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'T.H.E.-METHOD', A VISUALISED ASSESSMENT TOOL USED FOR INTEGRATED PRODUCT DEVELOPMENT.

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ABSTRACT:

Design education requires training methods that optimise students' ideation capacity of integrated thinking. They are key in the process of a practice-centred core competency in the field of Product Development. The 'Technology', 'Human', 'Economy' - method (T.H.E.-method), is a visualized assessment (VA) tool based on Verhaert's method and transformed into a pedagogical assist that shows the balanced integration of economic, technological and human-related components over 24 sub-aspects. In this paper the T.H.E.-method is explained and tested among 33 students enrolled in the first year master's course during a total, integrated design process from the initial design, a tennis ball collector, to the final product proposal. As a result, 33 students realised an integrated product development project with the average value of 3.73 on T., 3.24 on H. and 2.47 on E. Moreover, the T.H.E.-method revealed that the 5 most stimulating sub-aspects were the following: mechanical system, functionality, user behaviour, shape and ergonomics. Such is supported through the presentation of 4 case studies.

1. INTRODUCTION

Simultaneous interdisciplinary thinking is crucial in the course of the development of a new product (Galanakis 2006). Integrated product development is essential to generate visionary artefacts (Desouza et al. 2006 and Lee et al. 2007). With man living in a constantly evolving life and work environment (Rosenman et al.1998), each 'state-of-the-art' artefact is bestowed with new functions, designs and applications (Muller 1998). For a designer to come up, time and again, with innovative artefacts (Higgens et al. 2002) that distinguish themselves from any other existing product, when and wherever and in which cultural context it was designed, requires creative and interdisciplinary skills (Hsiao et al.2004, Sternberg 2005) taught in design courses. In fact, a high degree of ideation capability is essential to the ability to develop innovative products (Shah et al. 2003) . Vocational learning (Mascitelli 2000) does not only focus on mere rational and operational aspects: exploring emotional and irrational aspects are of equal importance for aspiring product designers (Quarante 1994).

The use of a visual assessment method seemed, therefore, obvious (Osman and Demirkan 2007) as a graphic representation allows students to instantly appreciate her or his degree of interdisciplinary thinking (Thiebaud 2003). The core skill of an industrial designer (Stal-Le Cardinal et al. 2006), (Tavcar et al. 2005) is her/his ability to generate ideas during a product design process that are simultaneously inspired by technological, economic and human sciences (Verhaert and Braet 2007), (Verhaert 1999).

In this paper Product Development students' capacity to generate ideas is measured by Verhaert's development methodology applied throughout a full development cycle.

More specifically, we managed to visualise the degree of integrated thinking in the course of an practical assignment in Product Development, allowing for an accurate measurement of the presence or absence of integrated thinking. The Higher Institute for Product Development, Design Sciences, University College of Antwerp uses the 'T.H.E. (Technologic, Human and Economic) -method' based on the method of Paul Verhaert in form of a visual spectrum that allows to measure whether or not an interdisciplinary approach is present during an integrated design process (Jeffries Karl 2007). This visualised measurement tool is called the 'T.H.E.-method'. In addition to providing a graphic representation of the full integrated design process, it is an effective pedagogical tool to measure a student's ideation capability.

2. MOTIVATION

A distinction is often made between 'talented' and 'untalented' designers. Measuring talent, however, is very complex as it relates to a variety of abilities (Lubart and Georgssdottir 2004) Indeed, students in Product Design need and deserve to know whether or not they possess the talents necessary to generate original, unprecedented and usable products with practical applicability (de Groot Frans 1993). It also shows whether students are apt enough to stay in control during a full product development cycle.
The mere listing of a series of pre-programmed development phases that need to slavishly be adhered to during a product design process is far from sufficient to stimulate dynamic product development (Ottoson 2004).
A VA method that measures 'ideation' in relation to integrated thinking capability is an essential educational tool for aspiring concept designers (Lubart and Georgssdottir 2004). Which is why the 'T.H.E.- method' is being presented here as a visual aid for students in Product Development.

3. PROBLEM STATEMENT

How can the capacity to find ideas be submitted to measurement methods ? And how can such a measurement method be used as a pedagogic instrument ? The amount of integrated thinking is indeed partly connected to the degree students have assimilated the Verhaert method (Verhaert and Braet 2007 and Verhaert 1999), but generating ideas is also partly connected to non-measurable thinking processes that are managed by the personality of each individual student (Mitterauer 1998). Consequently, to set up a pedagogic model that can measure the presence or absence of idea finding capability requires a double-angle approach: idea generating capabilities (or absence thereof) through assimilation of Verhaert's integrated thinking method on one hand, idea generating capabilities, or absence thereof resulting from each student's individual talent (Lubart and Georgssdottir 2004).
Therefore, the following three basic questions need to be asked:
- "To what extent is there a correlation between the method Verhaert and one's personal capacity to find ideas ?"
- "To what extent finding ideas is steered by the complex of technological, human-related and economic aspects ?"
- "Is another than Verhaert's method used to generate ideas ?"
In application of the Verhaert's design methodology, visualisation allows for the setting of a

reference frame by which the capacity of integrated thinking can be accurately measured. Other methods applied by the students are not taken into account in this paper.

4. T.H.E.-METHOD, THE VISUALISED VERHAERT'S METHOD

The method of Verhaert is an intricate method, which primarily stimulates creativity through a methodological process that is controllable, transferable and therefore manageable (Verhaert 2007). Creations are hereby not the fruit of intuition but of a methodological approach, whereby visualisation helps to monitor creative design processes, to communicate and to manage them. With the 'T.H.E.-method' this becomes possible as it consists of 24 sub-aspects that can each separately be designed as radians and that are equally regrouped under the 3 main components: technology, human-related and economy.

The sub-aspects: Production Method, Physics, Solid Construction, Assembling Environmental Impact, Electronic System, Mechanical System and Materials are pooled in the technological component (abbr.T.); the sub-aspects Functionality, User Behaviour, Buying Attitude, Cultural Vision, Shape, Characteristic User Concept, Social vision and, Ergonomics are pooled in the human-related component (abbr.H.) and the sub-aspects Price, Distribution Concept, Balance of the product potential, Competition, Market Definition, Time to market, Market Share and Development Cost are pooled in the economic component (abbr. E.).

The correlation between idea finding and integrated thinking is set out on a scale from 1 to 5, with 5 representing the highest possible degree of integration. The Technology, Human-related and Economy categories constitute the basic components in the 'T.H.E-method', each component heading a group of 8 related sub-aspects.

If in the course of a design project equal input from T., H. and E. is observed, such suggests a high correlation between idea finding and integrated thinking, as visualised in Fig. 1.

The visualisation of 'T.H.E.-Method' consists of 3 main axis: the Technology axis at respectively 0 degrees of the vertical axis, the Human-related axis at 120 degrees and the Economy axis at 240 degrees. each axis features a scale with values ranging from 1 to 5, the lowest value being represented by the small circle closest to the circle point. The 24 sub-aspects, 8 per group, are set out around the outer circle that represents the highest value 5.The average value of 8 sub-aspects in each group is represented by a square reference point at each of the 3 axes. Connecting the 3 square reference points (T., H. and E.) by a dotted line generates an equilateral triangle. The triangle's shape shows the degree of integrated thinking: a perfect equilateral triangle shows highly integrated thinking as all components and sub-aspects have been equally integrated in the ideation process in the course of a product development. Fig. 1 shows a balanced visual spectrum under the 'T.H.E. method'. Inversely, a shape of the triangle that moves further and further away from the perfectly equilateral triangle shows a decline in integrated thinking during the ideation process, as shown in Fig. 2. In this example the student's idea finding was primarily guided by a single component, technological aspects, and to a much smaller degree by human-related aspects. Economic aspects were also taken into consideration. After combining all other aspects the average values for the components T.,H., and E. respectively amounted to value 4 (T.), value 1.5 (H.) and value 3.3 (E), not exactly the reflection of an optimally integrated product development. Connecting the reference points of every category T., H. and E. by a dotted line produces a visual spectrum with a very irregular triangle and a freakish polygon indicating the absence of integrated thinking.

The 'T.H.E.-method's use of the triangle is, therefore, believed to provide an accurate tool to measure the extent to which integrated thinking was present in the course of the product development: a perfect triangle and a balanced polygon show a high degree of integrated thinking. The more irregular the triangle and the more freakish the polygon, the less the student resorted to integrated thinking during the product development process.

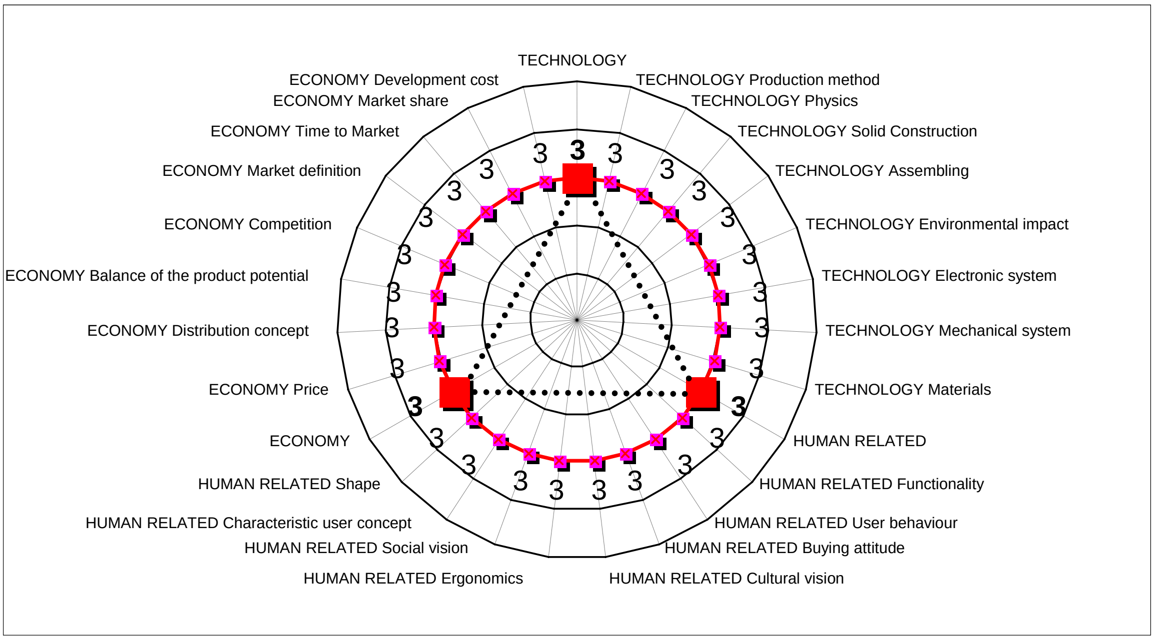

Figure 1: 'T.H.E.-method' visualises a wholly integrated development process

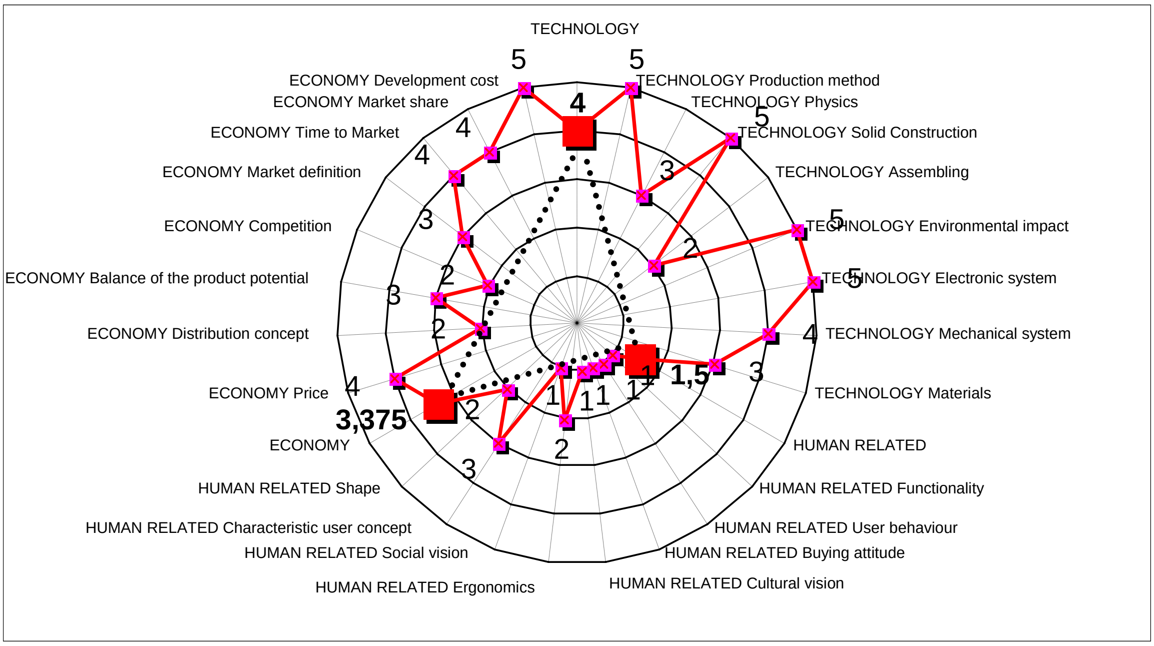

Figure 2: 'T.H.E.-method' visualises the lack of an integrated development process.

5. APPROACH

The validity of the hypothesis that there is a connection between idea finding and Verhaert's method was put to the test during a concrete development assignment of integrated product development. 33 students in the first year of the master's course in Product Development were given a questionnaire the aim of which was to examine to what degree a connection exists between idea finding starting from Verhaert's method and their personal idea finding. Participants were assigned to develop, over a period of 3 months, a 'Tennis Ball collector'.
The purpose of the exercise was to develop a tennis ball collector, that, operating in tandem with a tennis ball gun (Wilson's Portable Ball Machine) collects tennis balls and deposits them in the tennis ball gun during and after training.
Product specifications were the following: the ball collector can operate outdoors during training, on the same side of the tennis court as the tennis ball gun; tennis balls should be collected at a rate of 10/minute and 95% of the balls on the court must be collected.
The 'Tennis Ball Collector' has a 12 hour autonomy and is manually recharged every night. It systematically collects as many balls as possible on one side of the court. All along the development process, integrated thinking and design were steered by the 'Verhaert method'. In line with this method, project leaders coached each student individually.

The criteria for the final evaluation of each product project were:
- impact of technological sciences on product development
- impact of human sciences on product development
- impact of economic sciences on product development

As for product development driven by technological sciences, mechanical solution, construction and power working were retained as criteria. The level and quality of the technical realisation too were included in this component. As for product development driven by human sciences, user interaction and interfaces, organisation on the terrain, feasibility of seeker-, finder- and detection system were taken into account. As for product development driven by economic sciences, method planning and integration as well as presentation and representation techniques were included into this component. For the evaluation of the end result of each student, the project leaders relied upon the aforementioned criteria and could thus attribute a value to each item. Two months later the students were interviewed about their idea finding during the design exercise. 33 students answered the questionnaire as mentioned earlier under point 3. They were specifically quizzed on which of the sub-aspects of each component (T.,H., or E.) had steered their idea finding. For each item, students gave marks on a scale from 1 to 5, with 5 representing the highest degree of interaction between intuitive personal idea finding and the methodological steering of idea finding after Verhaert's method.

6. RESULTS

Analysis of the collected data highlights the existence of a clear correlation between idea finding and Verhaert's method. 14 out of 33 participants felt there was a strong correlation between Verhaert's method and their personal capacity to find ideas in the course of the 'Tennis ball collector' assignment. As illustrated in figure 3 the x axis shows the number of students (from 1 to 33) while the y axis shows the value from 0 to 5 (with value 5 for the highest correlation).

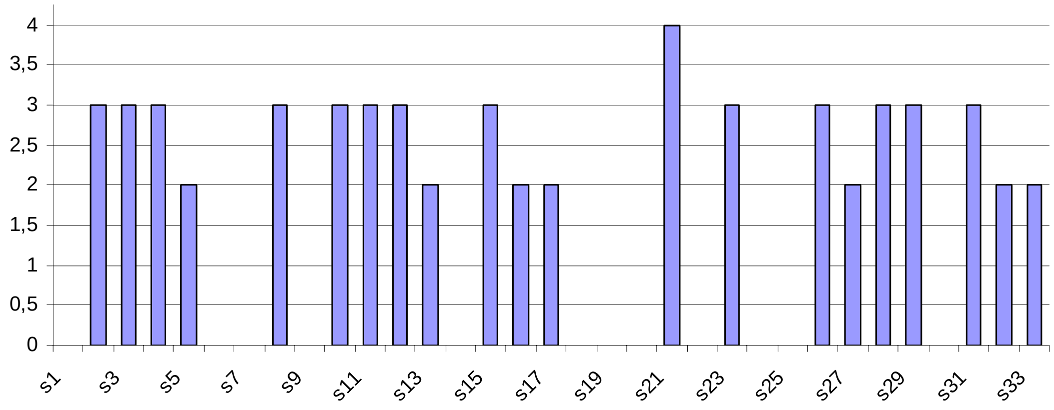

Figure 3: The degree of correlation between idea finding and Verhaert's method.

Results of the questionnaire further showed 7 out of 33 students used other methods of idea finding in addition to the Verhaert method (Verhaert and Braet 2007). Obtained data also helped to determine which of the sub-aspects within each component (T., H, and E.) had most strongly influenced idea finding in the course of the 'tennis ball collector project'. Mechanical System scored highest (value 4.48) followed by Functionality (value 4.24) and User Behaviour (value 3.90), followed by Shape (value 3.48) with Ergonomics ranking fifth (value 3.43) as illustrated in figure 4.

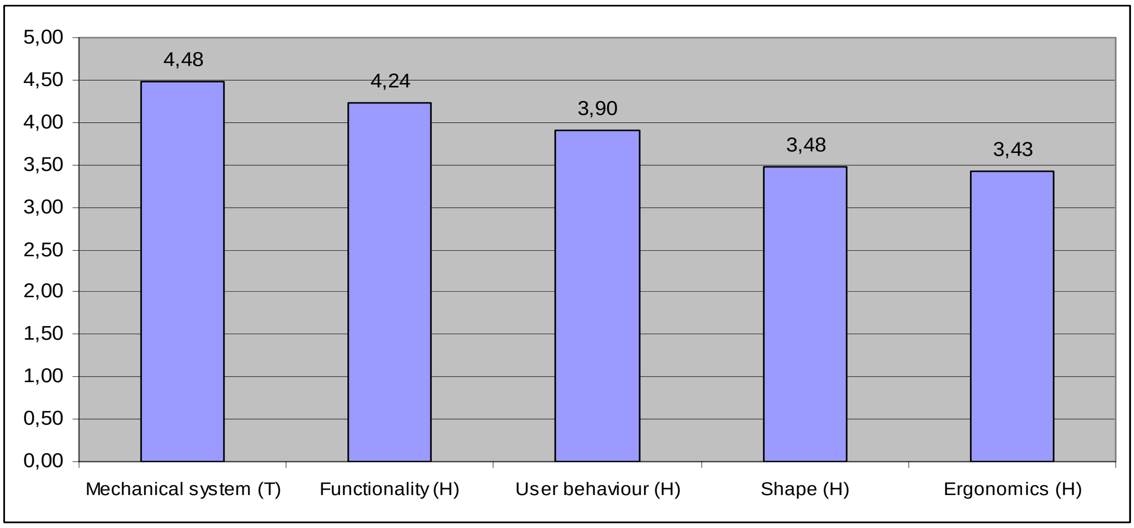

Figure 4: Most prominent ideation steering sub-aspects according to 'T.H.E-method'.

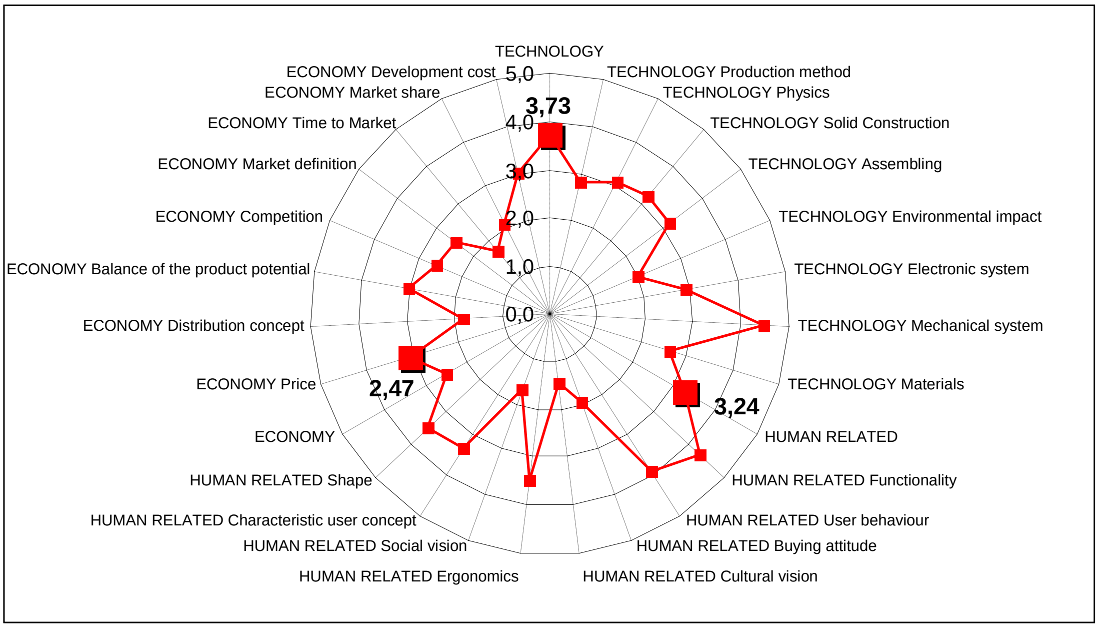

Figure 5: The average values of 'T.H.E.-method' applied to 33 students

Figure 5 shows the average value for all 33 students of the methodological approach of integrated thinking present during the design process. The respective values are 3.73 for T, 3.23 for H. and 2.47 for E. The shape of the triangle is a strong indicator that every individual student has indeed gone through an integrated design process. We then analysed the degree of correlation between integrated thinking (steered by T., H. and E.) and the actual design concept realisation. Those results will be discussed in the following section by means of 4 randomly selected projects.

6. 1. PRODUCT CONCEPT: TUBAL

Student Pieter Van de Velde got high marks for his design Tubal (Fig. 6a). He found his idea finding was very strongly influenced by Verhaert's method, although he used other methods as well. Idea finding in his design was primarily steered by: functionality, mechanical systems, shape and the characteristic user concept as illustrated in figure 6b. The level of integrated thinking was rated value 3.38 for T., value 3.88 for H and value 2.88 for E.

Figure 6a: TUBAL.

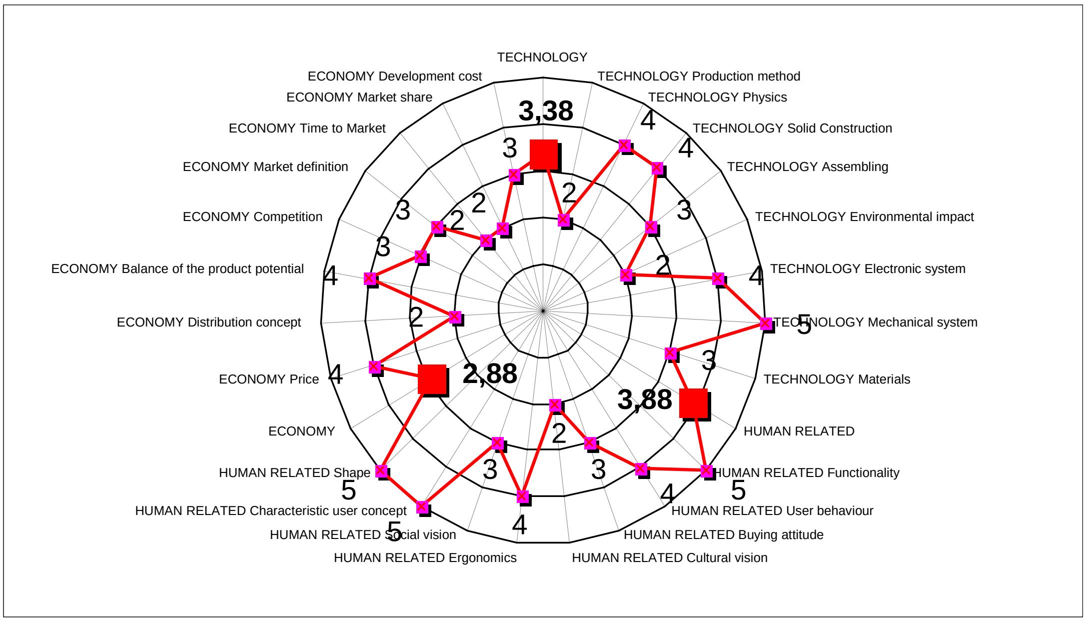

Figure 6b: The values the 'T.H.E.-method' attributed to the design process TUBAL.

6.2. PRODUCT CONCEPT: SWUNG

Student Steve De Wreede got a good final evaluation with SWUNG (Fig.7a) and found his idea finding to have been strongly influenced by Verhaert's method. He did not resort to any other methods. The idea finding was primarily steered by solid construction, mechanical system and user behaviour as illustrated in figure 7b. The level of integrated thinking was rated value 3.5 for T, value 2.87 for H and value 2 for E.

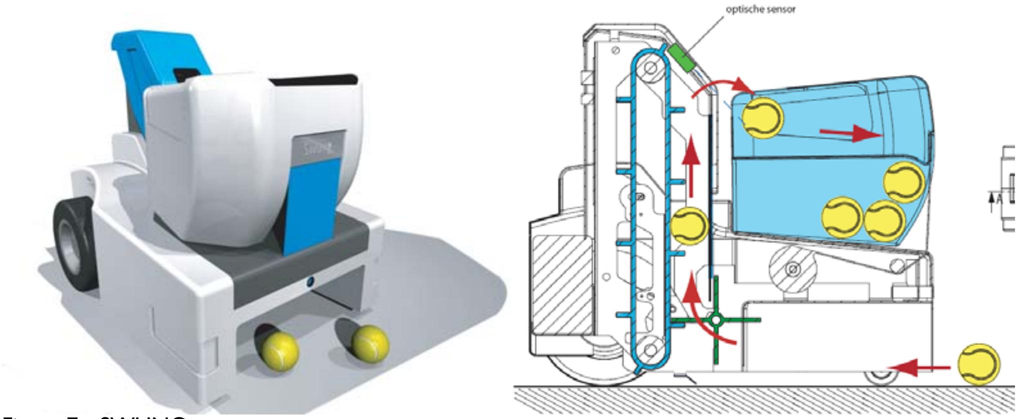

Figure 7a: SWUNG.

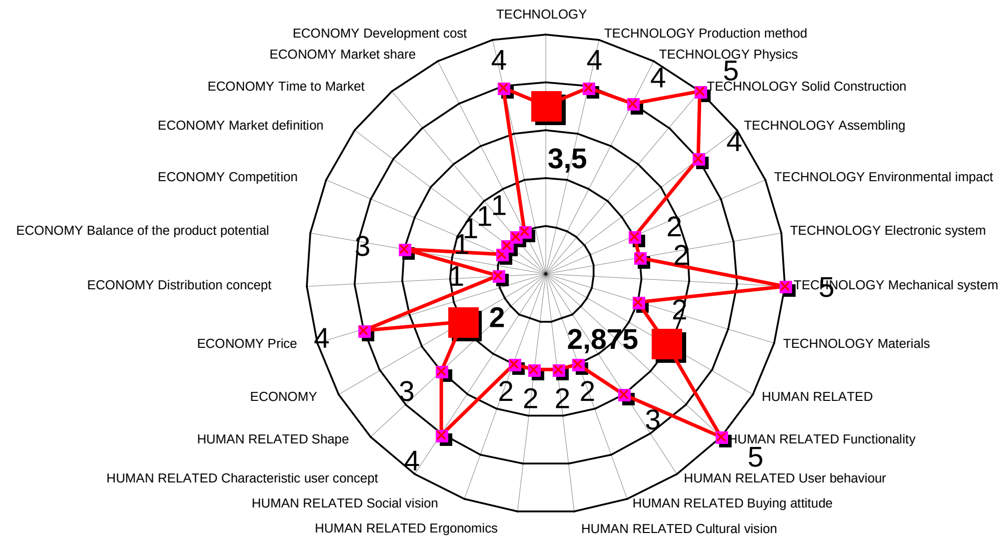

Figure 7b: The values the 'T.H.E.-method' attributed to the design process SWUNG.

6. 3. PRODUCTCONCEPT: THE BALL MOWER

Student Christophe Vyvey thinks his idea finding was strongly influenced by Verhaert's method, but used other methods as well. The idea finding in this design (Fig 8a.) was primarily steered by: mechanical system and as illustrated in figure 8b. The level of integrated thinking was rated value 3.25 for T., value 2.75 for H and value 2.5 for E.

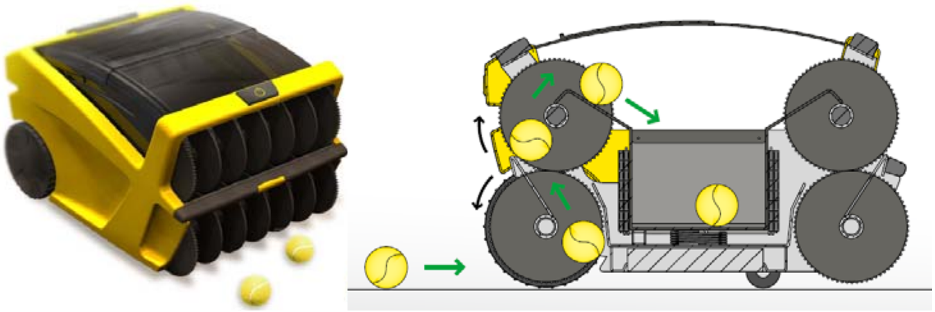

Figure 8a: THE BALL MOWER.

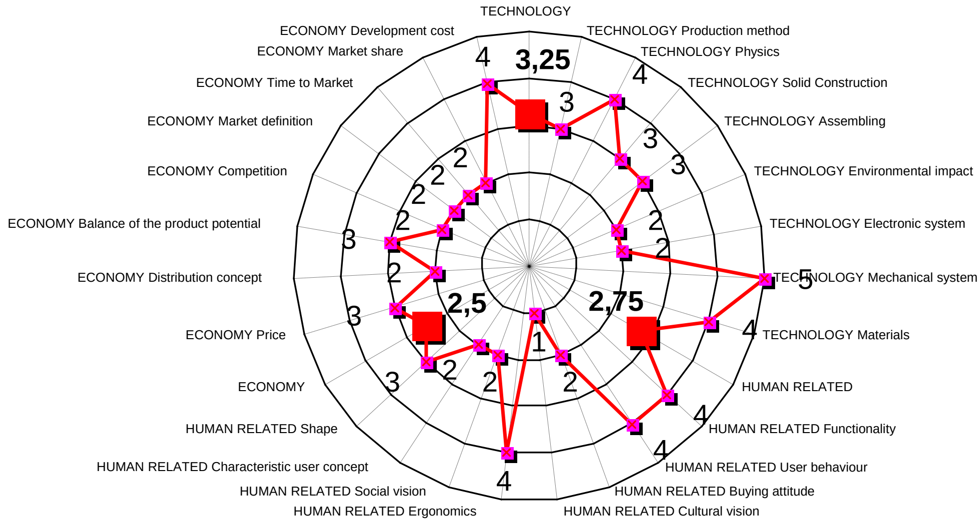

Figure 8b: The values the 'T.H.E.-method' attributed to the design process THE BALL MOWER.

6. 4. PRODUCT CONCEPT: SCARABE

Student Renée Verschaege found her idea finding also strongly influenced by Verhaert's method, but she too used other methods as well. The idea finding for this subject (Fig.9a) was primarily steered by human considerations of functionality but very well balanced with economic as well as technological considerations as illustrated in figure 9b. The level of integrated thinking is rated value 3.12 for T., value 3.37 for H and value 3.37 for E. SCARABE can be considered as an optimal example of product development.

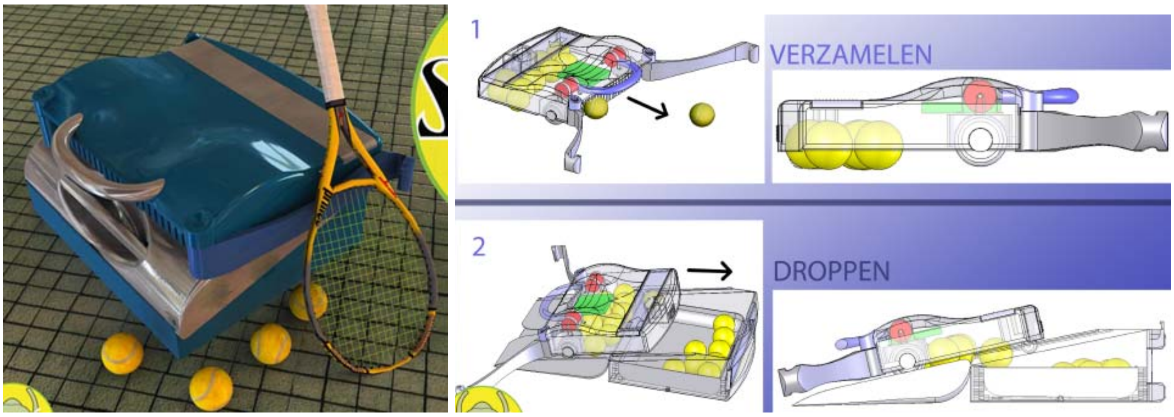

Figure 9a: SCARABE.

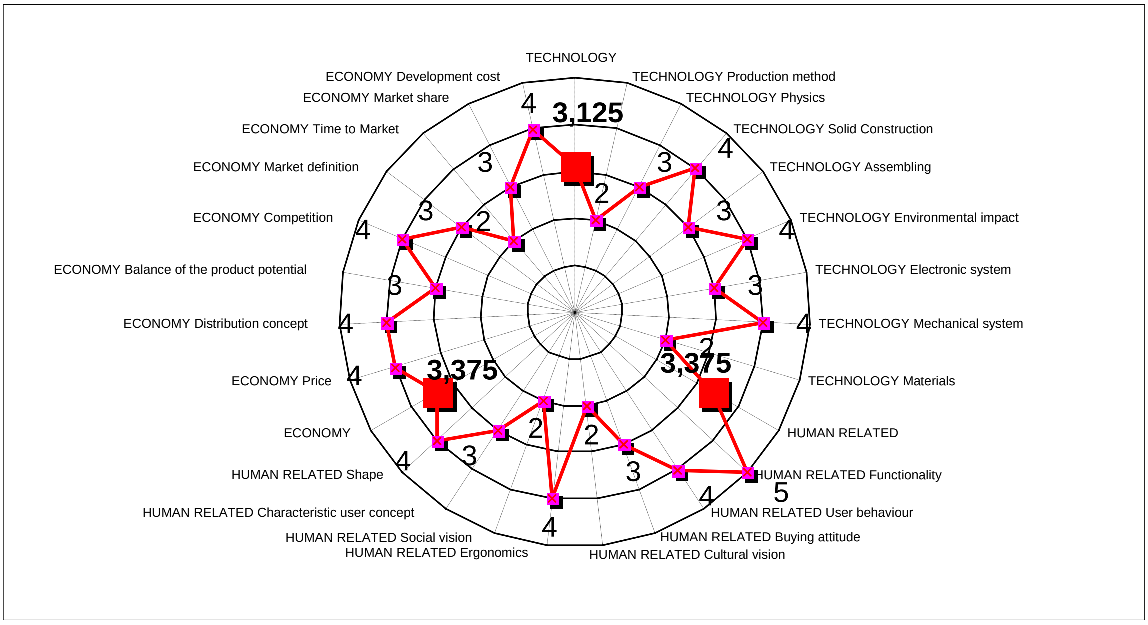

Figure 9b: The values of 'T.H.E.-method' attributed to the design process SCARABE.

7. DISCUSSION

Analysis of the data gathered from the questionnaire shows the following results:
Primo: top tier students, i.e. those who presented excellent product proposals, and showed excellent designing skills, confirmed the 'T.H.E.-method' through their approach to idea finding and design.
Secundo: students at the bottom of the group, whose product proposals were considered poor

despite them having relied on the ‘T.H.E.-method’ did not notably progress, as the use of the visualised Verhaert method in itself does not guarantee their ability to create innovative product designs.

Tertio: students in the mid-range, who used the ‘T.H.E.-method’ posted good results for integrated product development, as this method hands them a reference platform from where they can generate and try out new ideas.

One can therefore state that students with an average idea finding capacity and who embrace the ‘T.H.E.-method’, are more likely to create a successful product proposal than those who do not. Verhaert’s theoretical methodological approach was effectively applied all along the practical coaching process, which did not deter some students from drawing inspiration from other methods that could lead to very original designs.

One might argue against the equal importance allotted to the T., H. and E. components in the proposed method and in favour of a more proportionate balance between T., H. and E., as, indeed, design project specifications vary greatly between for example investment goods, consumption goods, user goods or services. Yet, idea finding is inherently interdisciplinary, hence not subjective to a weighing factor. As a matter of fact, steering from whatever sub-aspect can generate ideas. The sub-aspect ‘Cultural Vision’ could fairly well steer ideation for a more technologically oriented design assignment, as originality, distinctiveness and use would be approached from an angle very different from the ones usually referred to in daily life. Aforementioned visualisations, using the ‘T.H.E.-method’ demonstrate ideation needs not per se to be linked to the specificity of a particular product proposal.

While integrated thinking processes that steer ideation through all aspects of the ’T.H.E.-method’ may have run smoothly, in the end, it is for the student to take up the challenge to try and generate an innovative product. With the ‘T.H.E.-method’, odds are high that an integral, original and distinct product idea can be generated. An optimal application of the ‘T.H.E.-method’ during the creation process shows in an equilateral triangle for the main components and an equilateral polygon for the 24 sub-aspects of the Verhaert method. Depending on the degree of distortion of the equilateral triangle (components) and the equilateral polygon (sub-aspects) the presence of integrated thinking or the absence thereof can be swiftly diagnosed. As such the ‘T.H.E.-method’ constitutes an ideal pedagogical tool for practical use in the course of Product Development students’ education.

8. CONCLUSION

We have described how, in line with the Verhaert method, the ‘T.H.E.-method’ visualises ideation processes. In doing so, ideation capacity has been brought in correlation with the degree of integrated thinking. During the ‘Tennis Ball Collector’ design project, 33 students participated in a questionnaire about the idea generating process. Among average students using the ‘T.H.E.-method’ the gain in ideation capacity was most notable.

Four case studies demonstrated that a single design method, respectful of students personal style, can generate very different end results. Thus, the ‘T.H.E.-method’ claims to be a yardstick by which to measure ideation-integrated thinking interaction during design processes, key to optimised integral product development.

As to how pedagogical processes can be optimised to yield better final results for integral product development projects, how to use the ‘T.H.E.-method’ to draft design specifications, and as for the method’s potential to develop into an end evaluation tool, those issues may be the focus of future research.

REFERENCES:

Darren W. Dahl, Chattopadhyay Amitava, Gorn Gerald J., (2001) The importance of visualisation in concept design, Design Studies 22, 5-26.

de Groot Frans (1993) Design in Production, 25 years of Product Development Antwerpen” Symposium Productontwikkeling, Studio Atelier 5, 1-8.

Desouza Kevin C., Yukika Awazu, Arkalgud Ramaprasad (2006) Modifications and innovations to technology artifacts, Technovation, doi:10.1016/j.technovation.2006.09.002.

Galanakis Kostas (2006) Innovation process. Make sense using systems thinking,
Technovation 26 1222-1232.

Higgens James M., McAllaster Craig, (2002) Want innovation ? Then Use Cultural Artifacts that Support It, Orginizational Dynamics Vol.31 No 1, 74-84

Hsiao Shih-Wen, Chou Jyh-Rong, (2004) A creativity-based process for innovative product design, International Journal of Industrial Ergonomics 34, 421-443.

Jeffries Karl K, (2007) Diagnosing the creativity of designers: individual feedback within mass higher education, Design Studies, doi:10.1016/j.destud.2007.04.002.

Lee Kim C. K., Cassidy, T, Principles of design leadership for industrial design teams in Taiwan, Design Studies (2007), doi:10.10.16/j.destud.2006.11.007.

Lubart T.I., Georgsdottir A.S. (2004) Créativité, haut potential et talent, Psychologie francaise 49, 277-291.

Mascitelli Ronald, (2000) From Experience: Harnessing Tacit Knowledge to Achieve Breakthrough Innovation, Journal of Product Innovation Management 17, 179-193.

Mitterauer Bernhard (1998) "An interdisciplinary approach towards a theory of consciousness, Biosystems 45, 99-121

Muller W. (1998), Design discipline and the significance of visuo-spatial thinking, Design Studies 10, 12-23.

Osman Demirbas O., Demirkan, H. (2007) Learning styles of design students and the relationship of academic performance and gender in design education, Learning and Instruction, doi:10.1016/j.learninstruc.2007.02.007.

Ottoson S. (2004) Dynamic product development-DPD, Technovation 24, 207-217.

Quarante D. (1994) Elements de design industriel, Polytechnica Paris, 21-111.

Rosenman M.A., Gero J.S., (1998) Purpose and function in design from socio-cultural to the techno-physical, Design Studies 19, 161-186.

Shah Jami J., Vargas-Hernandez Noe, Smith Steve M. (2003) Metrics for measuring ideation effectiveness, Design Studies 24, 111-134.

Smets Gerda, (1986) Vormleer, De Paradox van de vorm, Bert Bakker, 30-124.

Stal-Le Cardinal Julie et al. (2006) Project: The just necessary structure to reach your goals, International Journal of Project management 24, 226-233.

Sternberg, Robert (2005) Creativity or Creativities?, International Journal Human Computer Studies 63, 370-382.

Tavcar Joze, Zavbi Roman, Verlinden Jouke, Duhovnik Joze, (2005) Skills for effective communication and work in global product development teams", Journal of Engineering Design, Vol.16, No.6, , 557-576.

Thiebaud F. (2003) Formalisation et développement de la phase de résolution de problème en conception industrielle, Ecole Doctorale Sciences Pour l'Ingénieur, ULP-INSA-ENGEES-URS, Strasbourg,18-41, 70-90.

Tzvetanova, Tang and Justice (2007) Evaluation of Emotional Web Usability, 12th International Conference on Human-Computer Interaction, Beijing, July 22-27.

Verhaert Paul (1999) De praktijk van de productontwikkeling, Acco, 3-168.

Verhaert P. and Braet J. (2007) The practice of new products and new business, Chapter 2. The new product development process, Acco Leuven, 47-65.