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DUTCH AND AUSTRALIAN EXPERIENCES ON TEACHING TECHNICAL INNOVATION TO ENGINEERS AND PRODUCT DESIGNERS

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ABSTRACT

Research on industrial applicability of design methods (project motto: “it depends”) show that, more importantly than geographic differences, there are different discipline-worlds, having their own inherent design methods. For the education in Integrated Design Engineering it predicts that the subject order and curriculum build up have a strong influence on the results. This was confirmed in comparative experiments on educating Product Design Engineering (PDE) students with a different background which were carried out in Groningen, the Netherlands and in Melbourne, Australia. The paper will deal with the background and effects of these phenomena.

Keywords: Integrated Design; Industrial practice; Effective Design

1 INTRODUCTION

For a better understanding of the complex nature of integral engineering design and competitive technical innovation, the model of 3 different co-existing realities for knowledge and know-how in all the related disciplines was introduced at the Delft-conference Sept 2004.(fig 1) [1].

In this model, the common ground for consumer-users, generalists and specialists is represented by the middle plane of the state-of-the–art and of the predictable reality. Here people have learned what to expect from technical and other systems and feel comfortable using them. Of course it depends on the depth of knowledge in the specific area or discipline, how far the utilisation of effects goes; it ranges from driving a car to repairing it or develop the next model. Here design quality is equivalent to “doing it

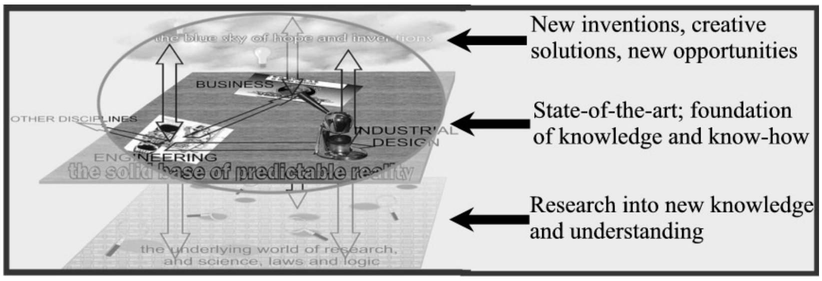

Figure 1.The scope of competitive technical innovation

right", applying the rules and the logic, and avoiding mistakes. Such an approach fits-in with the character and culture patterns of most people. The rules governing this world were developed from long standing experience, or accepted and taken from the other worlds of scientific research and inventive creation.
As was discussed at a previous ICED conference [2], within this kind of innovation there are two very distinct approaches to be recognised, that seem to be growing apart, one following "hard", quantitative rules, the other "soft" patterns. The "hard" one aims for technically sound solutions to achieve technical functionality, which is typically the issue in business-to-business situations, and is based on thorough engineering skills. Main approaches in this case are analytical, deterministic and methodical.

The other, "soft", world, where Industrial Design has grown into a sophisticated discipline, mainly covers the human-technology interface and is very important in consumer goods-innovation. The main approach and research here, focuses on the benefit for and the appreciation by the user and generating solutions untill one fits the bill (jig saw puzzle)

Only few educational institutions try and achieve to marry those -almost conflicting-disciplines. Good examples are the Loughborough MSc-course and the Glasgow-PDE courses [3] in the UK, a similar one at Swinburne University in Melbourne, Australia and the Mechanical Engineering-IPDE year at the Hanzehogeschool in Groningen, the Netherlands. Close cooperation and exchange between the institutes is crucial.

Close observation of the industrial practice of innovation and the study of literature, also on unexpected breakthrough ideas- like the French C-K theory [4]- reveals another aspect of innovation approach: the inventive/creative innovation happening in all disciplines including even the business area. Here no standard patterns, and rules are available, but mainly conditions, like a solid knowledge and know-how of relevant underlying technology and overlying application, and a trained open mind.

Interestingly enough, in the real world of industry, competitive technical innovation is mainly based on a mix of the above mentioned approaches. Innovation by scientific research, sponsored so heavily by political funding, proves to be less effective.[5]
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2 THE INFLUENCE OF THE ODD-RESEARCH – "IT DEPENDS"

Over the past few years a group of like-minded institutions from the UK, Holland, Germany, France, Denmark, Sweden, Finland and Eire and their industrial partners have collaborated to develop understanding about Engineering Design [6]: the Open Dynamic Design (ODD) Project. The approach was both from the scientific background, the industrial applicability and the educational consequences. The project included direct participation in a score of industrial innovation projects and deep discussions with the industrial and academic experts concerning the observations and results. The main conclusion of the project is: There is **NO** universally ideal form of engineering design.

2.1 Experienced engineers do it best on gut feeling

Over the last 50 years so many design methods and procedures became available, some now prescribed by law: FMEA, QFD, VA/VE, Conc. Eng., mindmap, thinking hats, etc Comparable to what Gladwell [7] observed, the best and most efficient practicing industrial engineering designers do not seem to use any system or structured method at

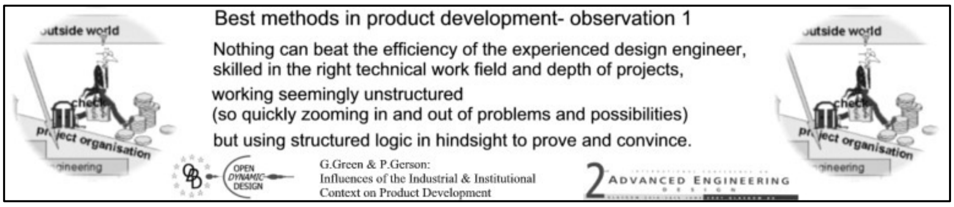

Figure 2. Confusing main outcome of ODD

all and they learned the trade over the years in a variety of ways. Generally between the experts there is consensus over the final result, but not over the process. As discussed at the Edinburgh conference [7] there is an essential role for a well-defined process of methods, tools and design procedures, valid for youngsters and experts alike: Both need these tools to check the results and to convey these to managers and team members.
Often, in design-research this "use in hindsight" is mistaken for "operational use" and design tools and methods are being overrated and generically prescribed.
In the ODD project, as a result of close participation and observation it was established that there is quite some difference between the best way how to create new product design solutions (strongly dependant on the individual personal situation) and how to check and convince the validity and value (strongly dependant on overall circumstances) of designs. It is interesting to notice the relief - for experts and students alike – the acceptance of this fact actually helps in dissolving roadblocks for introducing quality systems in design engineering.

2.2 The role of theory, methods and tools as a common language

An accepted set of design methods provides a quality-tool for evaluation, verification or procedural acceptance in industrial or educational setting, but even more important is its role as an accepted, trusted common language within teams and decision makers.

Within an organisation the most appropriate "language" (accepted design methods) may vary from the structured, analytical to the holistic and fluent ones. In industrial practice the choice is dictated by some key context factors, that are logical in their direct influences, but for less experienced observers they are difficult to recognise. Some context factors can be adapted by strategic decisions and actions, others are generic:

-law and state-of-the-art/standards of product groups: CE, DIN, ISO, BSI, Marine,…
-technology/discipline focus (industrial design-mech eng.-IT), depth of change.
-power hierarchy in supply chain and project management.
-psychological and cultural issues, organisational risk taking ability

Actually the only universal good tool is the model, the more physical the better.

2.3 Reverse order learning-by-doing

As reported in the Glasgow conference [6], the typical learning process both for individuals and organisations is first mastering down to earth matters of a certain discipline (like how to kick a ball), then to explore the possibilities of the technique (playing matches) and only at the end develop concepts. Starting an innovation project on a pretentious product and process concept with untrained, low skilled players happens sometimes in industry and very often in education.

Hands-on training under knowledgeable supervision on detail and overview is essential.

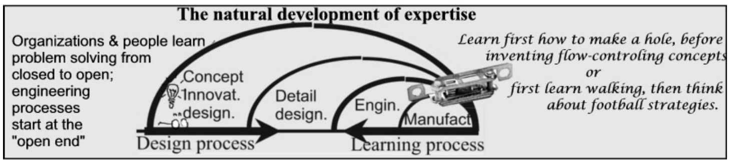

Figure 3. The natural "hard to soft" learning process

3 THE AUSTRALIAN-DUTCH EXPERIMENT

Hanzehogeschool, Groningen and Swinburne University, Melbourne, have over the last years established a good academic cooperation which included advance level student exchange. Staff visits resulted in experience sharing and extensive discussion on curriculum development etc. It concerned both Mechanical Engineering and Product Design Engineering courses and was similar to the bilateral cooperation both entertained with the already mentioned PDE-course of the Glasgow University and the Glasgow School of Art [3].

Both institutes educate for integral design engineering aiming at the full scope of competitive technical innovation, be it from different backgrounds. A comparative experiment was set-up to evaluate the above mentioned insights and their consequences towards curricula set-up for the targeted professions and industry-branches.

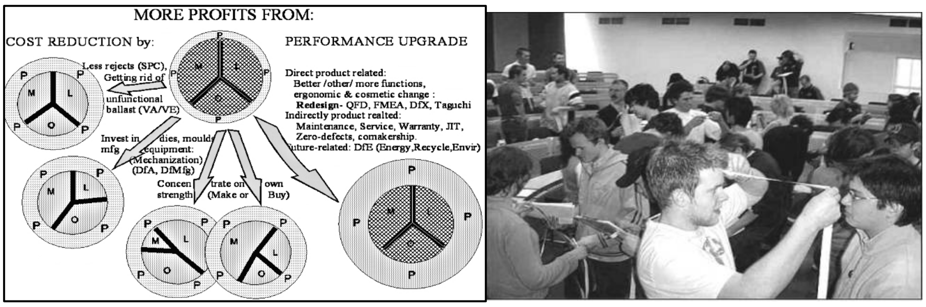

Figure 4. MLO-analysis and the design techniques; hands-on Taguchi

In the experiment 3 different final stage groups of students were exposed to the same:

- "it depends" insight and context explanation
- lectures on design methods in reverse order: from model making to Mfg costing to DfA, practical Taguchi, Function. Anal, semantics, market research, presentations.
- a short intensive project (team of 4-5, frequent professional supervision), focused on realistic profitability (the nutcracker) before the main project on new concepts.
- industrial design reviews on project results and written exams on theory understanding

3.1 Comparative observations

The projects proved to be the most revealing.

The aim of the early project, the nutcracker engineering project, Fig. 5, was used to teach the student how deeply the manufacturing and competition reality influences the product success. The simple, but realistic costing calculation format helped in finding the essential cost factors and identify useful cost reductions. In the design review the results should be convincingly proven, not by showing the process, but by discussing the essential details, overviews and business implications. This proved to be a new experience of responsibility for all students.

During the project itself and in the design reviews, it was obvious that the Swinburne PDE-students (50% industrial design background + 50% technology; jig saw puzzle process) had most difficulty adopting these new values. The Mech.Eng.-students (solid engineering background + industrial experience) adapted quickly and eagerly to the new challenge, producing less exciting, but far more realistic proposals. The Groningen IPDE (International PDE, Hanzehogenschool, Groningen) –students went much more "through the motions", covering up weak or impossible constructions, Fig 5. In this last case, the supervision was less reality-oriented or strict; a noticeable improvement was achieved during a second project with direct industrial participation.

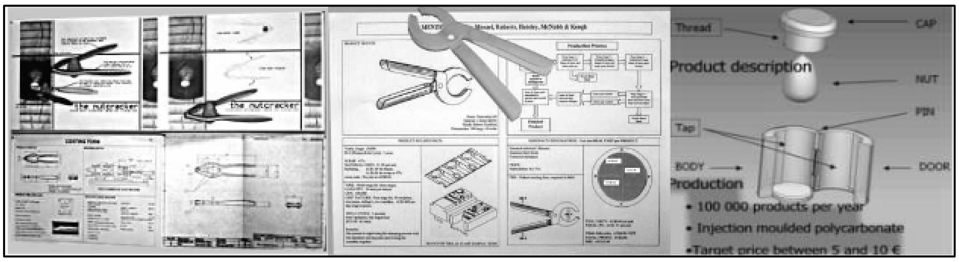

Figure 5. From left to right: nut crackers of: PDE (too much info) and Mech. Eng (clever, to the point) of Swinburne and IPDE of Hanze (too little detail)

In all cases, the physical models, varying from very simple cardboard demonstrators of mechanical movements to beautifully crafted wooden prototypes, worked to full satisfaction of students and supervisors. It conveyed not only all the information, but also revealed more strengths and weaknesses of the designs than expected by the makers. The exercise convinced most of the (Mechanical Engineering) students, who were not yet familiar with this very practical tool, that it is a very useful instrument.

Although from the discussions it was clear that the design techniques and methods that are introduced during the lectures are well understood, the actual application in the projects was poor. Cause and effect, concept, problem, solution, function, requirement, parts, systems and constructive elements are frequently mixed up by all 3 groups. Obviously the thinking at different levels of abstraction, the base for functional analysis and almost all design techniques, is a skill that needs to be developed over a longer period of time, including repetitive practical exercise. In discussions with students, they admitted that they "are going through the motions" to reach the conclusions or construction they would have chosen anyway based on "gut" feeling. Again, students with a longer industrial experience were able to do somewhat better in the application of the methods with realistic values and outcomes. The initial project proved to be a good reference to the "normal" issues of design theory. However, the specific ODD-logic of which methods would fit to which (in this case virtual) industrial, organisational and strategic context, and (real) product and personal context, proved to be far too difficult for students. Like we also observed in the industrial world, inexperienced engineers do not understand and master the methods enough to adapt to specific context factors, which are even harder to recognise.

3.2 Conclusions and recommendations

Indeed a-concentric learning proved to be useful for integrated design engineering, and the need for a solid technology and industrial practice base has been confirmed.
In the curriculum design, one should be aware how difficult unlearning a method is; early training with adequate flexibility might be an option.

Effective integration of disciplines, both on design methods and technical subjects, works if the separate subjects are supported by multi-faceted integrating projects. In these projects a consequent confrontation with techniques and effects during the projects make the students accept these design methods and theories. By frequent knowledgeable, experienced, detailed, participation and individual group tutoring the students cover all aspects and techniques seriously, in stead of just going through the motions, or not considering them at all. It requires staff of all related disciplines to be committed and fully involved in the projects, combined tutoring and formal or at least informal combined ownership of the course both by management and staff. Indeed, so much of the Aalborg experiment [8] is still valid.

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