific economic interpretation that the manager can understand and provide the values. The proposed model can be extended to introduce additional criteria. This model provides the best scheduling sequence that satisfies the manager's preferences. However, this approach is sensitive to the size of the scheduling problem to be solved. It requires a large computational time for the large scale problems. To deal with such difficulty, we recommend the use of metaheuristics which is the purpose of this paper.

The aim of this paper is to propose a metaheuristic based on the tabu search algorithm to solve a multi-criteria scheduling problem. The new proposed approach will explicitly incorporate the structure of manager's preferences with the use of satisfaction function concept.

This paper is organised as follows. The description of the proposed metaheuristic is given in the second section. In fact, this metaheuristic is based on three components which are the compromise programming model, the concept of satisfaction functions and the tabu search algorithm. The third section presents the different steps of the proposed metaheuristic. These steps are useful for obtaining the sequence of the best compromise. The computational experiments and results are summarized in the fourth section.

2. METAHEURISTIC COMPONENTS

Within this section, we will describe the proposed metaheuristic. This metaheuristic is based on the three following components: a) the Compromise Programming model, b) the concept of Satisfaction Functions, and c) the tabu search algorithm.

2.1. Compromise Programming Model

The Compromise Programming model (CP) was introduced first by Zeleny [29]. This model is based on the minimization of the distance between the achievement level ($f_q(x)$) of objective q and the ideal value (g_q^*) of this objective. This model is based on the Zeleny's axiom of choice where the solutions that are closer to the ideal points (g_q^*) are preferred to those that are farther (Zeleny, [27], [28]).

2.2. Satisfaction Function in Compromise Programming Model

In this section we will utilize the concept of the satisfaction functions to formulate a scheduling model where the manager's preferences are explicitly incorporated. Martel and Aouni [21] have introduced the concept of satisfaction functions in the Goal Programming (GP) model. Through this concept, the manager can explicitly express his/her preferences regarding the unwanted deviations between the achievement and the aspiration levels associated to the different objectives. Figure 1 illustrates the general shape of the satisfaction functions.

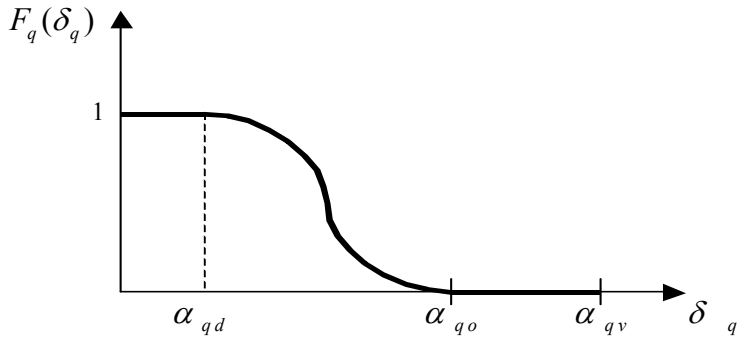

FIGURE1: General shape of satisfaction function

where:

$F_q(\delta_q)$: value of satisfaction function for deviation δ_q ,

α_{qd} : indifference threshold,

α_{qo} : *nil* satisfaction threshold,

α_{qv} : *veto* threshold.

The satisfaction functions measure the intensity of the manager's preferences regarding the unwanted deviations between the achievement level $f_q(x)$ and the ideal value g_q^* ($\forall q \in Q$). The intensity of preference $F_q(\delta_q)$ for each objective is defined on the interval $[0;\ 1]$. Thus, there is no need for computing the nadir point that usually used for the normalization procedure in the CP model. In their paper, Martel and Aouni [21] propose different shapes that the manager can adopt to elucidate explicitly his/her preferences. The manager can choose or adapt one of functions presented by figure2.

This list of satisfaction functions neither exhaustive nor restrictive. The manager will adopt the one that reflects better and accurately his/her preferences. For the purpose of illustration, we will utilize the satisfaction function of type (d) (Fig. 2). This function will be applied to the three criteria (makespan, total flowtime and total tardiness) that we are considering in our computational experiment.

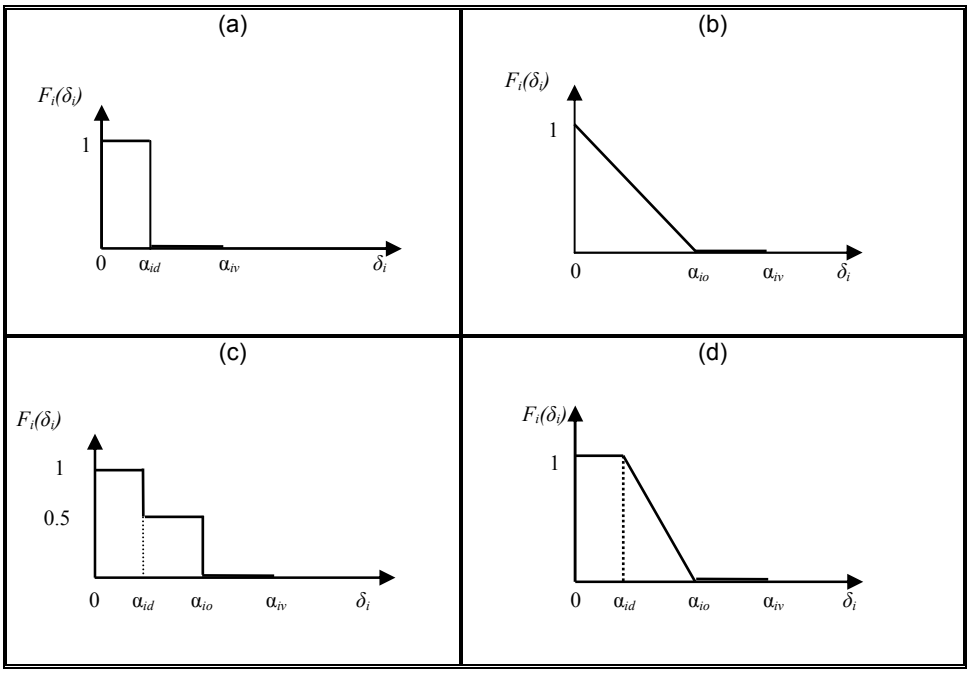

FIGURE2: Different shapes of satisfaction functions

2.3. The tabu search algorithm

The tabu search algorithm has been developed by Glover [11] and it was the first general framework for modern heuristic search. This algorithm is considered as a general iterative approach of combinatorial optimization. The details of the tabu search algorithm are available in the following references: Glover ([12],[13]), Glover *et al*. [15] and Glover and Laguna [14]. In this paper, – through a new metaheuristic based on tabu search algorithm, we look for a best scheduling sequence that takes into account the manager's preferences. The details of each step of this metaheuristic will be presented in the next section.

3. METAHEURISTIC STEPS

In this section, we will present the different steps of the proposed metaheuristic for multi-criteria scheduling problem. The first step determines the lower bounds of each criterion and the second step consists of determining the best compromise sequence.

3.1. Step 1: Finding the Best Values

We consider the best values as the ideal points obtained by optimizing each criterion separately. For this, a metaheuristic based on a tabu search algorithm was developed and has the following characteristics:

- ***Initial solution***: randomly generated;
- ***Neighbourhood structure***: we consider all permutation as a solution. The permutation's neighbourhood is created by a set of moves. Given a sequence *s*, let *i* and *j* be two positions in this sequence ~~*s*~~. A neighbour of *s* is obtained by interchanging the jobs in positions *i* and *j* which are randomly selected.
- ***Selection of the best neighbour***: the objective function is to minimize the makespan, the total flowtime and the total tardiness. In fact, we define best by reference to the objective function's value. The best neighbour has to be non tabu or tabu and satisfying the aspiration criteria.
- ***Tabu list***: the size of tabu list is fixed at 7. This means that the tabu list contains 7 prohibited moves. Note that this list is managed in a circular manner.
- ***Aspiration criteria***: we used the simplest form of aspiration criterion which is stated as follows: a tabu move is accepted if it produces a solution better than the best obtained so far.
- ***Stopping criteria***: the algorithm is stopped when it reaches a number of iterations without improvement of the evaluation function. This parameter is fixed in advance.

The developed metaheuristic was tested through a set of problems used by Taillard [24] and are in - "OR library" [22]. These problems have different sizes such as 20 jobs (5-10-20 machines), 50 jobs (5-10 machines) and 100 jobs (-5 machines). For each size of problem, we have tested 10 different instances.

In order to evaluate the performance of the developed metaheuristic, we are used Taillard's benchmarks for the makespan criterion. The obtained results are quiet similar to those presented by Taillard's benchmarks. The platform of our computational experiments is personal computer "Pentium Centrino: Dell Latitude D810" with a 1.73 GHz processor. These set of problems have been also used to determine the best values of the total flowtime and total tardiness. So, tables 1 and 2 summarize the best values of makespan and total flowtime criteria for the problem size 20 jobs – 20 machines and the CPU time. In the other hand, in order to obtain the best value of total tardiness criterion, we are, first, referred to the Daniels and Chambers [6] technique to generate due date of jobs. The due date (d_j) of jobs is randomly generated within the following interval:

$$d_j \in \left[ABP\left(1\text{-}T\text{-}\frac{R}{2}\right),\ ABP\left(1\text{-}T\text{+}\frac{R}{2}\right)\right],$$

$$ABP=\left(n+m-1\right)\bar{P} \text{ and } \bar{P}=\frac{\sum_{i=1}^{n}\sum_{j=1}^{m}P_{ij}}{n\times m},$$

where:

ABP: the Average Busy Period that serves as an approximation of the achievement time of the job in the sequence.

T: delay factor or average percentage of overdue jobs, $T \in \{0.4;\ 0.6;\ 0.8\}$,

R: factor controlling the extent of due dates, $R \in \{0.2;\ 0.6;\ 1\}$,

$\bar{P}$: Mean processing time,

n: number of jobs,

m: number of machines.

Problems	Best founded value	Time (seconds)
20_20_1	2297	16.794
20_20_2	2099	19.027
20_20_3	2326	19.805
20_20_4	2223	33.380
20_20_5	2291	21.391
20_20_6	2226	31.716
20_20_7	2273	39.386
20_20_8	2200	17.355
20_20_9	2237	22.001
20_20_10	2178	31.436
Average value of CPU time:		**25.229**

TABLE 1: Best founded values of 20PF/20/C_{max}

Problems	Best founded value	Time (seconds)
20_20_1	33816	41.157
20_20_2	31674	34.032
20_20_3	33920	31.281
20_20_4	31722	20.766
20_20_5	34557	48.234
20_20_6	32753	34.250
20_20_7	32922	35.516
20_20_8	32444	21.641
20_20_9	33623	42.046
20_20_10	32262	40.204
The average value of the CPU time:		**34.912**

TABLE 2: Best founded values of 20PF/20/ ΣC_i

Note that the due date of each job was computed with T equal to 0.4 and R equal to 0.6. Table 3 represents the best values of the tardiness criterion. In this context, the obtained values will help the manager to obtain a sequence which better reflects his/her preferences. In the second step, we propose a new approach that takes into account the manager's preferences by utilizing the concept of satisfaction function. We believe that this will give more flexibility to the manager to express explicitly his preferences.

Problems	Best founded values	Time (seconds)
20_20_1	11019	37.782
20_20_2	10435	44.391
20_20_3	12095	15.819
20_20_4	9509	48.343
20_20_5	13526	55.297
20_20_6	10402	43.253
20_20_7	12509	39.703
20_20_8	9334	38.062
20_20_9	10138	39.012
20_20_10	10478	40.204
The average of the CPU time:		**40.1866**

TABLE3: Best founded value of 20PF/20/ ΣT_i

3.2. Step 2: Determining the best compromise solution

A new metaheuristic based on tabu search algorithm has been developed to generate the sequence of the best compromise. The manager's preferences are expressed using the satisfaction functions.

a) Basis Concepts

The basic concepts of the proposed algorithm are presented as follows:

- ***Initial sequence***: it can be selected from the set of three sequences obtained by optimizing each criterion as it has been presented in the previous step. The selected sequence will be stored in memory.
- ***Neighbourhood structure***: the retained neighbourhood consists on a permutation of two jobs selected randomly.
- ***Selection of the best neighbour***: the best neighbour is the sequence which offers to the manager the highest satisfaction level. To do so, we evaluate the neighbourhood and we choose the best one non-tabu or tabu and satisfy the aspiration criteria.
- ***Tabu list***: the tabu list is managed in a circular manner. In this list, 7 prohibited moves can appear.
- ***Aspiration criteria***: we used the simplest form of aspiration criterion which is stated as follows: a tabu move is accepted if it produces a sequence better than the best obtained so far.
- ***Stopping criteria***: the algorithm is stopped when it reaches a number of iterations without improvement of the evaluation function. This number is fixed in advance.

In addition to these concepts, the set of Pareto optimal solutions is used. It contains all non-dominated sequences. In fact, the principle of dominance concerns only the value of the optimized criteria and not the value of the objective function.

b) The algorithm structure

The proposed algorithm is as follows:

Initialisation

- Initial sequence s_o
- $s_n = s_o$, $f^* = f(s_o)$
- LT = Φ, PE = $\{s_o\}$

Iterative Processes

1. – Generate the neighborhood of the current sequence s_n
   - Select the best neighbour of s_n, $s^* \in SV(s_n)$

2. A) if s^* is a non-dominate sequence
   - if the move s_n to s^* is non tabu
   » » update the tabu list LT
   - Update the set of Pareto optimal sequence PE
   - $s_{n+1} \leftarrow s^*$
   - if $f^* < f(s^*)$:
   - initialize the iteration counter
   - $f^* \leftarrow f(s^*)$
   - go to 3

   Otherwise, go to C)

   B) if s^* is a dominated solution
   - if the move s_n to s^* is non tabou
   - Update the tabu list LT
   - $s_{n+1} \leftarrow s^*$
   - go to C)
   - Otherwise:
   - chose s'^* such that $f(s'^*) = Max \{ f(s_i), s_i \in SV(s_n)$ and s_i non-tabu$\}$,
   - $s_{n+1} \leftarrow s'^*$

   C) i = i+1, (increment the iterations counter),

3. if the iterations counter is less than the number of iterations without improvement, go to 1..
   Otherwise, End.

Where:
s_o: initial sequence;
s_n: current sequence;
s_{n+1}: new current sequence;
LT: tabu list;
PE: set of the Pareto optimal sequences;
$SV(s_n)$: neighbourhood of the current sequence.

This algorithm is based on two stages which are: a) generating an initial sequence, and b) generating a neighbourhood sequence. The initial sequence is chosen from among the three calculated sequences in step 1. In this stage, the tabu list is empty and the set of the Pareto optimal sequence contains only the initial sequence which later becomes the current sequence of the second phase. The neighbourhood sequence is generated in order to choose the best that has the highest satisfaction level. Dominance tests will be established followed by an update of the set of Pareto optimal sequences and hence the current sequence. For each iteration, we proceed in the same way until we reach the algorithm's stopping condition.

c) The algorithm description

The initial sequence (s_o) is generated from step 1. At this stage, we obtain three sequences which correspond to the three criteria optimized alternately, so that the choice of the initial sequence is made in an arbitrary manner. This sequence is stored in memory as the best sequence found (s_n) and will be assigned to the set of Pareto optimal sequences. Thus, it is classified as a current

sequence. Starting from this sequence, the iterative process of the algorithm starts by obtaining a new sequence at each iteration. Indeed, a search in the neighbourhood is made to find the best neighbour (s*). The quality of the sequence is evaluated through the objective function value, but without taking into consideration the value of the objective function of (s_n). The best neighbour of the current sequence thus obtained will be tested for dominance over all the set of Pareto optimal sequences. This test is done by comparing the values obtained for each criterion. In such context, two cases appear:

- The best neighbour of the current sequence is not dominated:
This means that there are no sequences to be considered, belonging to the set of Pareto optimal sequences, which dominates. Therefore, this sequence will be chosen as the new current one if it is not subject to a tabu status, or through the application of the aspiration criterion which revokes that tabu status. An update of the list of the Pareto optimal sequences will be done by eliminating any soequence dominated by (s*). At this stage, we conduct a comparison between the best objective function value of the old sequence f* and the current sequence f (s*). If the latter case is better than f*, its value will be stored in memory and the counter of iterations will be initialized again to make another iteration. Therefore, the iterative process stops after a certain number of iterations without improving the objective function value.

- The best neighbour of the current sequence is dominated:
In such case, we will check the status of the sequence. If the movement from which the sequence was obtained is not tabu, the best neighbour is used to explore the neighbourhood in search of other sequences. It will serve as a starting point for the next iteration. Nevertheless, if this movement is tabu, the new current sequence of the next iteration is the neighbour who is not tabu and maximizes the objective function value. This process is repeated for each iteration until stopping the algorithm.

This metaheuristic was tested through a computational experience that we will present the results in the next section.

4. COMPUTATIONAL RESULTS

Several tests were conducted to check the performance of the proposed metaheuristic. We have used several problems, presented by Taillard [24] with different sizes such as: 20 jobs-5 machines; 20 jobs-10 machines; 20 jobs-20 machines; 50 jobs-5 machines; 50 jobs- 10 machines and 100 jobs-5 machines. For each problem, we took 10 different instances. Table 4 shows the date file of one scheduling problem characterized by 20 jobs-5 machines

4.1. Parameters file

In this file, we inscribe the information about the best values obtained for each criterion, type of satisfaction function used, different thresholds, weights of criteria, tabu list length, neighbourhood list length and the number of iterations without improvement.

```
                                \Satisfaction Functions/
      _____________________________
      Path and name of the data file:>sat205-1.txt

Number of tasks :20     Number of machines :5
      _____________________________
      Simulation parameters File:>excel205-1.txt
      _____________________________________
      Lower bounds, SF type and Thresholds

Makespan:>1278.00
            SF Type: 4      Weight:0.400
            Threshold 1: 100.00     Threshold 2: 180.00     Veto: 200.00

Flow time:>14108.00
            SF Type: 4      Weight:0.400
            Threshold 1: 500.00     Threshold 2: 1100.00    Veto: 1200.00

Total tardiness:>815.00
            SF Type: 4      Weight:0.200
            Threshold 1: 250.00     Threshold 2: 1400.00    Veto: 1500.00
      _________________
      Tabou parameters

Tabou list length : 7
Neighbourhood list length : 50
Number of iteration : 2000

      Introduce initial solution Y/N (y/n) ? :>y
      _____________________
      Initial solution file:>sat205-1.txt

Initial solution
9_15_11_3_13_17_14_19_6_5_1_4_2_18_7_8_16_10_20_12

CMAX:1278.000   ΣCi :15117.000   ΣTi:2045.000 Sat. level:0.4902
```

TABLE 4: Exemple of provided data

4.2. Initial sequence file

This file indicates which initial sequence will be used to start the iterative process of the algorithm. This sequence is chosen among a set of three sequences obtained through the optimization of only one criterion. We find also the values of the three optimized criteria and the value of the satisfaction level. Ten (10) test problems were generated. Table 5 and 6 summarize the obtained results. Based on the results we can conclude that the proposed approach is able to solve multi-criteria permutation flowshop problems in different sizes and integrate explicitly the manager's preferences. In fact, the obtained sequences respect the manager's preferences which may explain the high level of the achieved satisfaction. In this context, the average of satisfaction degree for the following problems (20-5), (20-10), (20-20), (50-5), (50-10) and (100-5) is equal to 1; 0.952; 0.9126; 1; 0.9508 and 1 respectively.

Based on the obtained results in Tables 5 and 6, some benefits of the proposed approach can be identified; it is fast and flexible. The speed of the approach is measured by the computation time required to solve different sizes of problems. The mean computation time is equal to 260.87 seconds for the 20 jobs -20 machines problems. This time may be acceptable. On its flexibility, the proposed approach can solve different problems with different satisfaction levels. Similarly, in its current version, this approach includes all necessary components to add other performance criteria.

Problems	Satisfaction level	Problems	Satisfaction level	Problems	Satisfaction level
Job_20_5_1	1	*Job_20_10_1*	0.9985	*Job_20_20_1*	1
Job_20_5_2	1	*Job_20_10_2*	0.6168	*Job_20_20_2*	1
Job_20_5_ 3	1	*Job_20_10_ 3*	1	*Job_20_20_ 3*	0.96
Job_20_5_4	1	*Job_20_10_4*	1	*Job_20_20_4*	1
Job_20_5_5	1	*Job_20_10_5*	0.93	*Job_20_20_5*	0.69
Job_20_5_6	1	*Job_20_10_6*	1	*Job_20_20_6*	0.834
Job_20_5_7	1	*Job_20_10_7*	1	*Job_20_20_7*	0.82
Job_20_5_8	1	*Job_20_10_8*	0.9814	*Job_20_20_8*	0.96
Job_20_5_9	1	*Job_20_10_9*	1	*Job_20_20_9*	0.894
Job_20_5_10	1	*Job_20_10_10*	1	*Job_20_20_10*	0.968
Average	**1**	Average	**0.952**	Average	**0.9126**

TABLE5: Obtained satisfaction level for problems (20-5), (20-10) and (20-20)

Problems	Satisfaction level	Problems	Satisfaction level	Problems	Satisfaction level
Job_50_5_1	1	*Job_50_10_1*	0.9955	*Job_100_5_1*	1
Job_50_5_2	1	*Job_50_10_2*	1	*Job_100_5_2*	1
Job_50_5_ 3	1	*Job_50_10_ 3*	1	*Job_100_5_ 3*	1
Job_50_5_4	1	*Job_50_10_4*	0.8919	*Job_100_5_4*	1
Job_50_5_5	1	*Job_50_10_5*	1	*Job_100_5_5*	1
Job_50_5_6	1	*Job_50_10_6*	1	*Job_100_5_6*	1
Job_50_5_7	1	*Job_50_10_7*	1	*Job_100_5_7*	1
Job_50_5_8	1	*Job_50_10_8*	0.9888	*Job_100_5_8*	1
Job_50_5_9	1	*Job_50_10_9*	0.848	*Job_100_5_9*	1
Job_50_5_10	1	*Job_50_10_10*	0.7837	*Job_100_5_10*	1
Average	**1**	Average	**0.9508**	Average	**1**

TABLE 6: Obtained satisfaction level for problems (50-5), (50-10) and (100-5)

5. CONCLUSION

In this paper, we have presented a new metaheuristics to solve multi-criteria permutation flowshop problems taking into account the manager's preferences. This metaheuristic is an improvement of the model proposed by Allouche *et al.* [2] which can be now useful for large scale multi-criteria scheduling problems. This metaheuristic is based on the tabu search algorithm. The concept of satisfaction functions was utilized to integrate explicitly the manager's preferences. The obtained sequence can be qualified as the best compromise. We have considered three scheduling criteria. However, this metaheuristic can be extended for additional criteria that the manager may want to consider. We believe that our approach is easy to use and requires a small number of parameters to be provided by the manager. This approach can be qualified as a good tool for multi-criteria scheduling problems.

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Offering a Model of Evaluation of Trust Suggesting Between Customers and E-Stores (B2C) Based on Approaches of Fuzzy Logic

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Abstract

To succeed in the e-commerce depends on lots of factors; one of the important and vital ones is trust. In this Paper, we will suggest a model of Fuzzy Logical System which depicts some of the hidden relationships between the critical factors such as security, familiarity, and designing in a B2C commercial website on the one hand, and the competitive factor to other competitors on the other hand. We are going to find the impact of these factors on the decision-making process of people to buy through the B2C commercial websites, and we also will analyze how these factors influence the results of the B2C trading. The study also provides a device to sellers in order to improve their commercial websites; in addition, it provides on-line customers a helping device to buy through the commercial websites. In the study, the sample in the first questionnaire was the investigation of experts of e-commerce, and in the second one was the customers of commercial websites. Also, we have used the Expert Choice software to determine the priority of factors in the first questionnaire, and the SPSS and Excel software for sampling and analysis procedures to find the Fuzzy rules. Finally, we used the Fuzzy logical kit in the MATLAB software to analyze the factors which generate the model.

Keywords: Fuzzy Logic, Trust, Clustering, Rules, E-commerce.

1. INTRODUCTION

The lack of trust in different components of the most e-commerce applications is known as one of the main reasons which may lead to some e-commerce companies to fail [3],[4].

Website designers must consider factors, in mind, in a website allowing the emergence of confidence between an online seller and a customer. A website retailer is the first factor that influences on the reliability of the seller toward the mind of customer, and this effect strongly can operate on the initial trust of customers [5],[7].

Marsh and Mitch in their plan, entitled as the Call to arms, have challenged the website designers and asked them to think of this point that how they can easily make the trust possible between an online website and its customers in the early stages of their partnership. They claim that websites can be designed in a special fashion so that the trust not only becomes the indivisible part of the plan, but also it can be considered as a further thought.

Furthermore, the decision about online purchase must be available based on the accurate and correct information rather than focusing on the partial insight, general concepts and individual experiences [1], [2].

The findings are mainly on the dissatisfaction of customers on the unstable E-commerce systems, a low level of personal data security, inconvenience systems, disappointing purchases, unwillingness to provide personal details and mistrust of the technology [9],[10],[11],[12],[13]. Indeed, customers may doubt the quality of the goods as they may find it difficult to engage in a transaction without proper testing, seeing and touching the products.

Moreover, a lot of trust models have been presented. Most of them are mentally active, effect as unclear and ambiguous confidence in e-commerce websites, and don't involve the experience and understanding of customers during performing online transactions [6] , [8].

Therefore, in summary, the following objectives are achievable:
•To identify trust factors between the customer and sale agents.
•To measure the effect of a factor on confidence in contrast to other factors by fuzzy logic.
•To identify factors or security components that considerably affects the customer confidentiality upon the online purchase.
•To help customers when shopping online.
•To help designers of e-commerce website to use important factors in designing commercial websites.
•To help online enterprises for finding the customer needs.
•To detect the level of transaction on a commercial website by the sale agency.

2. LITERATURE REVIEW

Trust is one of the important factors in social interactions and most dominant factors for the success of e commerce. Since e-commerce operates in a more complex environment than traditional business, a higher degree of trust is required between different stakeholders. In e-commerce, a trading party becomes vulnerable to the other party's behavior. In other words, both vendors and consumers assume risks in a transaction, although they do not meet face-to-face. A consumer can see a picture of the product but not the product itself. Vendors can make promise of quality and delivery easily, but consumers do not know if these promises will be kept. To deal with these issues, consumers and vendors must expose a high degree of online trust. Consumers' lack of trust has often been cited as a major obstacle to the adoption and widespread use of e-commerce.

The stability of a business depends on the right balance of trust and distrust. Furthermore, people face information overload, increased uncertainty, and risk when they are engaged in e-commerce. As members of an ecommerce community, people cope with these obstacles and risk

by relying on trust. The rationale of choosing the fuzzy logic approach is based on the underlying reasoning process behind online transactions, which is based on human decision-making. Though many factors influence the decision process of online transactions such as security and familiarity, the perception of an influencing feature is more important than the actual level of the feature itself. For example, if the perceived security level is higher than its actual implementation, then it will contribute positively by the users.

The Trust model presented in this study has various aspects of consumer trust, online Environment, website designs, security and familiarity of websites. We have also addressed the importance of online customer service and its impact on consumer trust. The trust model highlights the importance of building trust in the online environment with the process of customer service. The contribution to theory of this paper is based on empirical data and information from three websites regarding our research questions. Three case studies have given us intensive understanding on the area of our research.

A more comprehensive study could be conducted further considering the following points:

- Further study could be conducted on the online environment factors because websites act as the primary contact with the customers.
- It would further be interesting to conduct research on online customer service.

Too Many companies investigate lots of money on their commercial websites. It is essential for companies to know more about their websites for example how many visitors they have or how often do they buy and etc. Lots of companies lose great deal of budget just because they don't know how their website should be qualified. Today with this huge amount of competitors, all companies should have qualified websites because it is somehow essential to know that companies who use their websites for transaction, website quality may have a major impact on number of visitors. Therefore, it is obviously important to find out the dimensions of website quality and major factors which influence it, just to reserve a higher position for yourself in e-commerce.

3. PROBLEM DISCUSSION

Internet has changed every thing in our world, but there are some techniques and ways to do previous actions in virtual world (electronic world) and actually every body is looking for the Ways of promoting and being better than before.

Many times, even you experience that some websites ask you extra ordinary information than usual and you do not feel safe and forget them, never try to buy something online or do an electronic transaction.

At the same time you may quit your previous customers by unsatisfied or wrong services. So definitely you need a way to avoid loosing your customers and also change him/her to a loyal one, besides your needs to find a new customer, your target could be your costumer's trustworthiness.

It is clear that trust plays an important role on e.transactions and as an important factor, suppliers/sellers/manufacturers should focus on ways of developing/improving trust of their customers and this will be possible by understanding effective factors on trust, which by assessing them finally it could be possible to increase trust of the consumers.As an option to approach this, design of web site and improving basic infrastructures could be considered.

Actually if you have a unique vision for all your customers, certainly you can not keep all of them and make them content and loyal, so by categorizing them and finding their most important needs, you can have more customers and at the same time you can find probable future needs of other categories/customers and also it will be possible to get ready for their new demands.

From above discussion, the research problem for this study could be formulated as: To recognize and assess factors that have affects on increasing trust and depicts some of the hidden relationships between the critical factors such as security, familiarity, and designing in a B2C commercial website on the one hand, and the competitive factor to other competitors on the other hand.

4. THE STEPS OF RESEARCH

- Review on resources related to e-commerce, websites with type of b2c, and the importance of trust factor in them, and gathering information and existing models regard to confidence.
- Poll from experts about the most important criteria in the factors affecting on trust in e-commerce websites with the type of b2c, grouping factors in four major subgroups, and determining a model of trust.
- Poll from experts through questionnaires of AHP comparisons to determine the priority of each group and collect them.
- Prioritizing the viewpoints of executives and experts in the field of trust in e-commerce and b2c websites, using given scores and using analysis hierarchy process (AHP) to select the best factors of each group relied upon the priority objectives by the software Expert Choice.
- Creating a second questionnaire based on factors derived from previous stage and to poll of 150 online users in review from 3 suggested websites for discovering fuzzy rules.
- Collecting data from the second questionnaire and required computations by the Excel software and clustering data collected by the SPSS software.
- Extracting fuzzy rules from clustered data set from the former stage.
- Creating input and output memberships functions and investigates the impact of fuzzy rules on them in available fuzzy toolbox in the MATLAB software.
- Evaluating and testing the final model.

5. RESEARCH METHODOLOGY

The proposed model has been established based on this principle that each real level of transactions in B2C websites includes two factors as follows:
1-Trust (T) level in B2C web site.
2-Competitive (C) in b2c web site for purchasing purposes.
Therefore, we propose to investigate into the truthfulness of the equations 1:

$$\begin{aligned} T &= H(S, F, D) \\ L_{B2C} &= G(T, C) \end{aligned} \qquad (1)$$

The first part of equation 1 ($T = H(S, F, D)$) that has three inputs, S is as the level of security, F is as the level of familiarity and D is as the level of design and Level of trust obtains of these three parameters performance.

The second part of equation 1 ($L_{B2C} = G(T, C)$) that has two inputs, T is as the level of trust, and D is as the level of design and Level of B2C obtains of these two parameters performance. Figure 2 shows the structure of trust model.

6. FUZZY EXPERT SYSTEM COMPLETE MODEL

In order to get a complete picture of the fuzzy expert system, an inference diagram can give a detailed explanation of the processes involved. Figure 1 illustrates the steps and processes involved. The process with the crisp inputs to the fuzzy expert system; for example, this might be the crisp input for security, and familiarity to get a value for the trust level.

As can be seen, the process with the crisp inputs to the fuzzy expert system; for example, this might be the crisp input for security, and familiarity or design to get a value for the trust level.

Similarly a crisp level of Trust and Competitiveness will be required as inputs to the second level inference as given in Esq. (1). It should be noted that the initial input(s) are a crisp set of Numbers. These values are converted from a numerical level to a linguistic level. Following that the fuzzy rules are applied and fuzzy inference engine is executed. This will result in a given B2C level as varying degree of membership of fuzzy subsets of the B2C superset. The last step that is the defuzzification process, at which time we extract a numeric value for likelihood of the B2C transaction.

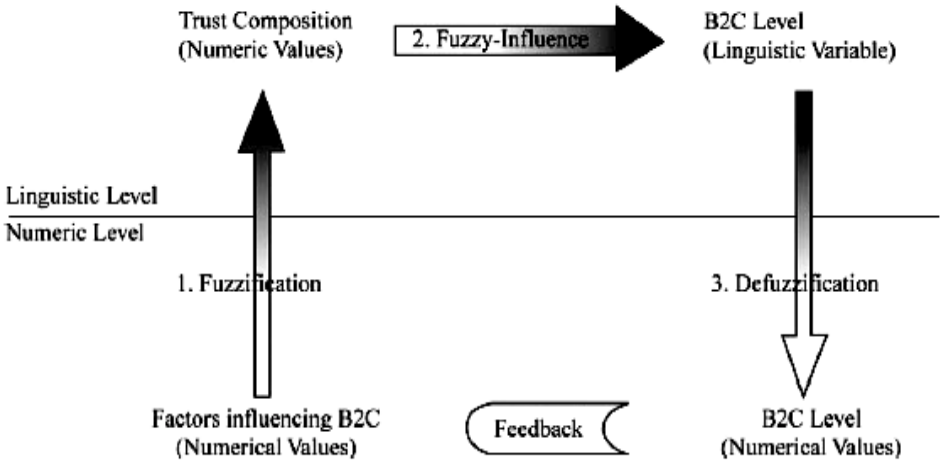

FIGURE 1: Complete Fuzzy Expert System

7. DATA COLLECTION AND ANALYSIS

This study used a web-based survey because of its advantages such as convenience; viable, effective way to access difficult-to-reach respondents.

The selected population in this study was included in two groups. The first group was included ten experts in the field of e-commerce and the Second group was included 150 numbers of E-Commerce and IT students.

The first group completed the first questionnaire and after obtaining results from the first questionnaire and the second group completed the second.

After collecting answer of first questionnaire and finding factors with higher priority, the second questionnaire was designed .it involves 4 major groups, too the method of scoring was chosen based on the likert scale of 5 degrees and 18 given questions in questionnaire were scored like 5 selections and in order of intensity of factor in each group from 0 to 4, like (0) very low (1) low (2) moderate (3) high (4) very high. In this questionnaire 16 questions are relative to 4 major groups, and 2 questions have been observed relative to the trust level and b2c level of website.

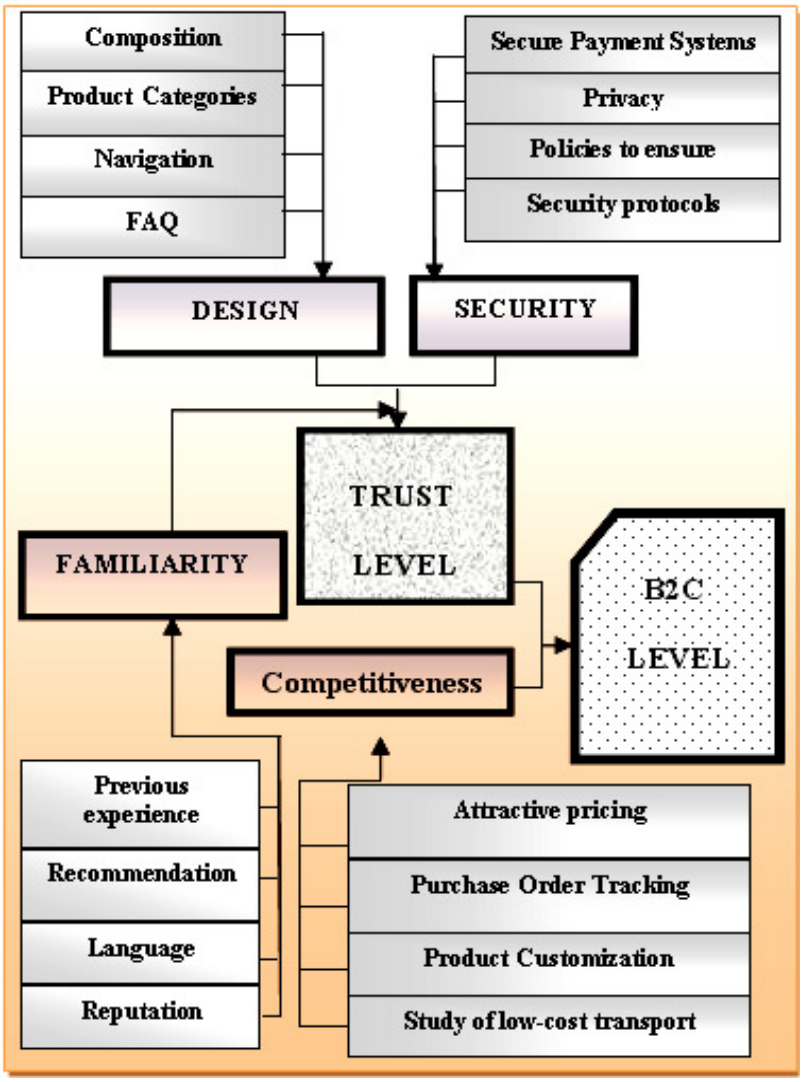

FIGURE 2: The Structure of Trust Model.

Determining the credit of questionnaire has been done by counting Cronbach's Alpha which has credit coefficient in accordance with table 1.

Cronbach's Alpha coefficient for each website		
Irshop.ir	Tobuy.ir	Parsim.com
0.85	0.83	0.83

TABLE 1: the counted credit coefficient of second questionnaire

The inserted credit coefficient in table 1 shows the acceptance of second questionnaire credit. After that customers referred to special website for experimental buying, it was asked the respondents to analyze 3 websites as parsim.com, tobuy.ir, irshop.ir.

During this process, they should answer some questions in security groups, familiarity groups, design groups, competitiveness groups, and trust and b2c level.

Finally respondents should determine the trust level competitiveness and b2c level of website after analyzing website and answering the questions.

The order of answering the questions is that first of all the respondents should analyze the website and answer the questions in security groups, familiarity, design and then they were asked to count the trust level and after that the it was weighted respondents were asked to evaluate the selective website for b2c dealings based on their expectation level of trust and competitiveness.

7.1 Calculating of security level

To count the level of security one sheet was created in EXCEL (security sheet) and linguistic values questionnaire were changed to numerical values. Actually it was related numerical value to each linguistic value (0, 1, 2, 3 and 4) in order to count the level of security the counted level of security is made by adding these values for each factor whose maximum for four factors is number 16.Also, its percent for level of security was counted that has been in table 2, and in general second equation has been used for level of security .the decided levels of design factor and familiarity are like table 2 too.

$$AccumulatedSecurityLevel = \sum_{i=1}^{4} x_i$$

$$PercentageOfMaximum = (AccumulatedSecurityLevel)/16) * 100$$

domain of values percent	Linguistic value
0-33	low
34-66	moderate
66-100	high

TABLE 2: Linguistic and Numeric Values for Security Level

7.2 The priorzed factor resulted from ahp method

The priority of counted factors in security groups, design, familiarity, and competitiveness has been noted in figure 1.

7.3 Rules indicating trust and B2C levels

For refining and finding the rules of fuzzy model, it has been the clustering technique, and the kind of clustering has been chosen the k-means too.
Equation 3 is as a major function in clustering k-means.

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \| x_j^{(j)} - c_j \|^2 \qquad (3)$$

All clustering activities were done in SPSS software and the fuzzy rules have been refine from clusters according to table 3.where || || is the criteria of distance between points and cj is the center of jth cluster.

Irshop.ir		Tobuy.ir		Parsim.com	
TRUST	B2C LEVEL	TRUST	B2C LEVEL	TRUST	B2C LEVEL
NUMBER OF RULES		NUMBER OF RULES		NUMBER OF RULES	
23	14	24	15	23	15

TABLE 3: Number of Rules of the Fuzzy System Model Obtained From K-Means Clustering

The rules describing the trust level are based on the degree of security, familiarity, and design that these degrees have been formulated like linguistic variable .similarly, the degree for trust level has been graded from very low to very high in 5 distinctive fuzzy ,collections .these rules have been reached from the users ' answers after ordering ,analyzing ,and clustering .

Table 4 displays the user's preferences for trust level Based on their perceived level of security, design and familiarity.

Rule	Security Level	Familiarity Level	Design Level	Trust Level	
No	Linguistic	Linguistic	Linguistic	Linguistic	Cluster No
1	High	High	High	Very High	2
2	High	High	Moderate	Very High	3
3	High	High	Low	High	12
4	High	Low	High	High	24
5	High	Low	Moderate	Moderate	10
6	High	Low	Low	Moderate	26
7	High	Moderate	High	Very High	18
8	High	Moderate	Moderate	High	19
9	High	Moderate	Low	Moderate	6
10	Low	High	High	Low	27
11	Low	High	Moderate	Low	11
12	Low	High	Low	Very Low	23
13	Low	Low	Moderate	Very Low	25
14	Low	Moderate	High	Low	17
15	Low	Moderate	Low	Very Low	23
16	Low	Moderate	Moderate	Very Low	17
17	Low	Low	Low	Very Low	13
18	Low	Low	High	Very Low	8
19	Moderate	High	High	Moderate	1
20	Moderate	High	Moderate	Moderate	7
21	Moderate	High	Low	Low	9
22	Moderate	Low	High	Low	5
23	Moderate	Low	Moderate	Low	22
24	Moderate	Low	Low	Low	4
25	Moderate	Moderate	High	Moderate	8
26	Moderate	Moderate	Moderate	Low	21
27	Moderate	Moderate	Low	Low	14

TABLE 4: Formation of Trust rules

One of the collection rules of confidence level can be like following:
If (security = high and familiarity = low and design = moderate) then (trust =moderate).
Trust has been shown like a five fuzzy collections, while competitiveness and B2C level has been shown as 3 linguistic variables for fuzzy collection.

One rule of the collection of trust level rules can be like following:
If (trust = low and competitiveness = highly) then (b2c level = moderate).
Totally there are 27 rules for trust that has been created by clustering the user's answers.

Also, the rules of the b2c level are 15 numbers. Table 5 displays the user's preferences for B2C level based on their perceived level of trust and competitiveness. The rules from base of resultant system that consist of 2 separate and relative systems in order that the b2c level is gained despite the security inputs, familiarity inputs, design inputs, and competitiveness level of website.

Rule	Trust level	Competitiveness level	B2C Level	
No	Linguistic	Linguistic	Linguistic	Cluster No
1	High	Low	Low	19
2	High	Moderate	High	9
3	High	Moderate	Moderate	18
4	Low	Low	Low	14
5	Low	Moderate	Moderate	10
6	Low	Moderate	Low	12
7	Moderate	Low	Low	8
8	Moderate	Moderate	Moderate	11
9	Moderate	Moderate	Moderate	1
10	Very High	Low	Moderate	13
11	Very High	Moderate	Very High	26
12	Very High	Moderate	High	3
13	Very Low	Low	Very Low	3
14	Very Low	Moderate	Low	17
15	Very Low	Moderate	Low	4

TABLE 5: Formation of b2c Rules

8. DEVELOPMENT AND ANALYZING FUZZY SYSTEM

8.1 B2c And Trust Levels In The Developed Fuzzy System

After discovering the rules related to trust level, relevant inputs and outputs for earning trust level in fuzzy tool box to be organized and were created relevant membership for input and output . Figure 3 shows the fuzzy system that can be used to derive the trust level.

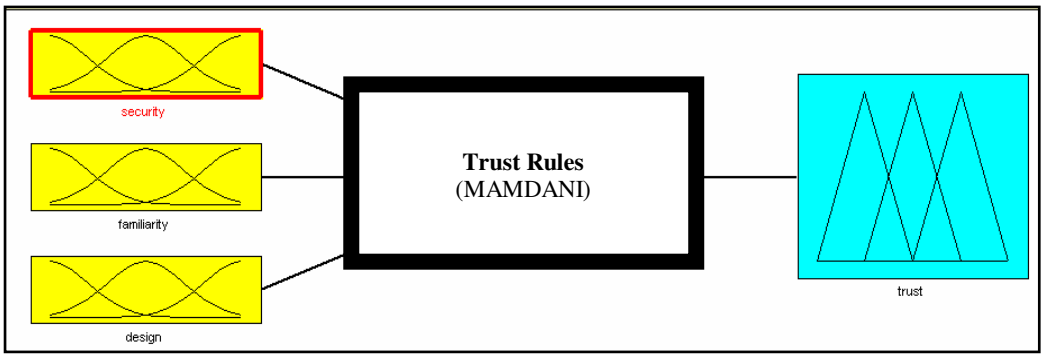

FIGURE 3: Fuzzy system to obtain trust level based on security, familiarity and design inputs

Also after that discovering the rules related to b2c level, relevant inputs and outputs for earning b2c level in fuzzy tool box were organized and were created relevant membership function for input and output. Figure 4 shows the fuzzy system that can be used to derive the b2c level.

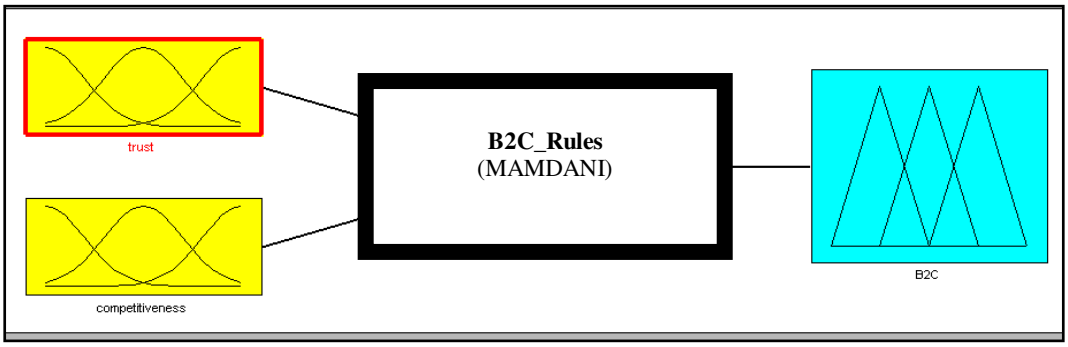

FIGURE 4: Fuzzy system to obtain trust based on trust and competitiveness inputs

8.2 Analysis of Trust versus Security Factor

For complete understanding of participation needed in trust level, it is necessary to separately test the participation of each factor.

The Figure 4 shows contribution to Trust of a given Website originating from the Security. Therefore, the contribution from Familiarity and Design has been kept constant at three levels, namely: low, moderate and high corresponding to numeric values for Familiarity and Design of (1–7 and 15).Figure 5 shows that Trust level is monotonically increasing for increasing perceived security of a website for any given level of Familiarity and Design. However when both F and D is 'High' (numeric value of 15) the Trust level is at its maximum for maximum Security. The three curves have one common feature that they exhibit a 'staircase shaped' curvature.

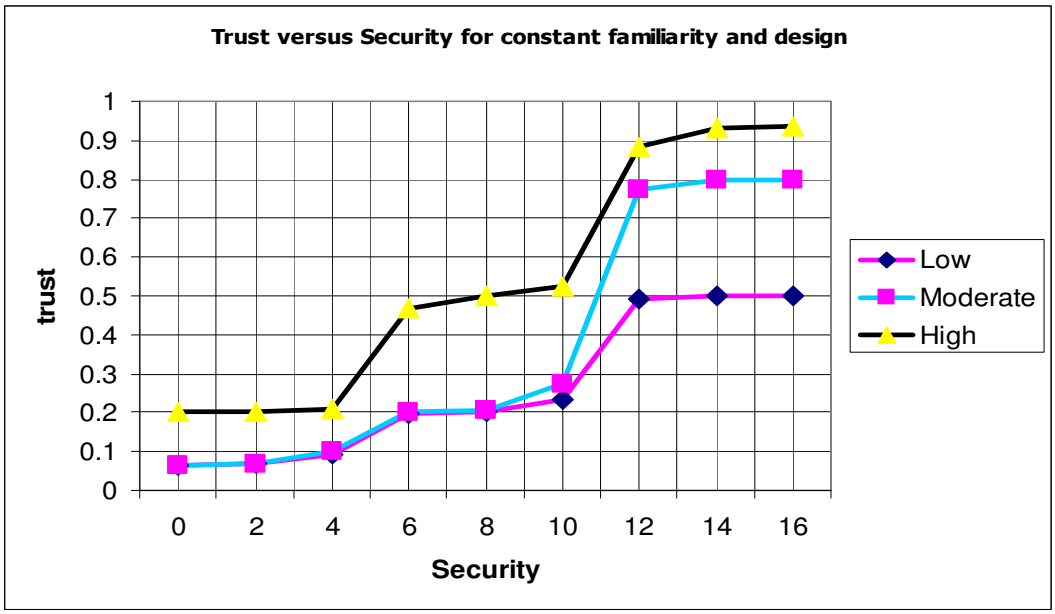

FIGURE 5: Trust versus security factor

8.3 Visualization of trust as function of security and familiarity

We now attempt to visualize the Trust level as a continuous function of its input parameters. Figure 5 Attempts to portray variation of Trust as encapsulated in the rules for Trust. The highest gradient for Trust is when Familiarity is 'moderate' and Security is 'moderate' to 'high'. This suggest that when people are somewhat familiar with a website then a small increase in security levels from between moderate to high security will boost their trust in a significant way. Looking at

Figure 6 diagonally from (low, low) to (high, high) levels of Security and Familiarity one observes three plateaus where the last one is around 0.937, and remains at that level even when the input factors are increased further. This result is somehow unexpected and may be due to the fuzzy nature of the expert system where a 'Trust' or 'Truth' level of 100% is unrealistic.

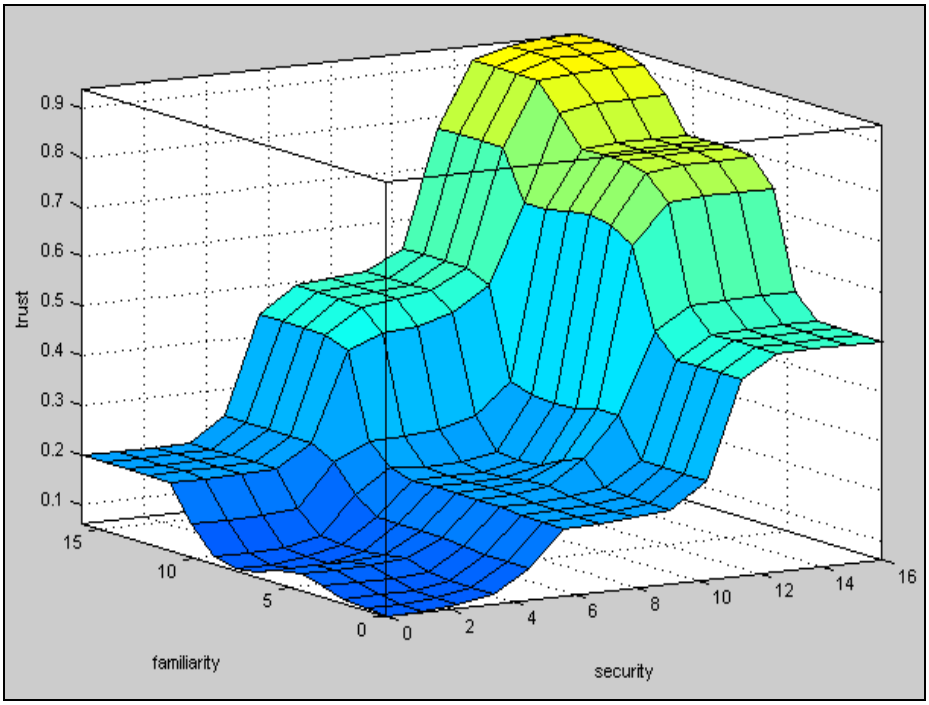

FIGURE 6: Trust level is positively related to levels of security and familiarity.

9. ADVANTAGES OF FUZZY LOGIC FOR TRUST MODEL

The trust relationships among customers and vendors are hard to assess due to the uncertainties involved. Two advantages of using fuzzy-logic to quantify trust in E-commerce applications are:

- Fuzzy inference is capable of quantifying imprecise data and quantifying uncertainty in measuring the trust index of the vendors.
- Fuzzy inference can deal with variable dependencies in the system by decoupling dependable variables.
- fuzzy logic is suitable for trust evaluation as it takes into account the uncertainties within E-commerce data and like human relationships, trust is often expressed by linguistics terms rather than numerical values.

10. CONCLUSION

The e-commerce has given increased choices to consumers due to the growth in the number of online Websites offering products with many variations. In our paper, a tool is defined to assist consumers and vendors to analyze the level of perceived trust in a specific Website.

The consumers can broadly be categorized into two groups, namely those who are technically critical of a site and capable of measuring its security features and those who are not. This survey can be used to step by step follow the instructions and based on actual level of a feature decide its contribution in a category and consequently derive a total value of a factor say Security. Hence the survey can make a buying decision more solid, based on actual appearances of various features. An added advantage would be to feed this data to the FIS for Trust and B2C and the user could compare his/her buying decision with that of others based on the outcome of the fuzzy expert system.

The vendor would benefit from the survey data that is aggregated over time and is used to amend or refine existing rule-sets. Since the data would be accumulated over time the responses would be a blend from both technical and no technical users. Hence the actual occurrence of a feature would be replaced by its perceived equivalence. Since the existence of a feature is only relevant to the user if it can be acknowledged, and if it cannot then the vendor must seriously reconsider inclusion of this aspect on the website.

In addition the vendor can use the survey data to ascertain the Trust level of the site as per user's perception and rectify if needed if this is not obvious or is having a negative impact on the Trust level. Furthermore a measure of the competitiveness is directly deductible from this survey and could be used to retain or increase market share. Lastly as the usage of the survey procedure matures (possibly by providing incentives as discounts on a completed transaction) the Fuzzy Inference Systems could be modified and adjusted where necessary. One limitation of the constructed FIS of this study is that all premises in the antecedent part of a rule have been connected with AND operation where OR operations could also be deployed. The implication and aggregation from the rule would then be significantly different.

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A Critical Analysis of Rational & Emotional Approaches in Car Selling

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Abstract

Investment in a Car is the costliest investment made in a life time only next to construction of a house, for any human being. It is a common knowledge that all of us are attracted towards cars right from childhood and we have developed our own perceptions for cars. When we acquire the capacity to buy cars, our experience of buying, involves both emotional and rational aspects which lead to a purchase decision. This research study discusses consumer behaviour and rational & Emotional aspects in car selling. It also focuses on role of sales person.

Keywords: Consumer behaviour, Car Selling, Rational, Emotional,

A well known fact is that investment in a Car is the costliest investment made in a life time only next to construction of a house, for any human being. It is a common knowledge that all of us are attracted towards cars right from childhood and we have developed our own perceptions for cars. When we acquire the capacity to buy cars, our experience of buying, involves both emotional and rational aspects which lead to a purchase decision. Unlike other consumable durables, the decision to buy specific brand of Car is shaped over a long period of time. The period between recognition of need to buy a car and the actual purchase may run into many weeks or even months. Considerable research has focussed on conceptually and operationally defining various factors that lead to a purchase decision. However, because of the inherent difficulties in deciphering consumer behaviour coupled with exponential changes in consumer aspirations, there is a need to constantly re-define our perceptions about consumer behaviour. Revealed Preference Theory of Samuelson & Bounded rationality Theory of Herbert Simon and many others have provided a conceptual analysis of Consumer Behaviour from the perspective of economics, we have still not been able to pinpoint whether consumers are Rational or Emotional when it comes to buying Cars.

According to some early economic theorists (e.g., Adam Smith, Jeremy Bentham, Alfred Marshall), man's/woman's desire for goods and services exceed his/her ability to pay. Therefore, buying decisions are made through a rational process during which we assign a value to each desired product or service offering based upon our assessment of the ability of that offering to satisfy our needs and desires. This want satisfying ability is termed "utility." As different offerings possess different levels of utility, rational behavior dictates that one seek to maximize utility. In contemporary parlance, this means seeking the most bangs for the buck. " [1] This assumes even more relevance considering the fact that the whole process of buying a car is complex in nature and earlier researches have pointed out that the whole family is involved in the decision making process. The explosion of information available on cars through various sources has been a mixed blessing as more information has led to more confusion & the consumer is unable to decide on his own, in most cases. As a result there are many cars in his consideration set and

[1] Jacob Jacoby , Working Paper #CLB-00-009 - IS IT RATIONAL TO ASSUME CONSUMER RATIONALITY? SOME CONSUMER PSYCHOLOGICAL PERSPECTIVES ON RATIONAL CHOICE THEORY , New York University Center for Law and Business

the consumer is waiting for the right guidance in spite of all the information available with him. This guidance can be provided by the Sales Person with an approach focussed on both Rational and Emotional Factors. In a path breaking paper by James Andreoni , an application of revealed preference to a common occurrence in experiments i.e. kindness among subjects was discussed. The author focuses on the fact that subjects are often found to act benevolently towards each other and there are many emotional elements attached to decisions . The study points out that the subjects were "irrational" because they did not choose to maximize their own monetary payoffs. This at times disputes traditional economic theories which dubbed man to be a Rational Man. Many other researches pointed out that the classical theory had failed and reiterated the need to appeal to other behavioral sciences to understand "non-economic" behavior. "But the axioms of choice indicate that what is "rational" is what is consistent, that is, it can be characterized by convex preferences. Hence, whether this benevolent behavior is rational is an empirical question that the experimental economist is perfectly suited to answer. The hypothesis to explore here is that subjects have consistent preferences for altruism." [2]

In this analysis, the authors, seek to understand various emotional and rational elements at play while buying a car . The study begin by identifying consumers who have a similar disposition to a specific brand. Such consumers will be grouped into two classes and tested through a Two Sample test to check if the mean differences in their perception are significant. If the differences are significant, then the process of identification of potential respondents will continue till such time we arrive at a group of 15 consumers who share similar perception about the brand. The subsequent process is to put identified consumers through two different Sales Persons from the same company during the buying cycle. The approach of the first Sales person would be rational in nature i.e. to influence the consumer on various features of the car that can be quantified . His Sales Pitch would focus only on the rational elements of why the product is superior compared to other products available in the market. His focus is to appeal to reason than to emotions. The approach is more mechanised but at the same time minute feature to feature comparison with competitor products were enumerated. Needless to say the focus on human elements was very marginal. The same consumer will then be followed up by a second sales person whose approach would be more emotional in nature. His focus is to establish trust in the consumer's mind through a straight forward communication focussing on broad level benefits of the car & features with little focus on rational elements. His approach is to gain the trust of the consumer through a high quality of inter personal relationship to leverage the name of the Brand. He does not use product to product comparison techniques but instead appeals to relationship by establishing rapport & using referrals and testimony from other customers using the same car.

The customers were not aware of the details of the approach employed. However, they knew that the approaches were different.

The consumers will then be asked to compare the two methods on the Degree of influence exerted by each of the two methods i.e. Rational Approach in case of the first Sales person and the Emotional Approach in case of the second sales person. The following hypothesis is tested using Wilcoxin matched pairs test that there is no difference between the persuasions, as experienced by the consumer, in both the approaches using a 5% level of significance.

WE selected Wilcoxin Matched Pairs test the hypothesis because we cannot be sure that the distribution of scores will follow a normal curve & there is no guarantee that the variances will be equal. This is largely because consumer behaviour is unpredictable & the same customer might give a different rating if observed after a gap of one month . In this study individuals were selected from the population and each one had an equal chance of being selected. The sample sizes were the same as is evident from the study had something in common i.e. the subject of observation.

During the interaction, the sales person using the rational approach was trained on all aspects of the following in order to influence the customer's purchase intention. The sales person was extremely knowledgeable on the product knowledge front . The features are rational because each of these can be quantified either ordinally or cardinally.

[2] Analyzing Choice with Revealed Preference: Is Altruism Rational? By James Andreoni Department of Economics University of Wisconsin Madison, Wisconsin 53706 and John H. Miller Department of Social and Decision Sciences Carnegie Mellon University Pittsburgh, Pennsylvania 15213

Rational Elements in Car Buying

Rational Elements		
S. No	**Features**	**Theme**
1	Safety features	Rational
2	Vehicle Dimensions	Rational
3	Air Bags	Rational
4	Service facilities	Rational
5	how big is the company	Rational
6	Top Speed	Rational
7	showroom should be large	Rational
8	Spare Parts Prices	Rational
9	Should have long service intervals	Rational
10	Service Costs	Rational
11	Schemes	Rational
12	Price comparison with other cars	Rational
13	Less Maintenance	Rational
14	Fuel Economy	Rational
15	Free Schemes	Rational
16	Discounts in Cash	Rational
17	Buy Back	Rational
18	Features	Rational
19	more space inside the car	Rational
20	Location of the showroom	Rational
21	ease of getting in and getting	Rational
22	More Leg Room	Rational
23	Upholstery Colour	Rational
24	colour availability	Rational
25	Power Torque etc	Rational

TABLE 1: Rational Elements in Car Buying

After the interaction, the customer was asked the following questions & were asked to experience and compare both the approaches on a set of scale items judged to be ordinal. The extent to which the overall purchase intention was influenced by both the sales executives were recorded & ranked as under.

Null Hypothesis :
Ho ; There is no difference in degree of persuasion of both the approaches

Alternate Hypothesis :
Ha : There is difference in Degree of persuasion of both the approaches .

WILCOXIN MATHED PAIR TEST Analysis

WILCOXIN MATHED PAIR TEST							
						Rank with signs	
Pair	Emotional Approach	Rational Approach	Difference (D1)	Absolute Value of Differenece	Ranks	" + "	" - "
2	69	70	-1	1	1.5		-1.5
11	59	58	1	1	1.5	1.5	
4	66	68	-2	2	3.5		-3.5
12	71	69	2	2	3.5	3.5	
13	64	67	-3	3	5		-5
1	67	71	-4	4	6.5		-6.5
9	75	71	4	4	6.5	6.5	
6	58	65	-7	7	8.5		-8.5
15	69	62	7	7	8.5	8.5	
14	67	59	8	8	10	10	
3	68	58	10	10	11	11	
5	62	73	-11	11	12.5		-12.5
8	69	58	11	11	12.5	12.5	
10	64	52	12	12	14	14	
7	67	53	14	14	15	15	
					Total	82.5	-37.5

TABLE 2 : Wilcoxin Mathed Pair Test Analysis

We are not dropping any pair as there is no data where the " d " value is zero and hence we can proceed with n = 15.

The table value of T at five percent level of significance when n = 15 is 25 (using a two tailed test because our alternative hypothesis is that T is 18.5 which is less than the table value of 25. As such we reject the null hypothesis and conclude that there is no difference between the two approaches . Both are equally effective in influencing customers purchase intentions .

CONCLUSION

We can draw a lot of inferences from the above study. While there is enough information available to consumers as a result of information explosion, yet consumers may not buy cars because of rational reasons alone when it comes to buying preferences. The results of the hypothesis will go on to show that Sales Persons have a large role to play in influencing consumer's purchasing decisions. The impact of two approaches in influencing the consumer's perception can be quantified and the result of the hypothesis will point to the right approach that can be followed in future. Irrespective of the merits of any single approach, it needs to be kept in mind that both the approaches are complimentary and proper balance is the key. The sales person should also be wary of the fact that the approach also depends on the nature of the consumer. The best method would be to use rational approach with focus on rapport building and using referrals and testimonies.

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Reflecting Upon Management Systems: Content Analysis and Synthesis

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Abstract

The purpose of this paper is to present and discuss/reflect on son well-known quality, strategy and excellence frameworks or models in order to understand the development of the management systems from the classical theory to now. In addition we try to understand the problems or limitation which such kind of models still may have, and in that sense, we proposed a possible macro elements and characteristics of an integral Management System. The studies examine some leading quality, strategy, excellence frameworks or models and discuss/identify their strengths as well as weakness. The chosen models and frameworks are Taylor's principles (1911), Fayol's operations (1914), System theory-frameworks (1969), Peter's and Waterman's eight excellence attributes (1982), the EFQM European Excellence model (1992), list of best practices (1998), the ISO 9000 norms (2000), Toyota's 4P model, and Kaplan and Norton's Management System (2008). Generally, quality, strategy and excellence models and frameworks are inspired by the classical management theory and/or Japanese practices and they recognize the importance to manage any organization using a Management System, which can be integrated by a hard and soft dimensions. Any dimension it is integrated by some elements and some characteristics. Therefore, as a result we attempt to make a first possible description of an integral Management System. On the other hand, our findings indicate that there are tendencies to interpret these models from positivistic view and ignore the soft dimension of the Management System (human aspect), when organization try to implement the model in their struggle to achieve quality and/or excellence, and when they try to translate the strategy in an effective process operation. An integral and holistic Management System can reduce these negative tendencies. The paper aspires to be of interest as much to researchers as to professionals in the manufacturing and service industry, whether they have middle management responsibilities, or are general managers, and also to all

those employees whose work is related to some positions of authority (managing people and resources), with the object of understanding the Management System as an integral and holistic view that any organization uses to develop its strategy and translate into operational action and monitor and improve the effectiveness of both.

Keywords: Management System, Models and Frameworks, Best Practice.

1. INTRODUCTION

The current economic and financial crisis and the prospect of world-wide pandemics are posing greater challenges to company survival and making life much harder for firms' managers. In our view, these challenges stem from four sources. First, there is the difficulty of managing companies to make them increasingly effective and efficient. The quest for "management excellence" is becoming harder and more complex because of external pressures (more demanding customers, more competitive markets, the need for both quality and fast response, economic and financial turbulence, potential pandemics, etc.). Second, when executives look at the vast body of knowledge on management, they are faced with a welter of complex theories that are often difficult to put into practice. Third, there is a big gap between academic knowledge and practical prescriptions in the management field. Fourth, from the practitioner's standpoint, it is hard to find more effective strategies and implementation for achieving management excellence. Here, it seems the traditional mechanistic model of management [1] seems ill-suited to coping with rapid, turbulent global change. This may explain why so few companies have risen to the challenge of attaining organisational excellence. Perhaps another reason lies in the dearth of work on what management means in the 21st century (in management system terms).

The academic and practical importance of this research lies in management science's need to find new challenges and visions for the 21st century. As Gary Hamel [2] observes, "modern management" dates from the end of the 19th century and has run out of scope for improvement. For this author and the group of scholars and CEOs from around the world who meet to discuss the subject, it is vital to chart new courses for management and to innovate in the field. Accordingly, this paper closely links at least five of the challenges identified by this group of researchers as facing 21st century management: *Challenge 3* - rebuilding the philosophical foundations of management; *Challenge 11* - radically reducing the influence of the past; *Challenge 9* - reinventing strategy creation as an emerging process; *Challenge 21* - free imagination; *Challenge 23* - bring management up to date so it can cope with an open world. Many managers today wish to scrap mechanistic approaches and are seeking alternative systems and technical approaches. They are doing so because they need to find better ways of coping with global pressures, cutting costs and boosting cash revenues - [3]. When company managers try to find these approaches, they are faced with a sea of information or, as Koontz puts it [4]: *"with a wave of great differences and apparent confusion"*. In other words, there are so many management fashions and trends that the systems and models that once worked (or that still work) are losing their originality [5].

The general purpose of this article is to give background on the quest for a *"Management System".* A subsidiary aim is to present, analyse, debate and reflect on some of the best-known models and conceptual schemes covering quality, strategies and excellence with a view to charting the development of *Management Systems* from classic theory to the present. The models and conceptual schemes selected were: The Principles of Scientific Management; Taylor (1911); Fayol classic theory (1914); systems theory and models (1951); Peter and Waterman's eight attributes of management excellence (1982); the EFQM (European Foundation of Quality Management) model (1999); the ISO 9000 norm (2000); the list of best practices (2004); the Toyota Motor Corporation's Business Model; the management system presented by Kaplan and

Norton (2008). In addition, we sought to understand both the strengths and limitations of these models for companies trying to cope with global pressures.

A further subsidiary aim of this research is to present the first conceptual descriptions from a *"Management System"* perspective. Accordingly, this paper sets out an initial definition of the elements and features of such a system, this being based on our theoretical analysis of the aforementioned concepts, models and theories. This task is far from simple and the authors are fully aware of the limitations to their approach (for example, it covers a small number of management models). It follows the line taken by work on other subjects [6] [7] and comes up with an initial theoretical framework for tracking down management systems in the scholarly and management literature.

At the end of this paper there is a section on contributions and discussion, followed by a section giving our final conclusions and managerial implications.

2. PRELIMINARIES

2.1 The Classic Management School (Taylor and Fayol)

This section describes the main features of Scientific Management as defined by Frederick Taylor (1911), and the theories of Henry Fayol (1914). In terms of the development of schools of management thought, the oldest classical theory is *Scientific Management or Industrial Engineering*, posited by Frederick Winslow Taylor [8]. Both Taylor's and Fayol's approaches to management are what Koontz [4] calls "the management process school" or what Lemack [5] referred to as "the classical paradigm". However, this author indicates that the work of Taylor and Fayol was not necessarily the first example of this paradigm, given that work by Daniel McCallum in 1850 grappled with how to design a 500-mile railway for optimum efficiency. Likewise, work by Josiah Wedgewood attempted to establish a cost-accounting system. There were also Charles Babbage's efforts to build the first analogue computer, and work by Charles Dupin in France [5].

Returning to our argument, Taylor revolutionised traditional work systems through the application of "scientific methods" in companies to improve productivity. These methods proved highly successful in dealing with the technical problems found in the workplaces of the time [8].The four basic management tasks were published in The American Magazine in three issues [9]:
First, They develop a science for each element of a man's work, which replaces the old rule of thumb method.
Second, They scientifically select and train the workman, where in the past he chose his own work and trained himself as best he could.
Third, They heartily co-operate with the men, so as to insure all of the work being done in accordance with the principles of science which has been developed.
Fourth, There is an almost equal division of the work and the responsibility between the management and the workmen. The management take over all the work for which they are better fitted than the workmen, while in the past almost all the work and the greater part of the responsibility were thrown upon the men.

Taylor (1911) proposed a functional, formal structure as the basis of scientific management, the need to set targets and then split the work up into small units (simple tasks), an action he termed "specialisation" or "functional management". Adopting this approach, Taylor noted that supervision should be split between various overseers specialised in particular aspects of the work. He also sought to ensure that each of these work tasks was co-ordinated within a Management System, with the result that workers would eventually become experts and find the best way to do their jobs within the system as a whole [10]. Taylor was a pioneer in creating management systems and in splitting work up into simple tasks that were then co-ordinated within an organisational whole. Some authors go so far as to argue that Taylor's approach revolutionised the way work was seen and opened a new path [11].

However, this division of work and the concomitant company hierarchy did not really take root until Henry Ford set up his automobile factory. Here, the work was directed by specialists or engineers who knew the work inside out. The workers were simply required to follow their orders. In other words, the engineers/specialists designed sophisticated manufacturing systems and the line staff simply followed their plans [12]. Taylor considered that workers need to be trained in accordance with the principles of Scientific Management so that they could overcome their own mental and physical shortcomings [13]. In Taylor's words:

Now one of the very first requirement for a man who is fit to handle pig iron as a regular occupation is that he shall be so stupid and so phlegmatic that he more nearly resembles in his mental make-up the ox than any other type. The man who is mentally alert and intelligent is for this reason entirely unsuited to what would, for him, be the grinding monotony of work [9].

As one can see, this kind of approach to Scientific Management focuses most on "hard" management aspects (i.e. those bearing on the planning and execution of work). The lack of "soft" elements in the management system created an imbalance in company management practice. In other words, workers were simply seen as cogs in the machine. The end result was lack of commitment, high staff turnover, lack of motivation and loyalty, and failure to work in teams [14]. As far as Taylor was concerned, work inefficiency could be explained away by "soldiering" (slacking): *"Soldiering" as it is called in this country, "hanging it out" in England, "ca canny" in Scotland, is thus almost universal in industrial establishments [...] the writer asserts without fear of contradiction that this constitutes the greatest misfortune, one might almost say the greatest evil, with which the working people of both England and America are now afflicted* [15]. Taylor's idea of unleashing the power of Scientific Management through the rationalisation of work processes established the basis for concepts such as cost-cutting and boosting productivity through process re-engineering. However, scant interest was shown in motivating workers.

Finally, despite all its negative consequences, Scientific Management theory focused on the "hard" part of the management system (technology, work, organisation) and was then a giant leap forward in organisational and management theory [16], requiring, as Taylor noted:

[...] the equally complete mental revolution on the part of those on the management's side – the foreman, the superintendent, the owner of the business, the board of directors – a complete mental revolution on their part as to their duties toward their fellow workers in the management, toward their workmen, and toward all of their daily problems. And without this complete mental revolution on both sides, Scientific Management does not exist [17].

The second theory analysed in this section was formulated by a French industrial engineer, Henri Fayol in his book "Administration Industrielle et generale", which was published in 1916. He came up with a fairly comprehensive theory that provided 14 management principles [18]. At the beginning of the 20th century, most management authors had been schooled in engineering and science and Fayol was no exception to this rule. His thinking on management therefore followed this kind of line. Fayol argued that all of company's activities/operations could be split into six groups [19]:

1.- Technical operations: tasks bearing on turning out goods (products and services).
2.- Sales operations: tasks linked to purchasing and sales transactions.
3.- Financial operations: tasks linked to fundraising and the effective use capital).
4.- Security: functions whose aim was to protect people and assets.
5.- Accounting: financial control tasks, bookkeeping, inventories, balance sheets, cost control, statistics.
6.- Administrative operations: forecasts, organisation, direction, co-ordination and control of all aspects of the firm's activities.

Fayol's work established the basis for management of the company as a whole within the framework of a Management System. The six activities set out above constituted the interrelated work processes carried out by any firm. In the sixth activity, which he termed administrative

operations, he established the planning, organisation, management and co-functions that still hold good today. For Fayol [19], each of these administrative activities was of prime importance for orderly management. As he put it: “These six groups of operations or essential functions exist in all companies, no matter how simple or complex, large or small they may be.” Finally, both Taylor and Fayol’s work, which lay the foundations for what we now know as the Management System, was strongly influenced by contributions from Max Weber [20] and his theory of bureaucracy. Although Weber’s work also embraced the political and social spheres, its six principles of bureaucracy: division of work, management hierarchy, formal selection of staff, formal rules and norms, neutrality, and professional orientation constitute the key features of what are known as mechanistic organisations [1]. Such organisations thus apply the scientific and bureaucratic principles identified by Taylor, Fayol and Weber [21].

2.2 System Theory and Models

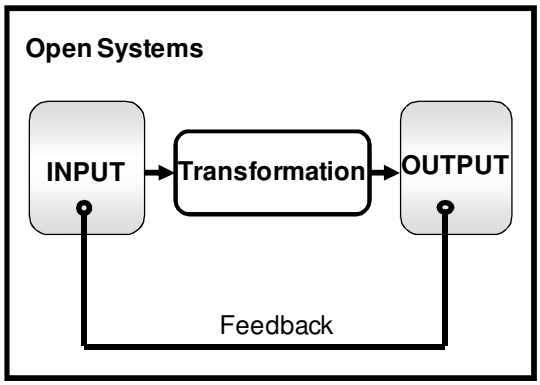
For time out of mind, man has tried link his knowledge to form a corpus that could explain all the interrelationships. Thus Plato and Aristotle’s cosmovision attempted to see reality from a holistic standpoint (from the Greek holos, meaning “the whole”) [18]. Although this provides a plausible system-based theory – that is, a set of elements with a common purpose and that behave in a common fashion because they are interrelated [22]– the idea did not take off until the 1990s with the publication of The Fifth Discipline by Peter Senge [23]. However the application of the term “systems” to the management field can be traced back to Barnard’s work [24]. For Barnard [25], an organisation is seen as “a system of consciously co-ordinated activities or forces of two or more persons”. Notwithstanding the importance of Barnard and Simon’s contribution, Harmon and Mayer [26] trace system theory back to Wiener and Forrester’s work in cybernetics, general system theory of Ludvig Bertalanffy and Talcott Parsons’ work in functional structural sociology. Systems theory may thus be seen as a synthesis between the classic approach and one based on behaviour and human relations [18].

In reviewing the literature on management approaches, we were struck by the work of the mathematician Norbert Wiener after The Second World War in the field of anti-aircraft teams, automatic pilot systems and radar. His work led Wiener to come up with the idea of self-regulation – the use of continuous feedback to guide a mechanical or organic system to adapt to environmental changes. Wiener applied this idea to organisations and management in his book Cybernetics [27] in which he set forth a very simple model of inputs that are processed into outputs by a feedback cycle to make corrections [28].The work of Jay Forrester, a computer pioneer at MIT, focused on what he termed “system dynamics” and stated that managers tended to act on “problem symptoms”, not on the underlying problems. He also argued that such symptoms are created by the system as a result of feedback [23]. Another strand in systems theory was woven by the biologist Ludwig Von Bertalanffy, who in 1951 argued the need for inter-disciplinary work to formulate a scientific language and methodology: “These considerations lead to the postulate of a new scientific discipline which we call general system theory. Its subject matter is formulation of principles that are valid for "systems" in general, whatever the nature of the component elements and the relations or "forces" between them... [29]”. Accordingly, Bertalanffy coined the term “general system theory” and left it to other scientific disciplines to interpret its supposed all-embracing scope, balance and the system’s interaction with its external environment [30].

Lastly, The Social Psychology of Organizations by Katz and Kahn [31], and Thompson’s Organizations in Action [32] rounded off systems theory and its models, which found their modern expression of a scientific paradigm in Thomas Kuhn’s work [33]. The main aim of Katz and Kahn’s book [31] was to provide a “skeleton” or a meta-theory for a broader model in which organisations were seen as open systems. Katz and Kahn postulated that repetitive activities by a group of individuals acting under time and space constraints possess basic system features – inputs, “black box” transformation and outputs. Figure 1 shows this scheme, which is described as the Open System Model (of which biological and social systems are good examples). It shows an analogy with a “black box” system in which interaction with the environment allows the system to receive inputs and turn them into outputs [24]. These authors argue that an organisation may become a large system transforming inputs into outputs to create a continuous flow of operations.

This vision is diametrically opposed to Taylor's Scientific Management, which sought to understand the component parts of organisations and fit them together to make the whole. The unit of analysis in the system model is the organisation's system or its sub-systems covering work functions and activities. According to Kast and Kahn [31], the sub-systems embrace: production; supply; institutional relations; staff functions; change processes; work management and control. To sum up, systems theory and models conceive organisations and their management in the following terms:

1.- An organisation's parts can only be understood in relation to all the other parts.
2.- The parts of an organisation, including its relationships, are important to the extent that they contribute to the functioning of the whole.
3.- Organisation, conceived as groupings, may be considered as analogous to biological organisms (open systems) that are faced by challenges and needs affecting the whole community.
4.- A system-based approach allows one to analyse an organisation's dynamics (i.e. organisational evolution and deliberate change) rather than just the status quo.
5.- An organisation has strong links with its setting, which furnishes the conditions needed for organisational management.



Fuente: Intrepretado de Freemont Kast y James E. Rosenzweig. Dic. 1972. *Academy of Management Journal*, 15(0004), Pág. 450.

FIGURE 1: The Open System Model.

2.3 Attributes of Peter and Waterman's Management Excellence model

Hermel and Ramis-Pujol [34] state that *"Excellence"* is a hard concept to pin down. The literature contains various definitions of the term, different approaches to management excellence and the criteria for success [6]. Although Hermel and Ramis-Pujol [34] came up with an evolutionary classification of management excellence, these authors and others agreed that practical application of the concept to firms dates from Peters and Waterman's book In Search of Excellence-Lessons from America´s Best Run Companies (1982). In the twenty seven years since then, the concept has cropped up throughout management literature and practices. Peters and Waterman [35] set out the following eight attributes of excellent, innovative companies:

1.- A bias for action, meaning that although companies' approach to decision making may be analytical, they emphasize the importance of experiments. It is believed that too many detailed analyses may be barriers against problem solving. Thus, their approaches to solving problems and challenges are often experimental and dealt with immediately or in a relatively short time through the establishment of cross functional teams where external partners such as customers or suppliers may also participate.
2.- Close to customer, meaning that the successful companies really listen to the voice of the customer and also use the voices as input for continuous improvement and new product and service development.
3.- Autonomy and entrepreneurship, meaning that all employees – not only people in R&D - are expected to be creative and innovative in their daily jobs.

4.- Productivity through people, meaning that people are expected to come up with ideas for waste reductions and productivity growth by providing the proper framework, i.e. respect, involvement and empowerment.
5.- Hands-on, value driven, meaning that the company's philosophy vision and values are seen as the main guideline and are far more important for daily activities and challenges than technological or economic resources.
6.-Stick to knitting, meaning that the excellent companies stay close to the business they know.
7.-Simple form, lean staff, meaning that the underlying structural forms and systems in the excellent companies are elegantly simple and top-level staffs are lean.
8.- Simultaneous loss-tight properties, meaning that the excellent companies are both centralised and decentralised. On the one hand, for example, they have pushed autonomy down to the shop floor or product development teams, and on other hand, they focus tightly on the few core values they hold dear.

However the fact is that some of the companies on which Peters and Waterman [35] based their study turned in poor results in the last decade of the 20th century and the first decade of the 21st century [6]. This indicates that the attributes that paid handsome dividends in the 1980s are not necessarily a recipe for success today. Furthermore, companies' need to operate through management systems may indicate the first step on the path to excellence [36] is fraught with hazards. Peters and Waterman's note [35] that the "soft" aspects of a company (i.e. values, motivation, leadership, staff participation) are the foundations for any management system.

2.4 The EFQM Model (European Foundation of Quality Management)

Set up in 1988 to foster Total Quality Management and excellence in European companies, the EFQM model has spread within European firms as a tool for evaluation and for achieving strategic change. The model provides a framework covering five facilitating agents: Leadership (10%); Staff (9%); Alliances and Resources (9%); Policy and Strategy (8%); Processes (14%). It also sets out four criteria regarding end results: customer results 20%; staff results 9%; social results 6%; key results in the company 15%. In other words, the five agents are the cause and the four results are the effects. The result criteria also provide information and feedback, guiding the agents' actions through learning and innovation (EFQM, 1999). Each of these criteria rest on the following eight planks: (1) results orientation; (2) customer focus; (3) leadership and constancy of purpose; (4) management by processes and facts; (5) people development and involvement; (6) continuous learning; (7) innovation and improvement; and (8) partnership development and public responsibility [37].

In practice, the model is applied through the self-evaluation carried out by each company in assessing its management performance using nine yardsticks to measure "strengths" and "areas for improvement". Both elements help identity the gap between present performance and ideal performance, and to plan improvement measures [38]. Some of the advantages of the EFQM model described in the literature are that it fosters: process standardisation and improvement; identification of opportunities for improvement and organisational learning; an integrated approach to improvement through a single management system that integrates strategies, processes and result (capitalising on previous experience); process measurement and redesign in the light of results; customer satisfaction; staff involvement in the form of improvement teams and other measures; value creation for all stakeholders [39].

Other authors have noted some of the drawbacks in implementing the EFQM model. These include: (a) the non-prescriptive nature of the model and failure to set out how it should be applied in specific cases [40]; (b) the sheer breadth of the model, which sometimes makes it difficult to know where to begin, how to make its results visible, and how to sustain improvements; (c) the danger of using the self-evaluation just to win the coveted EFQM Prize and forgetting the real purpose is to improve; (d) the difficulty of getting people involved, particularly in local government [41]; (e) despite the nine implementation criteria, some authors have reported that corporate culture and the company's maturity largely determine whether EFQM implementation is a success or failure [6].

Finally, both the eight key concepts and the nine application criteria may constitute sub-systems of the organisation's overall management system. Indeed, the EFQM model [38] describes itself as a management system that can be defined as: "a general scheme of processes and procedures for ensuring that the organisation carries out all the activities required to meet its objectives". Starting from this definition, some authors have indicated that the dominant management paradigm in the EFQM model is rational and measurement-oriented – in other words, it focuses on the "hard" part of the management system. Although the EFQM model includes "soft" or human aspects, when it comes to implementation it is precisely these elements that are the most intangible, difficult to apply and optimise [42] [43].

2.5 ISO 9000 (Version 2000): A Quality Management System

This quality management system is based on the International Organisation for Standardisation (ISO), a body set up in 1946 and based in Geneva. It fosters international norms in the fields of manufacturing, trade and communication [44]. The forerunner of the ISO 9000 family of quality management norms was British Standards - BS 5750, and was further extended in 1994 [45]. In 2000, the norms were thoroughly overhauled. The result was the ISO 9000 norm Version 2000. The main norm in the ISO family is *ISO 9001:2000 – Quality Management Systems – Requisites.* This was complemented with *ISO 9000:2000 – Quality Management Systems – Principles and Vocabulary* (ISO 9000, 2000). The norm comprises eight sections: (1) Purpose and scope; (2) Norms; (3) Terms and definitions; (4) Quality Management System; (5) Management responsibility; (6) Resource management; (7) Product or service production; (8) Measurement, analysis and improvement [46].

The 2000 Version of the ISO norm focuses on an organisation's ability to satisfy its clients and on process management and improvement. This is a change from the 1994 version of the norm, which focused exclusively on ensuring product/service quality [47]. In addition, the new norm includes Deming's PDCA improvement cycle (Plan, Do, Check, Act) in order to link ISO's guiding principles as part of continuous improvement of the whole management system [48]. In practice, the ISO 9000 norm is based on a set of documents (Quality Manuals, Procedural Manuals, Registers, etc.), which are evaluated through internal audits that compare the norms with the institution's daily management. Once documented and evaluated by the organisation, the quality management system is then submitted for certification through an external audit conducted by an outside body. Periodic re-evaluation is carried out in connection with existing certification [49].

The literature reports various benefits from implementing ISO norms, including: organisation; work standardisation and documentation (processes and procedures); establishment of a quality control system; reduction in faults and hence lower operating cost and budgetary requirements [50]. Other authors report that application of the ISO 9000 norm facilitates process standardisation and measurement and fosters greater customer satisfaction [49]. Furthermore, the norm also seems to encourage greater orderliness in the way staff work, cutting down the time needed to train new staff [51]. Reported problems in applying the norm include: (a) excessive documentation of procedures, norms, etc.; (b) improvement and innovation run into the sand and end up not being implemented; (c) paradoxically, the quality of the organisation's services and products may not be advanced, with defects cropping up after the certificate has been awarded; (d) lack of strong motivation, given that collaboration may be based on the goals/interests of certain groups; (e) departmental-based certification, forgetting the need for a cross-cutting approach to processes [52].

Finally, it is important to note that for ISO norm purposes [46], a management system is understood as: *"a system to establish policy and objectives and to achieve those objectives"*. This is a fairly vague definition, indicating that the ISO 9000 norm focuses more on the efforts made by an organisation to achieve a quality management system than on the detail. According to ISO norm [46] the quality management system is defined as: *"management system to direct and control an organization with regard to quality".* We are thus left in the dark about the relationship between management system and quality management system (if this kind of dual relationship

exist in the organization?). Lastly, we considered that the management sub-systems could be interpreted as ISO norm criteria.

2.6 Good practices as management sub-systems

As a result of Peters and Waterman's work [35], several authors have tried to draw up a list of good management practices for putting an organisation on the path to excellence [53]. Two studies stand out in this respect, The first was by Mansar and Limam-Reijers [53] who carried out an on-line survey between 2003 and 2004. They obtained a wide range of best practices covering process re-design. The questionnaire was administered to practitioners who had a great deal of experience in the field. The results revealed the following ten best practices: (1) task elimination; (2) task composition; (3) integral technology; (4) empowerment; (5) order assignment (one piece flow); (6) resequencing (task and resources); (7) specialist-generalist (move resources); (8) integration (the entire supply chain); (9) parallelism (parallel-processing); (10) numerical involvement (cutting the number of departments).

The second study was by Harrington [54], who analysed 60 companies in Japan, Germany, the USA and Canada to set a standard for best management practices. The organisations selected were drawn from two major industries - manufacturing (cars and computing), and services (hospitals and consumer banks). He found that only five practices significantly correlated with performance measured in terms of return on investment, added value per employee, and customer satisfaction. The practices revealed by the study were: 1) cycle-time analysis; 2) process value analysis; 3) process simplification; 4) strategic planning (deploying the strategic plan); and 5) formal supplier certification programmes.

One should note that some authors have indicated the broad relationship between process management and organisational management (management systems). That is why it was decided to select these two studies [55]. Although Harrington's study [54] focused on practices throughout the management system, his findings revealed the importance of process management and improvement, and of its strategic planning and implementation. Thus each of the best practices in the two studies can be considered as management sub-systems, although these might be grouped according to certain criteria. Nevertheless, the authors realise that there may be other studies grouping best practices in other management fields.

2.7 The Toyota Motor Corporation business model as a management system archetype

In 2004, Jeffrey Liker published *The Toyota Way*, in which he described the fourteen principles of the company's management system. In it, he tried to find the keys to success of the world's leading car maker. The book was one of the first to take a more integrated theoretical look at companies, embracing the whole of management instead of just its production system. Each of Liker's principles was placed in one of four main categories, which could be considered management sub-systems. Each category began with the letter "P": *Philosophy, Process, People/partners; Problem solving*. The following table shows the relationship between the management system's fourteen principles and the sub-systems proposed by Liker [56]:

Categories (subsystems)	Management System Principles
Philosophy (long term thinking)	1.- Base management decisions on a long-term philosophy, even that expense of short-term financial goals.
Process (eliminate waste)	2.- Create process "flow" to surface problems 3.- Use pull systems to avoid over production 4.- Level out the workload 5.- Stop when there is a quality problem 6.- Standardise tasks for continuous improvement 7.- Use visual controls so no problems are hidden 8.- Use only reliable thoroughly tested technology
People and partners (respect, challenge and grow them)	9.- Grow leaders who live the philosophy 10.- Respect, develop and challenge your people and teams 11.- Respect, challenge and help your suppliers
Problem solving (continuous improvement and learning)	12.- Continual organizational learning through Kaizen 13.- Go see yourself to thoroughly understand the situation 14.- Make decisions slowly by consensus, thoroughly considering all options; implement rapidly

TABLE 1: The categories and the 14 management systems principles of the Toyota Way. Adapted from Liker (2004)

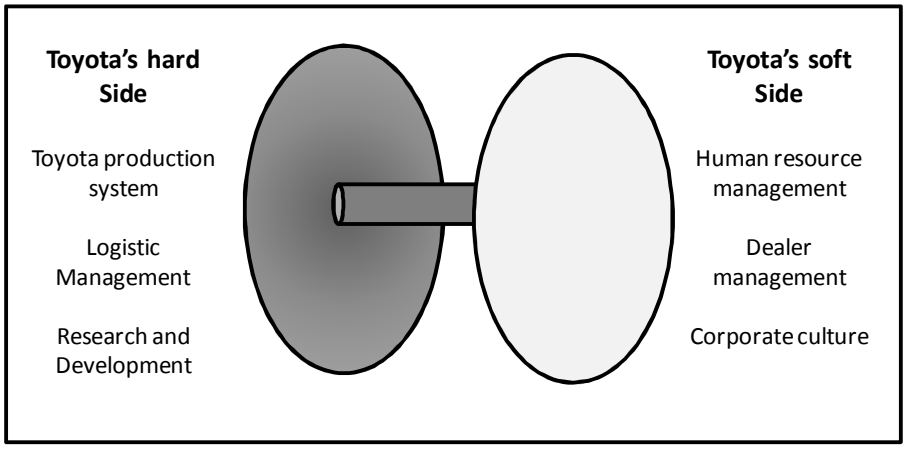
Liker's work [56] is extremely valuable because it set out to understand Toyota Motor Corporation's management system and its whole value chain over the years. However, Liker [56] also noted that each one of the sub-systems and its respective principles were also important and that selectively focusing on them could impair the proper functioning of the management system as a whole. As Dahlgaard-Park [6] noted, Liker presented four sub-systems and fourteen principles but that more might be required to attain organisational excellence. Indeed, the author indicated that Toyota Motor Corporation did not require so many sub-systems and principles. Rather, its management system – the Toyota Way (2001) – only set two basic sub-systems: Respect for people and Continuous Improvement or Kaizen [57]. This was intended to make the system easy to put into practice. The complexity identified by Liker was therefore not the way Toyota saw things [6].

In fact, other authors have taken a similar approach to explaining how a company works, looking at the various sub-systems making up a firm's management approach. For example, Monden [58] indicated that Toyota Production System (TPS) is a viable method for making products because it is an effective tool for producing the ultimate goal – profit. By cutting costs and seeking continuous process improvement and productivity, TPS fosters cross functional management, ensuring compliance with all of Toyota's strategic policies and targets [58]. According to Monden, TPS can be seen as a integral management system, not just only as production management system, driven by management and strategic decisions to deliver competitive advantage [58]. Indeed, the man who invented TPS, Taiichi Ohno, said as much: Toyota Production System has to evolve constantly to cope with severe competition in the global marketplace……we have to improve the bottom line (operational profit) of the income statement by considering 'all aspects' of the company and ensuring the continuous evolution of TPS. 'All aspects' refers not only to problems directly related to manufacturing but also those related to various indirect departments including production engineering, product development, and managerial offices [58].

Following a similar line, Osono *et al.,* [59] presented a conceptual scheme that set out to explain how the Toyota Motor Corporation's management system operated (although the authors do not use this term) (see Figure 2). According to Osono *et al.,* [59] this scheme is very different from a purely Taylorian company, which learns through doing. Part of the Toyota Motor Corporation manages the "hard" aspects of the company (of which TPS, logistics management, and R&D work are key sub-systems). However, this is balanced by management of "soft" aspects (see the right side of Figure 2), of which human resources, corporate culture, and management of

suppliers and partners are key sub-systems [59]. This two-pronged approach (which combines Taylorian methods and the flexibility conferred by a looser, more creative ethos) seems to be the secret of Toyota's success and what makes it worth emulating [59] [60]. It is possible that the classification used by Osono *et al.,* [59] regarding Toyota Motor Corporation's use of "hard" and "soft" elements in its management system is based on McKinsey's 7-S model, which distinguishes between "hard" components (structure and strategy) and "soft" elements (systems, shared values, skills, staff and style).

Hino [61] explains Toyota Motor Corporation management system in a similar vein (the author refers in a direct way of management system term). He argues that it comprises seven key elements: (1) Total quality control; (2) concurrent engineering; (3) Toyota production system; (4) human resource development; (5) labour-management trust; (6) long-term relationships; (7) long-term relationship with dealerships. Each of these elements can be grouped in the two sub-systems making up the management system: "the management function system, which runs the organizations, and a production function system, which generates products [61]".



Fuente: Osono , E., Shimizu, N., and Takeuchi, H. (2008). *Extreme Toyota. Radcal contradictions that drive success at the World's best manufacturer,* p. 20.

FIGURE 2: Hard and soft elements in the Toyota Motor Corporation.

Finally, Dahlgaard and Dahlgaard-Park [62] present a model that is similar to Liker's (2004). It features five critical variables (possible sub-systems) to achieve organisational excellence. These variables are: (1) building leadership; (2) people; (3) partnership; (4) processes; and (5) products. As the authors note, the model follows the principles of Katz and Kahn's open system theory (see Figure 1) [31] and a socio-cultural epistemology [63], in which great store is set by the interrelationships between processes, contingencies, and other parts of the system [6] [63]. From this standpoint, the management system presented by Dahlgaard and Dahlgaard-Park [62] is not a simple mechanism that maintains all of a company's elements unchanged. On the contrary, it drives the firm forward and constantly mobilises new capabilities, ensuring that information flows between management sub-systems deliver incremental improvements in a company's procedures and the way it is run [1] [6] [60] [63].

2.8 The Kaplan and Norton's management system

From another strategic management angle, Kaplan and Norton [36] note that successful strategy execution follows two basic rules: (1) understand the management cycle linking strategy and operations; (2), know what tools to apply at each stage of the cycle. In this respect, understanding the whole cycle from strategy right through to implementation is to understand the management system itself. Kaplan and Norton [36] define a management system as: "the integrated set of processes and tools that company uses to develop its strategy, translate it into operational actions, and monitor and improve the effectiveness of both". The importance of Kaplan and

Norton's work (2008) lies in their finding (supported by various studies over the last 25 years) that between 60% and 80% of companies do not implement their new strategies and thus fail to achieve the forecast outcomes. The authors advocate a closed management cycle to improve the chances of putting the strategy into action. Kaplan and Norton's management system comprises five stages: 1) develop strategy (mission, vision, and values); 2) translate the strategy (objectives and strategic teams); 3) plan operations (process improvement, sales plan, resource capacity plan, budget); 4) monitor and learn; and 5) test and adapt the strategy (cost and profitability reports and statistical analysis) [36].

From a practitioner focus, Kaplan and Norton [36] make a set of practical recommendations for company managers. The end result is a management system that helps: set clear strategies; allocate resources in keeping with the strategic aims; set competitive priorities linked to the strategy in terms of cost, quality, delivery, staff morale and motivation; deliver flexibility; recognise the impact of the strategy on the bottom line; update the strategic aims where necessary. In a nutshell, the management system proposed by these authors strikes a balance between strategic and operational spheres [36]. Nevertheless, as with other approaches focusing on the "hard" part of a company, the management system proposed by Kaplan and Norton does not specifically embrace other sub-systems affecting the "soft" part of the company. In other words, sub-systems such as staff management, staff development, work teams and even leadership are missing from the scheme. This may be because "soft" aspects are not amenable to the kind of measurement and control implied by the Balanced Scorecard approach advocated by Kaplan and Norton.

3. CONCLUSION & FUTURE WORK

3.1 Contribution and Discussion

Reviewing and analysing the literature in our search for management systems has made us realise tough it is to hack one's way through the "management jungle" [4] in search of a suitable theoretical construct. This bears out what various authors have said regarding the difficulties of cutting through the confusion to classify and clarify the various ideas on management [4] [5]. However, we did find writings that helped us grasp the nature of *management systems.* Our interest in this reflection research, based in our scientific curiosity, it is clearly to understand and discovering what constitutes a management system. Besides, this research interest it is also based in our experience with the "reality" of work practice. Therefore, in our experience, many companies are desperately keen to find the path to excellence but they find it strewn with obstacles when it comes to putting strategy into action. Put baldly, many companies fail in their attempts.

For that reasons, after we made a cross themes analysis (based in content analysis) of the various theories, models, and management systems in the quality, excellence and strategy fields, we discovered various common "codes", that represents starting points for defining the management system concept from a more academic standpoint. Also, we realise that it is inappropriate to apply and to generalise these common codes to all management fields, given that we only examined a small sample of theories, studies and models covering quality, excellence and strategy. Nevertheless, these common codes help define and understand a management system, its features and component parts in a first draft attempt.

The following table shows the cross themes analysis of each management theme studied:

Themes studied / Elements of analysis	Taylor	Fayol	Systems Theory	Peters and Waterman
Management field focus	Industrial Engineering	Management / Industrial Engineering	Open Systems Theory	Excellence and Quality
Unit of analysis	Division of work and operating efficiency	General mgmt.	The organisation as a whole	Management excellence
Definition of the Management System	No	No	No	No
Sub-systems	No	No	Includes interrelated sub-systems	No
"Hard" elements	Uses scientific methods and work studies	Division of work into basic operations	Understands the problems affecting sub-system interrelationships	Closer to customers and business realities – constitutes basic strategy
"Soft" elements. Focus on people	Scientific selection of staff and training	Workers must be rewarded	Creates dynamic socio-technological areas	Considers items such as leadership, motivation and participation
Managers' role	To draw up work instructions, plans and tasks	Managers must set an example to their workers	Based on a holistic, integrated vision	Motivates staff to come up with ideas for cutting waste
Strengths	Focuses on work efficiency	Design of the mgmt. process	Sees the organisation as a whole	Profiles excellent organisations
Weaknesses	Forgets the human side	Narrow "hard" focus	Loses sight of the details	Some attributes not applied today

Themes studied / Elements of analysis	EFQM	ISO 9000	Best practices	Kaplan and Norton	Toyota business model
Management field focus	Excellence and Quality	Total Quality	Management and Processes	Strategy and Operations	Management, Processes and People
Unit of analysis	The organisation's self-evaluation	Total Quality in the organisation	Process mgmt.	Strategic mgmt. and operational mgmt.	Excellence, quality and strategy
Definition of the Management System	Yes	Yes	No	Yes	No
Sub-systems	The 8 EFQM criteria	The 8 sections of the norm	Each best practice identified	No	Present in the four models studied. Classified under "hard" and "soft" items
"Hard" elements	The model focuses on mgmt. of work processes and results	The model is based on developing a Quality Management System	Focuses on process improvement and re-engineering	Not considered	These are indicated and cover Production, Logistics, Quality Management and Inter-functional Management systems
"Soft" elements. Focus on people	Considers staff, leadership and partners	Its elements put little emphasis on people's work	Does not consider everything	Not considered	These are indicated and cover staff management, supplier integration and leadership
Managers' role	Management using an established model of excellence	Mgmt. focuses on process quality	Participatory management	Directs the management system as a continuous, closed cycle	Coaching and support
Strengths	Self-evaluation fosters improvement	Documents work	Focuses on work processes and strategy	Strong link between strategy and operations	Stress on processes and problem solving
Weaknesses	Does not say how it should be applied	Can spawn red tape	Does not group all techniques	Forgets the human side	There may be too many principles in some models

TABLE 2: Comparative analysis to define a Management System

It shows how the common codes emerged from a cross theme analysis of the various theories, models and management systems. The first question was: (1) *What is a management system?* As one can see from the table, only the EFQM and ISO 9000 models provide a definition. Kaplan and Norton [36] also do so in their recent article, stressing the management focus they take to link strategy to operations. This finding reveals that the concept of a management system remains ambiguous and is difficult to pin down in theoretical terms, even though its origins lie in classic management theory. In this respect, and taking into account the three definitions found in the literature, one can indicates the following common features:

-What is it?: (a) A general scheme of processes and procedures [38]; b) a system [46]; c) An integrated set of processes and tools [36].

-The purpose of the Management System as stated in the definition: (a) to ensure the organisation carries out all the activities needed to reach its objectives [38]; (b) to establish the policy for meeting the objectives [46]; (c) to lay the strategy and turn it into action, and to monitor and improve both the strategy and its implementation [36].

-Additional elements: (a) Includes both macro hard and soft elements [59]; (b) Has independent, interrelated sub-systems [24] [56] [62]; (c) an effort is made to stick to competitive priorities by linking strategy with operation [36].

Bearing in mind these three codes, we propose the following preliminary definition of what constitutes a management system: "It is a set of sub-systems that may be considered work processes (whether independent or interrelated) and which may be placed in either the "hard" or "soft" dimensions of the system. Each sub-system is managed with a view to achieving the organisation's shifting strategic priorities, linking strategy (vision, mission, objectives) with operations."

With regard to our second question, "*What macro-elements make up a management system?,"* according to the literature, a macro-element can be understood as a group of management subsystems with two dimensions: one hard and the other soft. This group of macro-elements maintains and encompasses various subsystems which, at the same time, are integrated in other management practices. The aim is for the management system to be operated and applied within the organisation. The following rules emerged from the literature review:

-The *Hard* dimension: (a) processes and operations; (b) strategy; (c) problem-solving tools, process re-engineering and Kaizen continuous improvement; (d) philosophy; (e) resources and inputs; (f) activities, tasks and procedures; (g) quality and production systems; (h) products and services (i) R&D and the incorporation of technology (j) simple organisational structures [9] [19] [24] [35] [36] [37] [46] [53] [54] [56] [59] [61] [62].

-The *Soft* dimension: a) Leadership; b) focus on people (development and empowerment); c) integration with suppliers; d) cultural elements of the organisation; e) a client-based approach; team work (improvement teams) [35] [37] [46] [56] [58] [61] [62] [67].

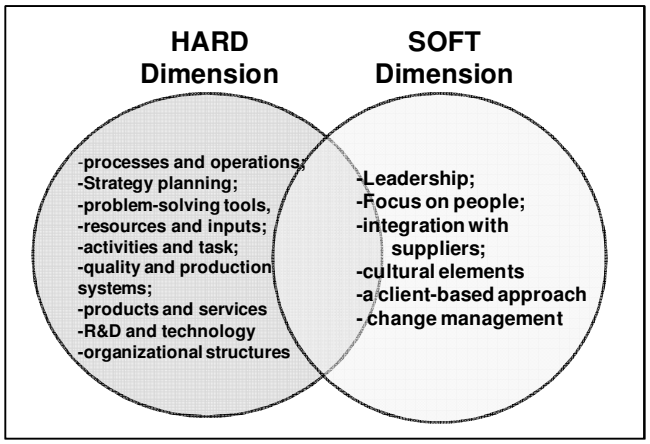


FIGURE 3: The macro-elements of Management Systems.

With respect to the third question, "W*hat subsystems make up each of these macro-elements?,"* each macro-element consists of certain management subsystems as indicated in the previous paragraph. A management subsystem, in turn, can be seen as a set of managerial practices used by an organisation to manage itself (Planning, Organising, Leading and Tracking). An excellent analogy making the relationship between the macro-elements and the subsystems clearer and more easily understood is the human body. The latter is a biological system which can be classified into macro-elements: the circulatory, respiratory, nervous, digestive and endocrine systems, amongst others. Each of these macro-elements also contains subsystems. For example, the nervous system includes the nerve cells in the brain and the nerve endings throughout the body. Another example is the circulatory system which includes the heart and all its valves (representing a subsystem within this macro-element in and of themselves), as well as the network of arteries, veins and capillaries. Another simple analogy which may help to clarify the relationship between management systems, macro-elements and subsystems is a biological cell. Each cell (an organisation) systematically carries out its biological processes, interrelating each and every one of its elements and subsystems. A cell's macro-elements could be the nucleus, the mitochondria, the cytoplasm and the cell membrane, and we could find biological subsystems working in each of these. For example, in macro-elements such as the nucleus, we find subsystems or processes to duplicate genetic material, while in the mitochondria we find processes to generate energy for the cell.

To summarise, we considered the two common codes found in the literature in relation to our questions and found that a management system may be made up of the four main macro-elements, which can then be used to group the various sub-systems:
1) Strategy/Philosophy;
2) Processes/Tasks;
3) People;
4) Tools and Techniques

Firstly, we have the *Strategy/Philosophy* macro-element within the *hard* dimension. It encompasses all managerial practices or subsystems related to planning and philosophy (values and principles). As such, it includes the organisation's *Vision, Mission* and *Values*. Similarly this macro-element also includes the company's organisational structure. This macro-element could thus be represented as the management system's "brain," long-term thought, its direction, principles and the way in which the company organises itself. The following figure illustrates this macro-element with its respective subsystems.

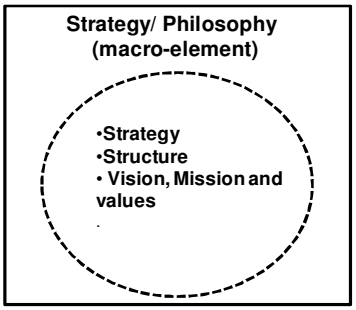


FIGURE 4: The *Strategy/Philosophy* macro-element

Another macro-element within the *hard* dimension is *Processes/Tasks*. Within this group we find the macro and micro processes which are management subsystems, in essence, due to their representing a set of tasks which transforms inputs into outputs internally (within the organisation) and which, simultaneously, interrelates with others in system dynamics, creating a set of nested processes [65]. In line with the analogy used for the previous macro-element, these (macro and micro) processes represent the organisation's "heart" because the entire flux of the products and services aimed at a client or end depend on it. The following figure illustrates this macro-element.

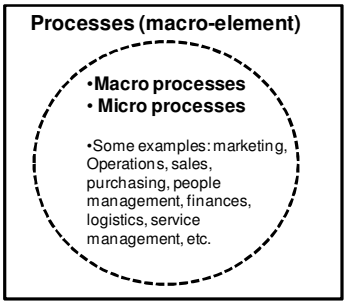


FIGURE 5: The *Processes/Task* macro-element

The third macro-element is *People* and it corresponds to the *soft* dimension. Within this macro-element are all the subsystems or managerial practices related to the company's soft dimension; human factor management and development, leadership management, change management and culture are some examples of the subsystems it includes. In keeping with our analogy, people represent the "human body" within the management system. This macro-element is vital in 21st century firms given that no management system can work, let alone improve, without people. The following figure illustrates this.

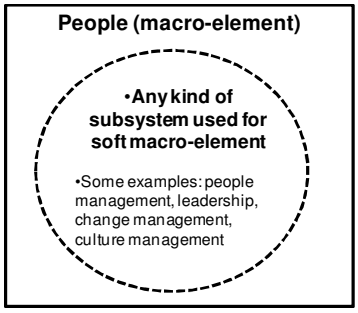


FIGURE 6: The *People* macro-element

The last macro-element analysed is found within the hard dimension: *Tools and Techniques.* This macro-element includes all the techniques and tools used by any subsystem within the above macro-elements to maintain and innovate the management system. Examples include: service quality, marketing, relations, improvement teams, process re-engineering methods, measurement tools (balanced scorecard), leadership techniques and coaching, Kaizen-like problem-solving methods, and strategic planning techniques. This macro-element can be seen as the "hands" of the management system, the reason being that the hands are one of the human body's main tools. The following figure reflects this idea.

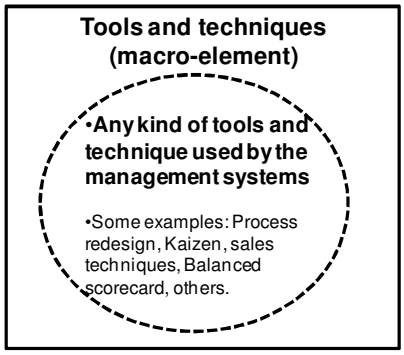


FIGURE 7: The *Tools and techniques* macro-element

With regard to our fourth question - *What management characteristics does a management system have?* – we looked at common codes matches indicating a management system's main features:

-It takes a simple yet practical holistic approach to management.

-It comprises macro-elements that group sub-systems, striking a balance between "hard" and "soft" dimensions when it comes to practical execution.

-It comprises interrelated sub-systems (which can also be seen as managerial practices) that enable the management system to operate.

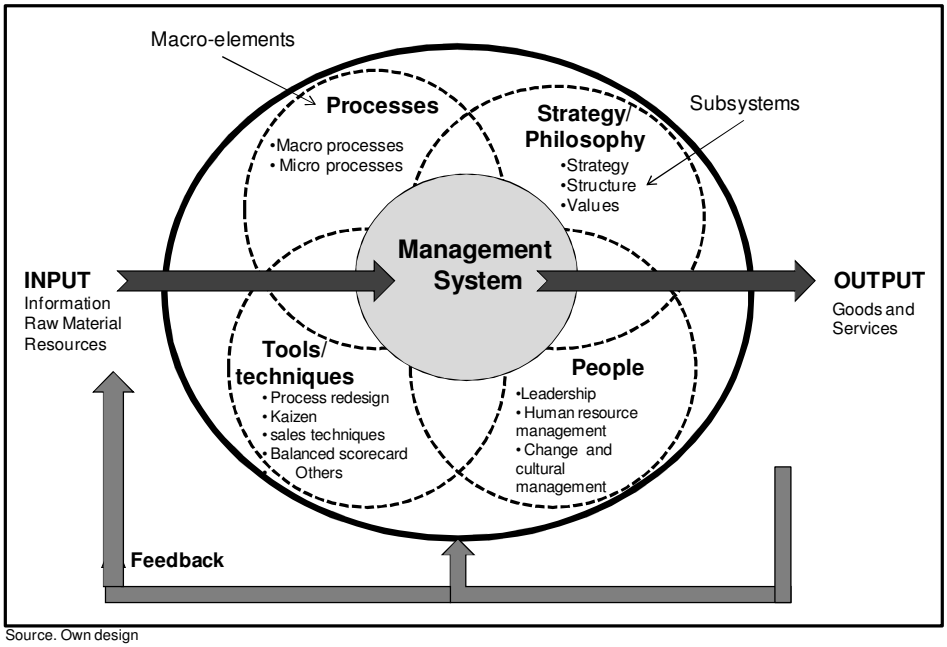
-The management system allows daily maintenance and improvement of organizational processes.

-Its purpose is to ensure the company's competitive priorities are met in terms of quality (Q), cost (C), delivery (D), flexibility (F) and innovation (I), this competitive priorities are already formulated in the strategic planning of the organization. Its ultimate purpose is to achieve organisational excellence.

-The *soft* element (a focus on people) plays a crucial role in putting a management system into effect. We are convinced in the light of the literature review that understanding the full range of management realities in a company means embracing cultural/change management and adopting a people-friendly approach (respect, staff development and retention). It is highly unlikely that a firm today will achieve organisational excellence without such an approach. Accordingly, the real challenge facing 21st century companies in their quest for excellence is to ensure that their "soft" sub-systems (i.e. the human element) reduce the negative impact of "hard" (read mechanistic) elements on the firm's staff.

-Lastly, benefits reported by literature, which can bring to an organization equipped with an effective management system ranges from managing social, environmental and financial risks; improving efficiency and operational effectiveness; reduce costs; increase the satisfaction of customers and stakeholders, achieve and promote continuous improvement and innovation, to protect brand and reputation, achieve consistently successful and flexible strategies, and bring clarity to the market.

The following conceptual framework condenses and synthesises all our conceptual analysis of macro-elements and subsystems:



Source. Own design

FIGURE 8: A management system framework

When describing the operational dynamics within the conceptual framework, we should observe the management system's focus in Figure 9. It is holistic in terms of operation and design. In fact, it is in line with the open system model proposed by Kast and Rosenzweig [24] as shown in Figure 1 above. In other words, it has a group of inputs which, by operating the macro-elements and subsystems, are transformed into outputs such as goods and services. This transformation is carried out by managing the organisation itself. Specifically, it begins in the management system's hard dimension with the interrelation of its strategic macro-elements and the processes for their application (the dotted-line circles in the figure represent this application), all the while attempting to establish a close bond between strategy and operations. At the same time, during the business management process (management system operation), the People macro-element (within the soft dimension) works to provide a sense of purpose and direction to all the people working there. Lastly, each time a subsystem is operated, any tool within this macro-element can be used. For example, if the company begins to apply a process innovation programme, it can use techniques such as process redesign.

3.2 Final Conclusions and Managerial Implications

"Management Systems" is a term that is still hard to find in the management literature. This research aimed to hazard a definition of such systems and to identify their macro-elements, subsystems and characteristics. A conceptual framework was produced to depict our findings in graphic form. Finally, one should note that a possible limitation of our research lies in its small (albeit representative) sample of management models, conceptual schemes, theories and systems in the quality, excellence and strategy fields. Accordingly, our findings do not permit empirical generalisation of management systems, although an analytic generalisation could be presented on the basis of the evidence found of our content analysis. Furthermore, this approximation needs to be refined if future avenues are to be mapped. Such studies might be of a qualitative or quantitative nature and either confirm or re-work the concept (definition, elements, characteristics) in the light of modern or XXI centuries companies' application of the conceptual framework proposed in this conceptual research.

At least four practical implications of this conceptual analysis can be identified, possibly underscoring the importance of management systems in organisations and answering a basic question such as "How am I going to manage my organisation?":

1) Executives and managers must understand the importance of having a management system which represents the means or how to apply the organisation's business models.

2) In addition to serving as the means to apply the business models, it is the primary vehicle to link strategy with operations.

3) Management systems not only represent the execution of general practices (subsystems) within the hard dimension (processes, structures, tasks and activities); they also integrate the organisation's entire soft dimension (people management, culture, leadership and change) which is generally forgotten in the systematised management of organisations.

4) It allows executives and managers to organise and prioritise their management tasks from a systems perspective, abandoning the "old" ways of working as per classic theory (mechanistic organisations).

We want to close this paper with one of the responses that makes Gary Hamel academics and businessmen that have generated from his article "Moon Shots for Management" in Harvard Business Review indicated below: "The challenge in reinventing management is to create systems and processes that encourage employees to bring their very best to work. The goal is to make organizations that are as adaptable, innovative, and engaging as the people who work within them, and accomplishing that will require making organizations feel like genuine communities instead of hierarchically structured bureaucracies [66]". The Hamel's response in Harvard Business Review matches the conclusions found in our research and begin to emerging trends in the management for the future.

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A Three-Step Procedure (3SP) for the Best Use of Skilled Labor

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Abstract

As the manufacturing is becoming more and more globalization, the manufacturing jobs, especially low skilled jobs, have been moved to the developing countries for a lower production cost. For those jobs, such as skilled labor jobs, currently still kept in the developed countries, more and more cost pressure is experienced in these countries as those jobs will eventually be moved to the developing countries once their infrastructure, efficiency and skill level are improved.
Therefore one of the challenges currently faced by the Canadian companies is how to improve the manufacturing productivity. Currently those companies are using their own way to improve the productivity. As a result, a company may repeat what another company has already done for the improvement of the productivity, and waste the effort. In some cases, a company even has no idea how to pursue the action to improve its productivity.
In order to provide the Canadian companies some sort of systematic approach in the course of improving productivity, a systematic qualitative guideline for the best use of skilled labor, called as "Three-Step procedure" (3SA), is developed and described in detail in this paper.

Keywords: Manufacturing, Process analysis, Production, Productivity improvement, Skilled-labor, Skilled-labor intensive manufacturing, Three-step procedure.

1. INTRODUCTION

Canadian manufacturing companies are experiencing extreme challenges in retaining the production inside the country, since more and more manufacturing jobs, especially those low skilled labor intensive jobs, have been moved to developing countries such as China and India where the lower cost of labor significantly reduces the production cost. The jobs that are still remaining in Canada or other developed nations are mainly skilled labor or machine intensive jobs. Even for these jobs, they may eventually move to developing countries once their infrastructure, efficiency and worker skill level are improved.

In order to keep as many jobs as possible in Canada is now a major concern by Canadian companies. One of ways to reach this aim is to reduce production cost while maintaining the required quality, quantity and delivery time level. Currently most companies are using their own way to reduce the production cost through reducing the waste. This situation may cause the

useless effort in the course of improving the productivity since a company may repeat the effort that has already been done by another company. In some cases, a company even does not know how to pursuit an action to improve its productivity. So it would be benefit for all companies if a systematic approach could be available to improve the productivity. However, no such way exists currently and maybe because of "Difficult to Recognize the Manufacturing Problem", "Difficult to Locate the Root Cause", "Difficult to Find the Solution" and "Unavailable Standard Procedure" [3].

- **Difficult to recognize the manufacturing problem** since the problems occur randomly with multiple symptoms. Randomly occurring means the problems could occur at anytime and at any location in the course of production; Multiple symptoms mean a problem could be presented in multiple ways and easily block the human being's recognition process.

- **Difficult to locate the root cause** since the linkages between the problems and causes are extremely complicated, in some cases no information is available at all. Complicated linkages mean the links between problem and causes could be "One to one, One to many, Many to one and Many to many"; No information is available at all means the required information, such as electronic version of BOM, is missing since it may not be collected at first place.

- **Difficult to find the solution** since it is very difficult to find the root cause, and the attempt solution may not solve the root cause and the similar or the same problem may occur again in the future.

- **Unavailable standard procedure** since it is not developed so far and the different companies use the different procedures to solve their specific problems. It makes the solution searching procedure very subjective and less effective than it could be.

In order to provide a systematic approach to improve the productivity when skilled labor is used, a "Three-Step Procedure" (3SP) is developed and described in this paper.

2. LITERATURE REVIEW

The improvement of productivity is mainly related to the deduction of waste in terms of what is waste and how to reduce waste. Therefore, the literature review has focused on the "Definition of Waste", "Identification of Waste in Manufacturing", "Solution of Reducing Waste", "Costing Process" and "Systematic Approach of the Best Use of Skilled Labor".

2.1 Definition of Waste

In order to identify waste, it is necessary to know what the waste is. From an ecology point of view, everything on the earth has a purpose and no waste exists. So that the term "Waste" is a relative concept, for example, recycled paper is a waste for most industries, but not for the recycling industry since it is the source of its revenues.

Therefore waste is defined by many ways in the literature. Hesham K. Alfares et al. (2005) stated "The deteriorating items and deterioration of process are considered to be a kind of waste since both deteriorating items and deterioration of process cost money"; Kenne J.P. et al. (2000) [10] said "Inventory cost and back order penalties will affect the performance of production, and is considered to be a waste".

Generally speaking, waste is any unwanted or undesired material left over after completing an activity such as a transformation of raw materials to semi-finished or finished products.

In this paper, "Waste" is defined as "Any unplanned loss in terms of quantity, quality and time in manufacturing". Based on this definition, a "Planned loss" is not a waste since it is supposed to occur. In some literatures, this definition is called a "Pure waste".

2.2 Identification of Waste in Manufacturing

Once the waste is defined, how to identify it in a manufacturing is the next question that is another topic in the literature review. The first attempt in the searching was focused on the identification of waste in skilled labor manufacturing, but no paper could be found. Then the searching was expanded to manufacturing and reviewed as follows.

Not many papers could be found related to the identification of waste in manufacturing, which was indicated by Britney, Brand and Lubicz, as "A relatively little work has been done to explore the process improvement on the cost saving by comparing to the research on the number and placement of inspection stations for the production costs like the costs associated with maintaining inspection stations, performing inspection tasks". Some papers found are listed as follow:

Smith Marc (2008) [19] stated that the identification and elimination of waste is the core of any supplier development activity. He defined waste, and looked at possible causes and symptoms in a supply chain system.

Naruo et al. (1990) stated that expert system could be developed for diagnostic decision support, which transforms the cause-effect relationships into production rules and uses forward or backward chaining to infer fault causes from fault symptoms. Although the expert system overcomes the problem of computational complexity by employing heuristic knowledge, its ability to solve a problem is restrained to what is in the knowledge database due to the inability to learn and generalize knowledge.

Knapp and Wang, et al. (1992) presented in the paper "Neural networks for system fault diagnosis". Another example was presented by Ye and B. Zhao (1996) [20] in the paper "A hybrid intelligent system that integrates the neural networks with a procedural decision making algorithm".

Peng and Reggia (1990) stated that from an Operations Research point of view a diagnostic problem can be considered as an optimization problem that represents a solution in terms of optimization indicators that are subject to constraints such as the cause-effect structure of a target system. Operations research is basically mathematics and statistics based approach to analyze the data.

As a summery, the identification of waste is a complicated and subjective process, and few researches have focused on this topic so far.

2.3 Solution of Reducing Waste

Once the waste is identified, the next consideration in the literature review is the solution to reduce waste.

Many solutions can be found to reduce waste in manufacturing, for example, D. Challis et al. (2005) stated "TQM, JIT and Advanced manufacturing technology are important, however, the 'soft' human resource management practices such as leadership, teams, and employee performance is also significant in improving the manufacturing performance". Other examples are:

Hallihan A et al. (1997) stated "Some types of waste could be eliminated by using JIT. This would be done with management support and by setting the JIT in a specific manufacturing context which is the combination of people, machines, materials, processes, products, and managerial policies".

E. Houghton et al. (2005) stated "A cross-training of workers to perform multi-skilled jobs is one of the modern trends in job design for cost savings".

Inderfurth K. et al. (2005) [8] noted that it is necessary to coordinate the production and rework activities with respect to the timing of operations, since the state of defective items may change in the course of time while they wait to be reworked. Such a deterioration of rework-able goods can result in increasing rework time and rework cost per unit, which increases cost.

Lin Z-C et al. (2002) [12] stated "A tolerance design, based on neural networks, in product components could produce a product with the least manufacturing cost possible, while meeting all functional requirements of the product".

Lee B. (1999) [11] stated "Under the assumptions of profit maximization and cost minimization and ignoring the potential inefficiency in IT investment and management, the increase in the IT intensity will significantly reduce the technical, allocation and scale inefficiencies".

2.4 Costing Process

Once waste and solution are found, they need to be assessed for the implementation in terms of cost since the trade off needs to be determined between cost of waste and cost of solution. In some cases, "Leave waste as is" maybe feasible if it is too expensive to implement solution unless it is a legal requirement.

The costing process in this paper refers to what and how to measure the cost, which is subjective and complicated, as stated by Jha N.K. (1996) [9], "Costing in manufacturing is a complicated process. The normal approach to costing is to estimate the cost based on time required for the production processes, and the costs for materials, and then add some profit margin on top that is pre-determined by the managerial judgment and experience".

Many processes could be found in the literature, but most of them are case based. For example, Newnes L. B. et al. (2007) [14] mentioned an on-screen real-time cost estimation used in the early phase of design of injection moldings to identify the avoidable cost; Shehab E M et al. (2002) [18] used an object-oriented and rule-based system to estimate the product cost at an early design stage. The main function of the system, besides estimating the product cost, is to generate initial process planning, including the generation and selection of machining processes, their sequence and their machining parameters, to recommend the most economical assembly technique for a product and provide design improvement suggestions based on a design feasibility technique.

Some processes do provide a general approach, but no detailed "step by step" approach is available. For example, Michelle stated "There are basically four steps in assigning production resources to the end product in the costing process: 1) Define activity groups that have a direct relation with the end product; 2) Determine resource drivers that show the relation between production resources and activity groups and cost drivers that show the causal relation between an activity group and a type of end product; 3) Assign the costs and resources to activities based on the resource drivers; 4) Assign the costs of activity groups to the end product based on the Cost" (ABC Forum, 2008) [1].

Simon observed that it is essential to first make the decision about the level of detail that needs to be captured in the costing process. At the strategic level, about 100-150 activities are most commonly used to determine the profitability of a customer or a product. At an operational level the number goes up to 500+ activities to improve the costing process (ABC Forum, 2008) [1].

Park J. et al. (2005) [16] also stated that estimation of the production cost of a family of products involves both estimation of the production cost of each product in the family and the costs incurred by common and variant components/design variables in the family.

The way to determine cost includes: 1) Allocation, in which the production activities and resources needed to produce the entire product lines in a family are identified and classified with an activity table, a resource table, and a production flow statement; 2) Estimation, in which the

production costs are estimated by cost estimation methods; and 3) Analysis, in which the components/design variables possible for the product family are investigated with resource sharing methods through activity analysis.

P.R. Roy et al. (2008) [15] developed a process "Function-based cost estimating" that links the commercial and engineering communities through a structured approach at the conceptual design stage. This process is to translate the un-quantified terminology and the requests associated with the product specifications by using a standardized approach.

It starts with functional decomposition, and then identifies product parameters that are related to a top level function, and finally associate product costs to the function using past knowledge and data. It is validated in two case studies from the automotive and aerospace industries.

Sharma Rajiv Kumar et al. (2007) [17] presented a quality costing in process industries through QCAS: a practical case, which is to implement, sustain and manage a quality-costing program in a process industry by attaching fuzziness to the notion of "quality".

2.5 Systematic Approach of the Best Use of Skilled Labor

A systematic approach of the best use skilled labor is another focus in the literature review. However, unfortunately no paper could be found related to the topic of "Systematic Approach of the Best Use of Skilled Labor" in the literature.

3. Three-Step Procedure (3SP)

When the field managers or industrial engineers were deciding how they would improve manufacturing productivity, the first thought in their mind was, "How do I proceed this task in terms of 1st step, 2nd step and so on?" and "Was there any procedure in reality or the literature that can be followed by field personnel?" Based on an extensive literature search, although many manufacturers do variations of improvement of the productivity informally or set up a rigorous structure for parts of the improvement for themselves, the whole statement has not been found anywhere. The papers found so far are either for a specific problem or for an overall problem without detailed approach.

For example, Park J. et al. (2005) [16] stated the procedure in the design phase could be: 1) Identify and classify the production activities and resources needed to produce the entire product line in a family with an activity table, a resource table, and a production flow statement; 2) Estimate the production costs; and 3) Investigate the components/design variables possible for the product family with the resource sharing methods through activity analysis.

Therefore it was necessary to develop a new procedure to provide field personnel with a new standard qualitative procedure for the best use of skilled labor.

Based on the extensive interview with field personnel, the steps in the procedure should be, in order, "Whether skilled labor should be used in the first place?" "What is the maximum potential achievement to be set as a benchmark if skilled labor is selected?" and "How could the defined benchmark be attained and maintained?"

In order to facilitate the above questions, a "Three Step Procedure (3SP)" is developed in this paper, which includes: "Step 1: Determine whether to use skilled labor"; "Step 2: Define the most suitable specifications for using skilled labor" and "Step 3: Attain and maintain the defined productivity", as shown in Figure 1.

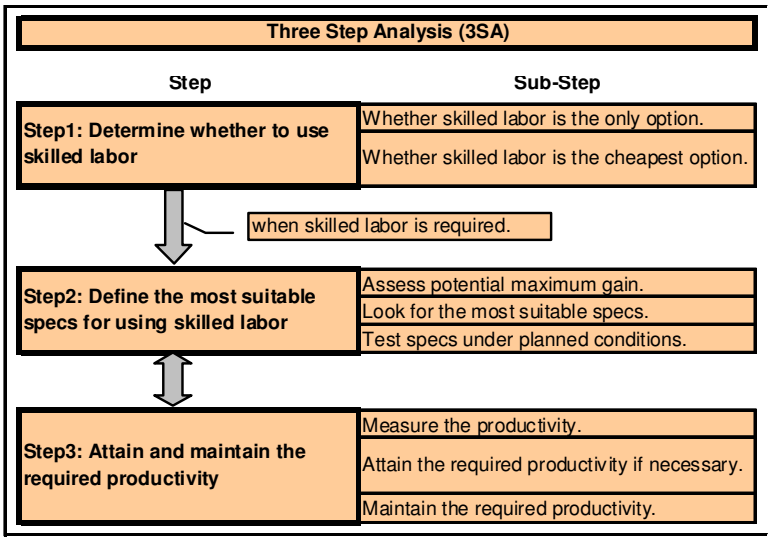

FIGURE 1: Three-Step Analyses (3SP)

3.1 Step1: Determine whether to Use Skilled Labor

Many production options such as skilled labor, un-skilled labor and machine are used in manufacturing to complete an order. The question is which one is the best one for the required job in terms of effectiveness and efficiency. Thus two issues are raised here: "Whether skilled labor is the only option" and "Whether skilled labor is the cheapest option". If skilled labor is chosen to be used, the issue will go to Step 2 otherwise no further discussion is needed in this paper.

- **Whether Skilled Labor Is the Only Option.** The purpose to check this issue is to reduce the decision effort since it is unnecessary to go through the cost procedure if skilled labor is the only option to do the required job effectively and efficiently.

  A list of situations is identified where skilled labor is the only option, which includes "Small volume of orders; Non existent machine; Unavailable documents; Complex item with small volume; Uncertainty in process; Extreme accuracy, Extensive measurement and adjustment required; and Significant judgment required".

  - **Small volume of orders** addresses the case when the order is small. In such a case, expensive machines cannot be justified, since each operation would have to carry a large part of the capital cost. If the machine also requires a significant setup time, the setup cost per operation for a small volume run would be large. For example, when only milling 100 cases of the radial aircraft engines per year, it will be very expensive per case if a NC machine is used because of its high capital cost.

  - **Non existent machine** addresses the case when no machine exists to do the required job, and the only way is to use skilled labor. For example, for aligning the metal sheet on the body of an old type of aircraft with an extreme surface smoothness, no machine currently exists to handle this job, and the only way is to use skilled labor. Another example is that an extremely accurate alignment is required when joining two sheets together to avoid "Oil canning" (a situation when two sheets do not fit perfectly together and cause a slightly curved rather than a flat surface, and with slight force the curve pops in or out easily). However, no machine could be found to perform this job since the machine does not exist and using skilled labor becomes the only way to do this job.

  - **Unavailable documents** address the case when the required documents are unavailable to do the required job, and skilled labor is the only option. For example, "Bill of Material

(BOM)" of an old type of engine with many variations is not available, and causes significant difficulty to determine which parts fit where. The solution could be recreating a BOM or use skilled labor with the knowledge of BOM for this type of engine.

- **Complex item with small volume** addresses the case when the requested item is complicated and the order volume is small as well, and skilled labor is the only option to do the job in terms of cost effectiveness. For example, a customized motor cycle requires many unique assembling operations such as "Fitting and aligning", which requires a sophisticated process that could only be done by skilled labor.

- **Uncertainty in procedure** addresses the case when the next step is unknown until the current step is completed. For example, when cutting a diamond, the placement of the next cut can't be known before the current cut is completed because of the variations in physical properties throughout the natural diamond. In such a case, skilled labor is the only option.

- **Extreme accuracy, extensive measurement and adjustment required** addresses the case where intelligence is required. For example, two pieces of thin metal sheet are often aligned very accurately when assembling the aircraft. Because of the combination of the extreme accuracy requirement and the flexibility of the sheets, no machine could be found to do this job, and skilled labor is the only choice.

- **Significant judgment required** addresses the case where good knowledge and judgment is required for doing the job. For example, when sorting the worn parts for useable, rework and scrap, good knowledge is required to do a correct sort; otherwise a good part may be treated as a bad one or vice versa if non-skilled labor is used; when lapping a cylinder valve, significant judgment is required for determining the smoothness of surface.

- **Whether Skilled Labor Is the Cheapest Option.** When more than one option is available to do the job, a cost comparison is necessary. For example, both NC welder and skilled labor are available to do a "Welding" job and the question is which one is the cheapest. When the batch size is small, using skilled labor is usually the cheapest because the setup cost of the NC welder is normally very higher per part welded. Some rules are summarized in the analysis in order to reduce the analysis effort, which are:

  - **Rule 1:** Machinery is always considered as the first option to do the job when the unit cost is acceptable since the machine always provides the least production time, the greatest quantity, the best and most consistent quality. Considering whether to use the machine usually depends on the unit cost determined by the production volume.

  - **Rule 2:** Non-skilled (un-skilled or semi-skilled) labor is the second option to do the job when the worker has the minimum required skill since the wage is medium. But, it is expected that other costs may be increased, such as longer production time or more defects.

  - **Rule 3:** Skilled labor is the least desired option to do the job if other options are available because of high labor cost.

  - Rule 4: Contract is a possible option to do the job if the cost is acceptable.

  In summery, in an industrialized country, machinery is always the first option, un-skilled labor is the second option, and skilled labor is the last option. Contract may be an option.

  The comparison in this step means to determine whether skilled labor has the least cost, which includes four steps: 1) Analyze production flow, 2) Determine factors to measure, 3) Identify losses and 4) Estimate cost, as briefly described as follows.

1) **Analyze production flow** is to understand how the production is done in terms of information and material flow.

The information flow includes the static information (e.g. aim, task, penalty policy, throughput, scrap, delay and cost) and dynamic information (e.g. where the value is added or lost and how the involved steps are linked).

The material flow shows where the material or part comes from and goes to.

One example of production flowchart is shown in Figure 2, which is a real process of "Grind and Lap Valves" performed in Aero-Recip (Canada) Ltd. This process is one of processes in rebuilding the cylinder of P&W R985 engine. The reasons for performing this process is that the ring on the valve seat in the cylinder is a soft metal part and needs to be replaced if it is worn and out of specifications. When a new ring is installed, it must seal with the valve without gas leaking otherwise engine power will be lost significantly if this process is not performed.

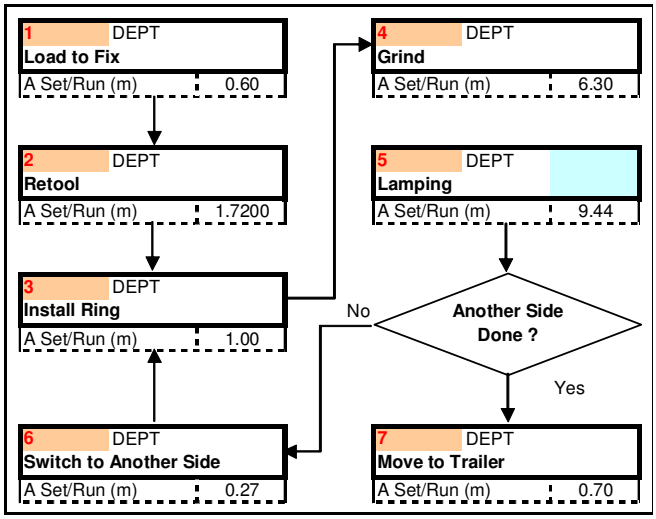

FIGURE 2: Grind and Lap Valves (Cylinder, P&W R985)

The details of the process are: Operator moves a cylinder in which new rings have been installed, from a trailer and loads and secures it on a fixture. He sharpens the sand stone (used for grinding) to the correct angle if necessary. He grinds the area on the ring where the valve will touch (called "Contact area") and checks the result several times until enough material is removed, and then cleans the grinding area with a cloth.

Next, he does a "fine" operation (called "Lap") to smooth the "contact area" to make sure no gas will be leaked through this area when the valve seals with the ring. The way to do this is: He takes the valve, which is specifically used for the valve seat being lapped, from a case and puts the lapping compound on the contact area on the valve. He takes a pole with a suction cup on the bottom (lapping tool) and mounts it on the flat side of the value seat, and puts the valve on the ring of the valve seat 1, then he starts lapping by rotating the pole. After rotating a while, he cleans the contact area and visually checks the smoothness. If the lapping is not completed, he repeats these pasting, rotating, cleaning and checking steps until the smoothness level which gives a good seal level is reached. Then he turns the cylinder to the second side that is valve seat 2 and repeats the above operations done for valve seat 1. Once both sides are completed, the operator removes

the bolts and takes the cylinder off the fixture and places it on the trailer. The operation time is also shown in Figure 2.

In order to create a correct flowchart, it is crucial to use a knowledgeable person, obtain management approval and get all involved parties to agree to the flowchart. The tools used in creating the flowchart include observation, video, interview, questionnaire, process analysis and data analysis.

2) **Determine factors to measure** is to decide what to measure in terms of cost spent on "Quantity, Quality and Time", which is related to "Input, Control, Doing and Output" and listed as follows.

a. Input

i. **Material:** Quantity (from actual measure) and unit cost (per piece, from accounting book).

ii. **Labor:** Number and unit cost (per unit of time, from accounting book), which includes wages, salary, fringe benefits and support cost.

iii. **Machine (including tool, fixture and computer):** Quantity, unit cost including the capital cost and maintenance cost (per piece or unit of time, from accounting book) and depreciation period.

iv. **Space:** Size and unit cost (per area or per unit of time, from accounting book), which includes the deposit and renting cost.

v. **Contract:** Quantity and unit cost (per part or unit of time, from accounting book).

vi. **Tied cost:** Interest paid for the stored material, which depends on the "Interest rate" (from accounting book), "Time stored" and "Quantity of material" (from actual measure).

vii. **Energy:** Amount of energy used (electricity, water and compress air, from actual measure) and unit cost (per watt, volume or unit of time, from accounting book).

b. Control

i. **Penalty:** Payment (determined by the penalty rates and quantity involved) for dissatisfaction of the customer in terms of quantity, quality and time. The penalty is usually pre-set (from accounting book).

ii. **Organizing:** Cost for scheduling, meeting and etc, which depend on the "Cost per unit of time" (from accounting book), and "Time spent for those efforts" (from actual measure).

c. Doing

i. **Time:** Time spent for doing the job which includes the planned time (from production statement) and actual time spent (from actual measure).

d. Output

i. **Quantity:** Quantity produced (from actual measure).

ii. **Quality:** Quality produced such as scraps and reject items (from actual measure).

iii. **Time:** Time spent to complete the job (from actual measure).

3) **Identify loss** is to get the loss information including planned and unplanned losses.

4) **Estimate cost** is to evaluate the cost includes a total cost, value added and value loss.

The sources for obtaining the above information are “Production Statement”, “Accounting Book” and “Actual Measure”. The tools used to collect the above information are video, interview and observation. In this step, estimates of times and losses may be used instead of actual measure if the measurement is very difficult.

If skilled labor is chosen, the analysis process will go forward to Step 2 for further evaluation, otherwise no further discussion will be undertaken in this paper.

3.2 Step2: Define the Most Suitable Specifications for Using Skilled Labor

After skilled labor is chosen to do the job, it is necessary to know how to use skilled labor to obtain the maximum output rate with the least manufacturing error. Therefore, “Define the most suitable specifications for using skilled labor” is identified as the task of Step2 and discussed under two topics: 1) Assess maximum potential gain and 2) Determine the most suitable specifications.

- **Assess maximum potential gain** is to estimate the potential maximum gain with the least loss under the planned condition (e.g. the required materials are always ready for use and the operation is not delayed). The analysis here is based on the ideas of operation designers who are experienced in designing skilled labor manufacturing operations. In order to get the least loss, four general directions are identified in this thesis: 1) Optimize the utilization of resources; 2) Minimize the process time; 3) Minimize the error occurrence and 4) Maximize workplace safety.

    - **Optimize the utilization of resources** such as raw material, skilled labor and machine. For example, assign one operator to operate on two or more machines, rather than have one operator per machine; carefully define the used part acceptance level in overhauling process, rather than use an unnecessarily accurate specification that rejects useful parts; have unskilled labor perform some steps to reduce skilled labor involvement; keep defined scrap low, especially related to cutting parts from a piece of material.

    - **Minimizing the process time** includes setup and run. For example, run a larger batch to reduce setup time per part if setup time is long; eliminate unnecessary steps by carefully analyzing the job to determine the minimum work to be done; reduce skilled labor waiting time for parts or tools to become available, or for a machine driven process to finish; use assisting tools to increase process speed.

    - **Minimizing the error occurrence** is very important because some errors always occur when skilled labor is used to perform complex tasks. For example, design the workstation for easy access to check the operation and parts whenever required; set more inspection stations in place if cost effective; provide more instructions for trouble-shooting when an error occurs; use assist tools, fixtures and machines for better accuracy; design the operation and the parts to keep the possibility of mistakes low.

    - **Maximize the workplace safety**, for example, add sensors to suitable locations of machines to prevent operators’ hands from entering the work area during an operation; redesign the workplace using ergonomic techniques to decrease the potential work risk. However, this issue is not a focus in this thesis since it is a more legal issue than cost issue.

    Note that the information related to how the maximum potential gain is achieved is described above for the reader’s ease of understanding. This information can be found in many articles.

Also most skilled labor manufacturers have operation designers that are experienced in this area (Nahmias Steven, 2004) [13].

- **Determine the most suitable specifications** after the general structure and techniques for the operation have been worked out, the operation is designed in detail and run to see how well it works. With complex operations using skilled workers, a major consideration is the reduction of operational errors and smooth recovery when errors are created.

  If improvements can be made to the operation, an iterative procedure of improving and running is used until a suitable result is achieved. To obtain the best results the following procedures are used: 1) Analyze production flow, 2) Determine factors to measure, 3) Determine production design weak points, reasons for weak points and potential solutions, and 4) Estimate cost.

  - **Analyze production flow** is the same as the one in Step 1.

  - **Determine factors to measure** is the same as the ones in Step 1.

  - **Determine production design weak points, reasons for weak points and potential solutions** means any errors that occur under expected conditions. For example, as expected conditions, everything supporting the job is as it is supposed to be, including material with the correct specifications available at the expected time and, operators with the required skill levels performing the operation; a detailed statement of the job is used as a reference, and all inputs to the job, control of the job, and running of the job must fit this detail job statement. If this statement does not exist, it will have to be created.

    - **Production design weak points** are any errors that occur under expected conditions. For example, as expected conditions, everything supporting the job is as it is supposed to be, including material with the correct specifications available at the expected time and operators with the required skill levels performing the operation; a detailed statement of the job is used as a reference, and all inputs to the job, control of the job, and running of the job must fit this detailed job statement. If this statement does not exist, it will have to be created. To find the weak points, all measures are under close observation, noting everything of importance in production, including: exactly how long each step in the production takes; the likelihood of material being used improperly; and the likelihood of out of specification product being created.

    - **Reasons for weak points** are the possible causes for the errors. For example, labor with less than the required skill is used to determine the reusability of a part from the engine to be overhauled may reject a good part or accept a bad one because the labor's skill or training is too low.

    - **Potential solutions** are the possible solutions to eliminate the cause. For example,

      - Use a step improvement approach, which is to use a very different approach than is presently being used. For example, designing a new product in a way that the manufacturing process will be easier, or that will allow the use of more machinery. This solution is desirable in manufacturing but associated with a high product development cost.

      - Re-design the processes to simplify the work, do less work, or wait for less time, by splitting, combining and merging. For example, waiting could be eliminated by changing the operation sequence or production schedule; the distances of a tool movement could be reduced by changing the operation sequence or combining the tasks.

- Re-design the layout to reduce loss, for example, unnecessary travel distance between two machines. Another example is that if a hot gun is used, the operation should always be kept away from a cold environment; e.g. never near doors that may be opened in the winter time.

- Re-design the information system to add extra data, such as information related to Loss, cause and solution.

- Redefine the process to reduce the overall cost of some operations. For example, since labor intensive operations always have losses caused by the operator, change the operation in a way that slightly increases the time, but reduces the chance of damaging the part.

- Redefine the specifications where possible, for example increase the allowance of a hole to allow a bolt to be installed more easily.

- Redefine the specification to accept more used parts by carefully considering the maximum wear of used parts that will not hurt the product being rebuilt.

- Add plan to consider savings not normally considered, such as energy saving, when defining the operation.

- Assist with machine, tool and fixture to improve the consistency of quantity, quality and time. Machine assistance can add speed and accuracy and reduce "out of specification parts". For example, a fixed caliper is used to make a common measurement rather than requiring the operator's skill and extra time to use an adjustable caliper. The automatic equipment is used as much as possible to perform the load, unload, inspection and locating.

- **Estimate cost** is the same as the one in Step 1.

All above determinations can be thought as "Define the process requirement". One key issue that has to be addressed is that the person to do the above determinations should have significant training and experience with manufacturing operations. The developed procedure must be tested under tightly controlled conditions to determine how well the design actually works. It is an iterative determination process, going between design and test until the best result is found. The testing also uses an extensive video recording, data analysis and discussion with operators to determine what runs smoothly and what gives problems. The result of this determination is used as the production baseline of measurement for the next step: Step 3.

3.3 Step3: Attain and Maintain Required Productivity

After skilled labor is chosen and the most suitable specifications are defined, it is necessary to know how to attain and maintain the defined productivity which is identified as the aim of Step 3 and supported by three sub-steps: 1) Determine the productivity level; 2) Locate the cause; and 3) Find a solution.

- **Sub-Step1: Determine the Productivity Level.** In order to improve the productivity that is defined as the "Inverse of cost" in this paper (Strong, 2003) [2], it is necessary to understand the current productivity level to see whether any waste exists.

  In terms of waste, everything on the earth has a purpose and no waste exists from the ecology point of view. Therefore the term "Waste" is a relative concept since waste for one person may not be waste for another. For example, recycled paper is a waste for most industries, but not for the recycling industry since it is the source of its revenues. Generally

speaking, waste is any unwanted or undesired material left over after completing an activity such as the transformation of raw materials to semi-finished or finished products.

In this paper, **"Waste" is defined as "Any unplanned loss in terms of quantity, quality and time in manufacturing"**. The main point in this definition is that the waste is measured against the "Planned" quantity, quality, time and cost. For example, an unplanned idle is a waste, but is not a waste if the idle is planned. Based on this definition, this "Waste" is also referred to as "Pure waste" in some literature.

This sub-step is supported by the further 4 steps: 1) Analyze production flow; 2) Determine factors to measure; 3) Identify waste and 4) Estimate cost, which are basically the same as the ones in Step 1. The tools used to collect the information include interviews with the foreman and operators and independent observation of the operation, and obtaining information from reliable production information system. The only difference is "Identify loss" in Step 1, while "Identify waste" in this step.

The waste here is defined as "Unplanned loss", such as excessive availability, excessive capability and unplanned busy.

- **Excessive availability** indicates the quantity of resources is greater than planned, such as two workers doing a job that actually requires only one worker and causes over payment.
- **Excessive capability** indicates the capability of resources is greater than planned, such as a skilled worker is doing a low skilled job and causes an over paid wage.
- **Unplanned busy** indicates the time spent is for unnecessary activity like doing an inspection twice.

A detailed "step by step" approach to implement this sub-step will be submitted for the publication.

- **Sub-Step 2: Locate Cause of Waste.** Once the waste is roughly identified in the sub-step 1, the cause of waste has to be located, which is defined as the aim of sub-step 2.

The **cause of waste is defined in this paper as "Any issue to create waste"**. For example, an unskilled worker causes a higher reject rate; the parts received with inconsistent quality causes a longer operation time; a slightly incorrect shape of fixture may cause part damage.

In order to provide an exact direction to locate the related causes of waste, a detailed investigation is required, which includes: 1) Analyze production flow and 2) Locate cause of waste.

- **Analyze production flow** is the same as the analysis in Step 1 with the major focus on the cause of waste. For example, for a particular waste such as a waiting time for a part coming to a drilling operation, a specific production flow (A kind of inserted mapping chart to show the detailed linkages between this drilling operation and other operations) is created to show the causes from up stream, which may reveal a labor shortage in the upstream operation resulting in an inability to deliver the required part on time.
- **Locate the cause of waste** is to map waste to the related cause, which sometimes requires a great detailed investigation and data analysis. For example, an inconsistent quantity of the parts received between batches causes extra time to handle the different batch sizes since the resources structured for one batch may not easily handle a significantly large or smaller batch size, and cause an increase in loading and unloading

time; lack of a required part causes the operator to wait for the part coming instead of working on the part; a part received with a missing hole causes a reject; A higher fuel price causes a higher material cost.

- **Sub-Step 3: Find a Solution.** Once the cause(s) is located, a solution should be found, which includes short-term solution and long-term solution.

  A short-term solution is the solution to make the customer happy through restoring the customer satisfaction as soon as possible, in terms of Quantity, Quality and Time. For example, adding more inspectors at the blocked inspection station to speed up the inspection operation to decrease the level of jam; repair or rework on the defects as soon as possible. The way to find the solution includes an interview with foreman, supervisor, manager, expert; data analysis and simulation.

  For the short-term solution, cost to implement the solution is not main concern since the satisfaction of the customer is the highest priority.

  A long-term solution is the solution to maintain the productivity level as long as possible once the customer satisfaction has been restored through a short-term solution. For example, when determining the reusability of a part core, a less skilled worker may sort a good part as a bad part, or vice versa. This causes the purchasing of the extra part if a good part is sorted as a bad one or the creation of a defective product if a bad part is sorted as a good one. The "Less skill level" is identified as a root cause in this case, and more training is required as a long-term solution. The way to find the short or long solution includes the interview with foreman, supervisor, manager, expert; data analysis and simulation.

  For the long-term solution, cost to implement the solution must be assessed for whether the solution should be implemented. In some cases, "Leave the loss as is" may be the best solution if the cost of implementing the solution is too significant.

The implementation of the solutions is not a focus of this paper since it is really another big issue.

4. Flow of Using 3SP

The flow of using 3SP provides a fairly detailed idea on how to use 3SP for making decisions for the best use of skilled labor, which is shown in Figure 3.

For a "New production process", the flow includes: 1) Analyze process; 2) Step 1: Determine whether to use skilled labor; 3) Step 2: Define the most suitable specifications for using skilled labor; 4) Step 3: Attain and maintain the defined productivity defined in Step 2, which is the benchmark.

1) **Analyze process** is to understand the process designed, for example, product name, production volume, planed time and throughput.

2) **Step 1: Determine whether to use skilled labor** is to compare skilled labor with other production alternatives such as unskilled labor, machine or contract. Two routes are involved in this determination: 1) Whether skilled labor is the only option; and 2) Whether skilled labor is the cheapest option. If skilled labor is not selected, no further discussion is required; otherwise the issue goes to the next step.

3) **Step 2: Define the most suitable specifications** is for effective and efficient use of skilled labor. These specifications represent "No unnecessary losses exist related to quantity, quality and time while performing the activity", which means the maximum potential gain. These

specifications can be considered the process requirements to be achieved and used as benchmarks to assess the productivity of the actual production.

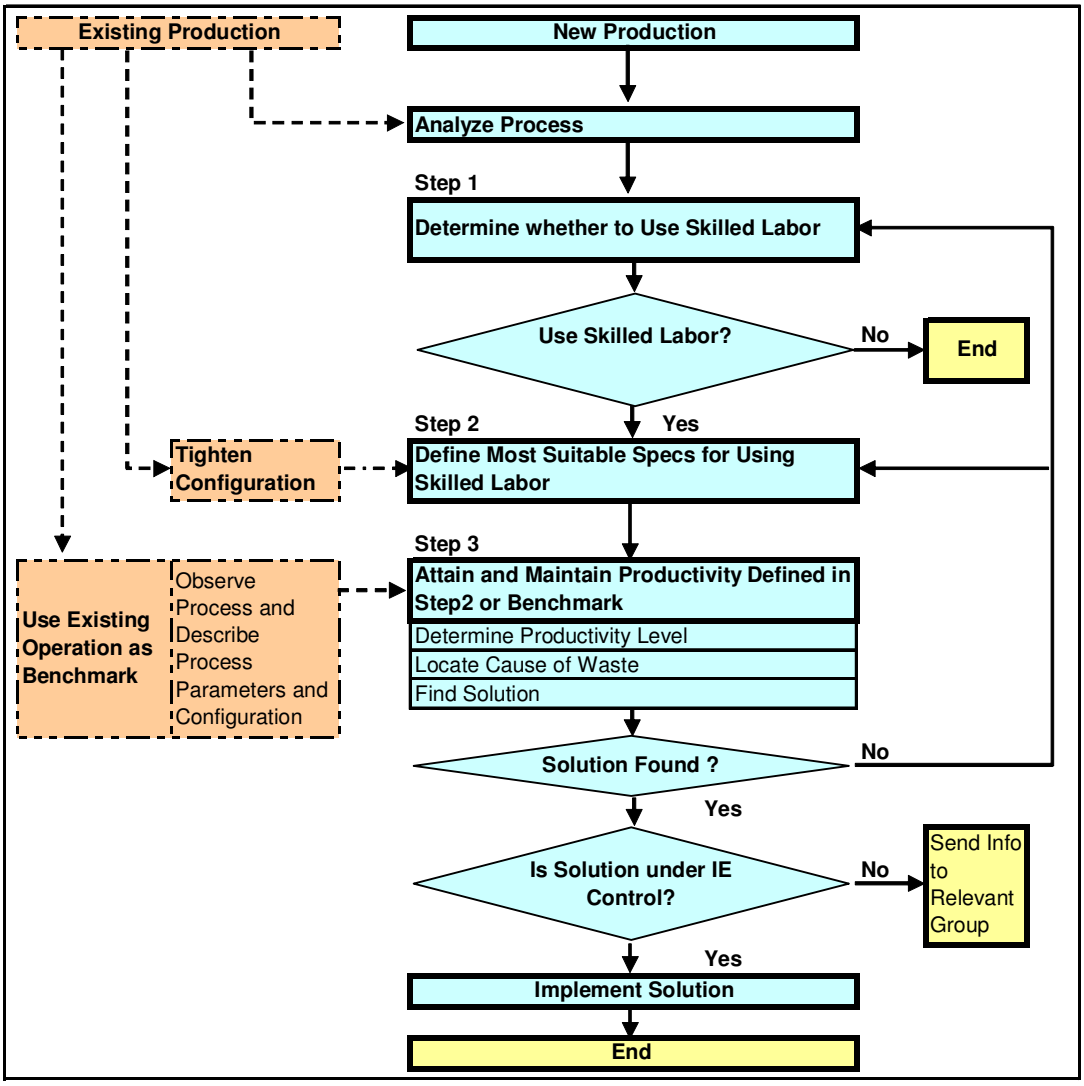

FIGURE 3: Flow of Using 3SP

4) **Step 3: Attain and maintain the defined productivity defined in step2 or benchmark** is supported by three tasks: 1) Determine the productivity level; 2) Locate the cause; 3) Find a solution.

Determine the productivity level means to determine waste in the process based on the cost analysis.

Locate the cause is to map waste to related cause(s), which requires a detailed investigation. For example, an unskilled worker causes a high reject rate; the part received with inconsistent quality causes a longer operation time; a slightly incorrect shape of fixture causes the part to be damaged.
If the causes located are under the control of the Industrial Engineer, the issue goes to the next decision point; otherwise it is handled over to relevant groups for further decision. For example, a cause of “Higher wage” is handled over to a union for further decision.

Find a solution including both short-term and long-term solution.

A short-term solution is to satisfy the customer as soon as possible in terms of the quantity, quality and time that the customer requests. For example, if the inspection slows down the production flow, an additional inspector should be in position to speed up the inspection operation.

A long-term solution is to maintain the defined productivity for a long-term. For example, train the low skilled worker, who should not have been assigned to do the job, to a level that he can perform the job effectively and efficiently. The long-term solutions can be classified as four possible routes: 1) Return the situation to the specifications as defined; 2) Go back to Step 2 to redefine the specifications; 3) Go back to Step 1 to reassess whether using other production alternatives such as machine and unskilled labor etc; 4) Leave as is.

3SP can be used flexibly in reality since it has three independent steps. As a summary, Step 1 concerns the general structure of the activity and determines which manufacturing method is the most suitable one; Step 2 organizes the activity to make it as productivity as possible and uses this productivity as a benchmark to measure the production; Step 3 looks at the indicators to see whether the activity runs as expected, and if not, finds short-term and long-term solutions to attain and maintain the productivity level.

These steps could be used in several different ways. For example, if the issue is to determine which production method is the most suitable way to produce the required items, Step 1, 2 and 3 must be done one by one; If skilled labor is already used, only Step 2 and 3 should be done; If skilled labor is in place and the most suitable specification are already reached, only sub-step 3 (Maintain productivity) in Step 3 should be done. For “Existing production process” as shown as dashed line in Figure 3, the possible decision points are: 1) “Analyze process” if required; 2) “Define the most suitable specs for using skilled labor” if “Tightened configuration” is required; 3) “Attain and maintain the defined productivity” if “Use existing operation as benchmark” can be done.

The details of the implementation of the solutions are very important, but too big and extensive to be covered in this paper.

5. CONSLUSION

3SP (Three-Step Procedure) provides **a standard procedure** to determine whether skilled labor should be used and how to attain and maintain high productivity with skilled labor.

3SP is basically **a qualitative procedure** to guide the user on how to proceed when the best use of skilled labor is required.

If 3SP is used for a more complex system, its structure will be similar but the contents in the structure need to be modified for fitting the new situation.

3SP has been used to improve the productivity in Bristol Aerospace Limited and Aero-Recip (Canada) Ltd, which are two labor intensive manufacturing companies.

3SP could be used not only in manufacturing to improve the productivity, but also in other industries such as banking, health or government. The author is using this approach to improve the efficiency in a law enforcement organization.

More validations need to be done to prove its usefulness in improve the productivity.

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