APPLYING DESIGN THINKING CONCEPTS TO REJUVENATE THE DISCIPLINE OF OPERATIONS RESEARCH/MANAGEMENT SCIENCE

N.M. Viljoen[1] and **H.M. (Ria) van Zyl**[2]
[1]Department of Logistics and Quantitative Methods
Council for Scientific and Industrial Research, South Africa
nviljoen@csir.co.za

[2]Department of Visual Arts
University of Pretoria, South Africa
ria.vanzyl@up.ac.za

ABSTRACT

Over the last three decades, the discipline of Operations Research/Management Science (OR/MS) has experienced a pronounced crisis in identity, spurring heated debate in the discourse of the discipline. Central to this crisis is the gap between theory and practice. The gap brings into question the continued relevance of OR/MS in industry. This paper briefly names the key problem areas within the discipline that have been highlighted in literature, and proposes the introduction of design thinking concepts as a solution. Design thinking is the obverse of scientific thinking and therefore this approach is slightly unconventional. By exploring these concepts in light of the OR/MS crisis, the paper aims to highlight the potential merits of collaboration between designer thinking and operations research in recapturing the relevance of OR/MS.

OPSOMMING

Gedurende die laaste drie dekades het die dissipline van Operasionele Navorsing/Bestuurswetenskap (ON/BW) 'n aansienlike identiteitskrisis beleef wat gelei het tot hewige debatvoering oor die dissipline. Sentraal tot die sogenaamde krisis is die gaping tussen teorie en praktyk wat die vraag laat ontstaan of ON/BW steeds relevant is vir die bedryf. Hierdie artikel noem kortliks die dissipline se hoof probleemareas soos beklemtoon in die literatuur. Verder stel die artikel voor dat konsepte van die ontwerpersbenadering aangewend word as kuur. Die ontwerpsbenadering is die teenoorgestelde van die wetenskaplike benadering en effe onkonvensioneel. Deur dié konsepte te ondersoek in die lig van die ON/BW-krisis, beoog die artikel om die potensiële meriete van samewerking tussen die ontwerpersbenadering en ON/BW te beklemtoon sodat die waarde wat ON/BW in die hedendaagse praktyk kan hê, weer ontsluit kan word.

[1] The author is a researcher in the Department of Logistics and Quantitative Methods, Council for Scientific and Industrial Research
[2] The author is a lecturer and researcher at the Department of Visual Arts, University of Pretoria and owner of a design consultancy.

1. INTRODUCTION

Disciplines often need to be re-invented to stay relevant. Debates concerning the Operations Research/Management Science (OR/MS) discipline clearly indicate the necessity for rejuvenation of the discipline, specifically in redressing the imbalance between theory and practice. This paper explores whether the concepts and approaches of design thinking could be a possible remedy. Design thinking is in many ways the obverse of scientific thinking, as it presents a synthetic approach as opposed to an analytical approach when addressing complex problems.

The paper is structured as follows: Section 2 provides a brief overview of what is regarded as the "crisis" in OR/MS, and discusses five prominent problem areas that need to be addressed within the discipline. Section 3 introduces design thinking, which is discussed using Owen's[15] two-domain creativity model and conceptual map of fields. Section 4 unpacks particular design thinking concepts under four headings, to address the OR/MS problem areas mentioned in Section 2. Section 5 highlights the conflicting perceptions of interdisciplinarity held by designers and operations researchers that would impede collaboration. Finally, Section 6 concludes the discussion, proposing that industrial engineers act as mediating agents to enable the collaboration between design thinking and OR/MS.

2. THE CRISIS IN OR/MS

OR/MS was first conceptualised during World War II as a quantitative approach to improving the efficiency of military operations. These tools and techniques proliferated and were soon adopted by an increasing number of civilian organisations, both in the public and private sectors. The three decades from 1940 – 1970 are considered the "golden age" of OR/MS as during that period, OR/MS became popular amongst managers because it usually improved efficiency when applied to almost all kinds of projects. The techniques developed proved teachable and by 1970 OR/MS was viewed, both in Britain and the USA, as a legitimate subject for academic discourse. OR/MS is regarded as an applied science. It uses a multidisciplinary approach to solve real life problems by using quantitative methods and models. The classical OR/MS problem solving approach is illustrated in Figure 1.

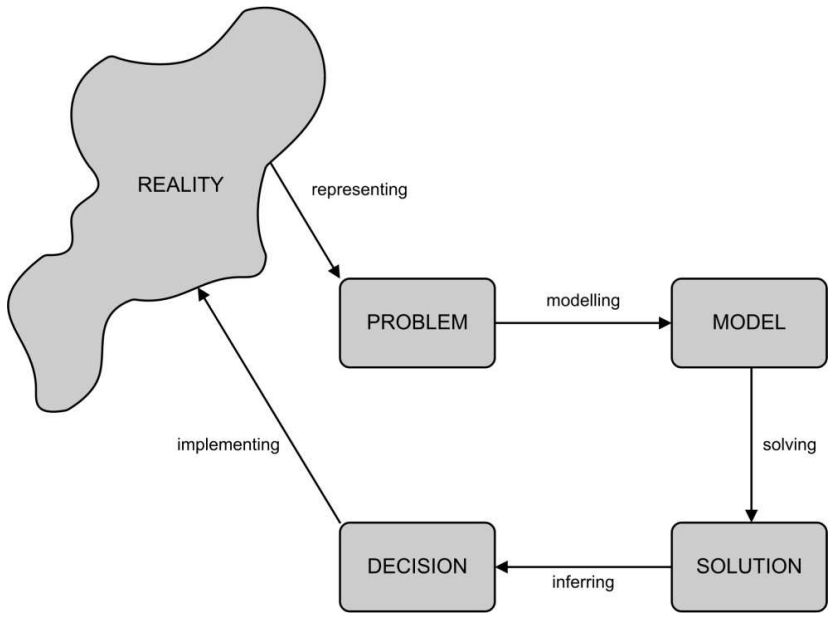

Figure 1: Illustration of the OR/MS problem solving approach [Adapted from Rardin[17]]

The next three decades (from 1970 – 2000) saw a cloud descend on the discipline of OR/MS. What has now become known as the “crisis" in OR/MS, started to afflict the British community in the 1970’s and its American counterpart in the 1980’s. The question that plagued the discipline was whether OR/MS can still be a relevant and useful tool to solve real life problems. Pierre Hansen (Kirby [9]), an American operations researcher, identified the commonly encountered explanations for the crisis:

1. OR/MS is obsessed with tools and techniques and ignorant of managerial needs (Perversion theory).
2. OR/MS has already been applied wherever it might have been useful (Obsolescence theory).
3. Evolving management needs resulted in problems too complex to be solved using OR/MS (Inadequacy theory).
4. Misguided practise of OR/MS in certain instances have undermined its credibility (Counterperformance theory).

Widespread debate ensued within the global OR/MS community. To date these debates have raged between different parties, leaving a plethora of publications. For more information about this, the reader is encouraged to refer to a thorough chronicle of the thirty years of debate, written by Maurice Kirby (2007), for an objective retelling of the history of the OR/MS crisis.

In their discussion of the crisis facing the discipline, Corbett and Van Wassenhove[6] classified the different activities found in the field, by dividing them into three domains, namely Management Science, Management Engineering and Management Consulting. In Management Science, the goal in solving problems is to improve and expand the myriad of quantitative tools available in OR/MS, thereby increasing the body of knowledge about the discipline. Management Consulting lies on the other end of the spectrum, where the goal is to solve practical problems using well-developed standard OR/MS tools. The middle ground, Management Engineering, adapts existing tools or uses them in innovative ways to solve real life problems, thereby bridging the gap between Management Science and Management Consulting. Instead of flogging the proponents of the Management Science domain for losing touch with reality through their “mathematical masturbation" (Ackoff [1]), Corbett and Van Wassenhove[6] impute the crisis to “... a relative shortage of fundamentally novel approaches and applications, such as would arise from the domain of management engineering". This perceived imbalance amongst the development of the three domains is illustrated in Figure 2.

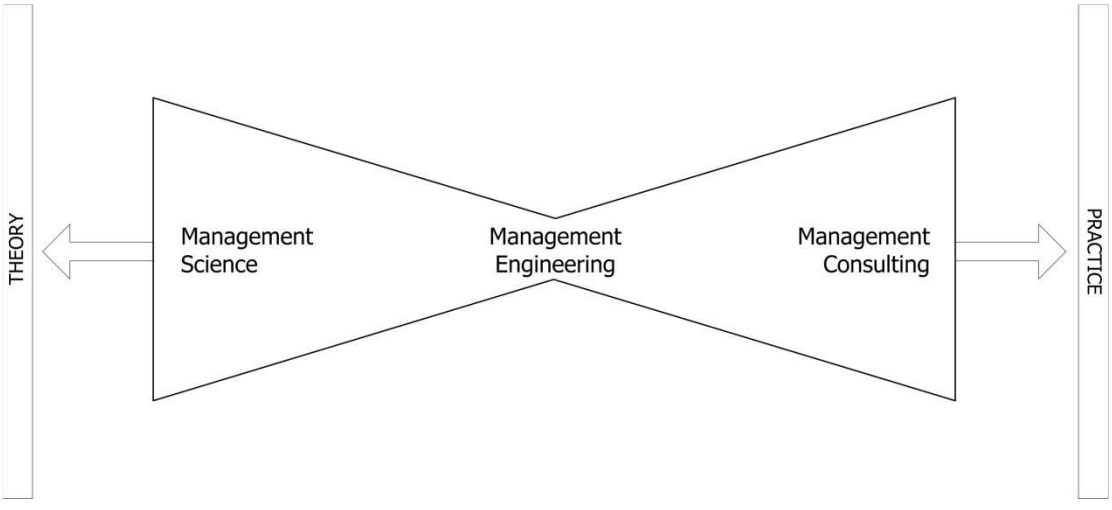

Figure 2: Perceived imbalance amongst the development of the three domains of OR/MS as described by Corbett and Van Wassenhove[6]

Corbett and Van Wassenhove[6] maintain that the fundamental issue underlying the OR/MS crisis is the necessity to strike a balance between OR/MS as knowledge-oriented science and OR/MS as problem-oriented technology. They define five problem areas that require redressing if OR/MS is to again become a valuable and relevant discipline that can yield practical and useful tools with which to solve real life problems.

1. **Tool-orientation vs problem-orientation**. OR/MS emerged because of the necessity to optimise efficiency of certain types of operations. Because it was birthed by necessity, in its initial stages there were very few tools. Soon after, there was a rush to develop tools to be used in OR/MS. This laid the foundation of the discipline. Continuous improvement of current tools and development of new innovative tools hold obvious advantages, as the problems that need to be tackled using OR/MS become larger and more complex. However, it is believed that an unhealthy obsession with analytical sophistry, instead of practical solutions, has resulted in the unit in OR/MS becoming the quantifiable problem and not the management mess. As Ackoff[1] points out, "[m]anagers do not solve problems; they manage messes".
2. **Client relations in OR/MS**. There are three aspects to this issue. Firstly, a communication barrier exists between operations researchers and managers, as the former uses precise language and scientific terminology whereas the latter uses the loose terminology of business. Secondly, the image of the OR/MS discipline needs to be improved through better public relations and visibility. Lastly, a clearer understanding of *how* OR/MS can be of value to the client must be cultivated. This aspect is more intricate than it may seem, as value is not only added by the final solution delivered to the client, but throughout the entire problem solving exercise.
3. **The learning effect of an OR/MS study.** In practice the goal of an OR/MS study is often not the actual solution obtained from the model. The goal may rather be to help management understand the complex problems they face, gather research material about an unknown topic or determine the decision factors driving a certain dilemma. This learning effect, however, has not received much attention from OR/MS literature, and the discipline requires fundamental research into how managers learn from such studies (Corbett and Van Wassenhove [6]).
4. **The relevance of OR/MS at a strategic level**. OR/MS is known for its successes in supporting tactical and operational decisions, but whether OR/MS can add value at a strategic level is strongly debated. Many authors, cited by Corbett and Van Wassenhove[6], are of the opinion that OR/MS can be an invaluable strategic decision making tool if applied correctly. Indeed, if OR/MS is to climb the corporate ladder out of the organisational bowels of route optimisation, production scheduling and staff rostering algorithms, it must rise to the occasion and prove its worth to managers. OR/MS successes are found where the discipline has been applied to large-scale strategic projects, especially military applications, but unfortunately there have also been failures that severely discredit the successes. Failures are generally a result of a "bottom-up" approach where practitioners attempt to construct large scale strategic models by pasting together a myriad of smaller operational models. This approach usually results in the final product being either strangled by its own complexity, or becoming invalid. A holistic systems approach is required for these projects to succeed. Such an approach is impossible unless practitioners fully understand the underlying dynamics of the system, subsequently solving the "bigger picture".
5. **The interdisciplinary nature of OR/MS**. At its inception there was no such thing as an "operations researcher". The field was inherently interdisciplinary, uniting scientists from many diverse fields. It is argued that the gravitation of OR/MS towards the mathematical sciences (whether through using actual mathematical models or merely quantitative logic), has precluded invaluable input from social and management sciences. William Pierskalla (President of the OR Society of America 1982 – 1983) stated in his article *Creating Growth in OR/MS*[16]: "If we are

to grow, we must reach out to new areas of knowledge and to new approaches, and integrate them into our field".

Much of the literature is pedantic about the specifics concerning the causes of the crisis and who is to blame. The overarching problem areas, however, are undisputed, and this paper proposes concepts and approaches of design thinking as remedies to these. The remainder of this paper discusses the nature of design thinking and the merits of the application of certain design concepts and approaches in the field of OR/MS.

3. THE NATURE OF DESIGN THINKING

Charles Owen explores design thinking and its application in his article, *Design Thinking: Notes on its Nature and Use* (Owen [15]). He views design thinking as complementary to scientific thinking instead of antagonistic to it. Scientific thinking is illustrated as the sifting of "facts to discover patterns and insights", whereas design thinking is the invention of "new patterns and concepts to address facts and possibilities" (Owen [15]).

Owen maintains that there are two types of applied creativity – "finding" and "making". "Finders" exercise creativity through discovery and usually practise more scientific or scholarly professions. Conversely, "makers" demonstrate creativity through invention and often gravitate towards the fields of art, engineering, architecture and so on. He illustrates this concept by means of a two-domain creativity model (see Figure 3).

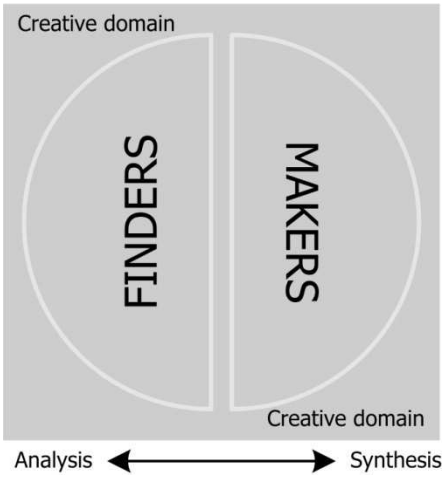

Figure 3: Two-domain creativity model. [Adapted from Owen[15]]

By exploring the correspondence of scientific and design thinking at a greater resolution, one can develop a conceptual map upon which different disciplines can be positioned in relation to their context (their realm of activity) and process (their way of doing). This map (Figure 4) has two axes dividing it into four fields. The horizontal axis represents the *process*, having on the left, fields that are analytic in nature, and on the right, fields that are more synthetic - similar to the differentiation between discovery and invention in Figure 3. The vertical axis represents the *context* with symbolic fields mapped in the top half and real fields in the bottom. Symbolic fields deal with more abstract subject matter such as human interaction, institutions and policies, language and so on. Fields more concerned with real world objects and systems are mapped in the bottom half. For further explanation of the philosophy behind the conceptual map the reader is encouraged to refer to the article by Owen.

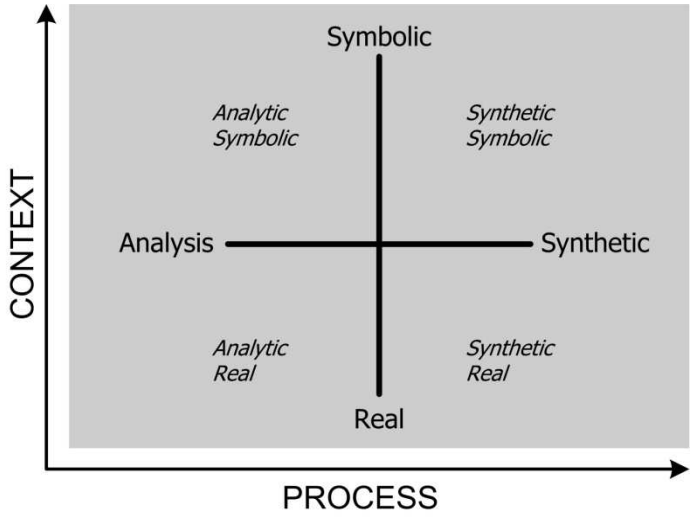

Figure 4: Conceptual map differentiating between process and context. [Adapted from Owen[15]]

The map provides a means to visualise the relationship between scientific and design thinking with regard to the two dimensions. Referring to Figure 5, science is regarded as heavily analytic in its use of process, and symbolic in context, as theories, experimentation and development of scientific argument are abstract by nature. There are, however, aspects of science that deal with matter that is not abstract, such as in the natural sciences, and elements of science that are synthetic in process, such as materials science. Design, in contrast, is synthetic and concerned primarily with real world artefacts, firmly entrenching it in the lower-right quadrant. However, once again there are disciplines in design that deal with communication and symbolism, and it cannot be denied that some degree of analysis is required in order to perform synthesis. Therefore, similar to science, design also appears in the other quadrants. The way in which the two ways of thinking complement each other is visually exemplified in Figure 5 as, in conjunction, these two fields cover most of the space.

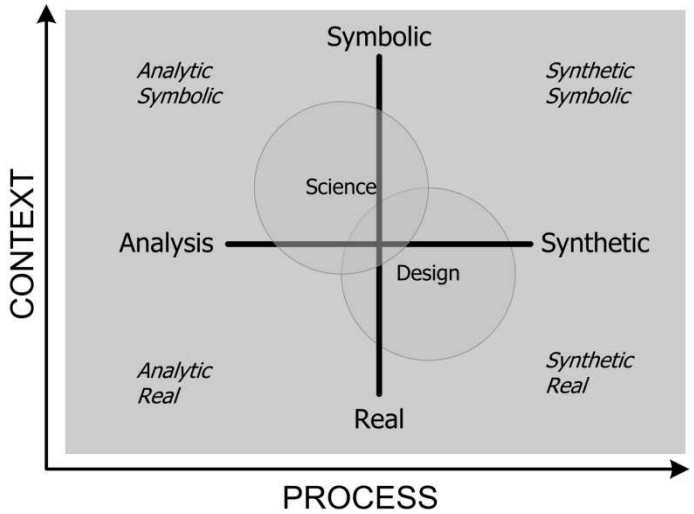

Figure 5: Differentiating between the fields of science and design using the framework of context and process. [Adapted from Owen[15]]

There are many taglines for design thinking - each alludes to the context within which the person who coined the tagline operates. David Burney (Hyer [8]), Vice President of Brand Communication & Design at Red Hat Magazine, discusses design thinking in relation to its capacity to bring competitive advantage to organisations. According to him design thinking is

> *"…a way of thinking about solving problems, a way of creating strategy by experiencing it rather than keeping it an intellectual exercise, and a way of capturing value".*

Tim Brown of IDEO describes design thinking in the Harvard Business Review[3], as

> *"a methodology that imbues the full spectrum of innovation activities with a human-centred design ethos".*

He believes that innovation is powered by a thorough understanding and direct observation of human needs. The article furnishes a number of examples where design thinking has been successfully implemented to solve practical problems. According to Beverland and Farrelly[2], design thinking is an embedded corporate culture that is cultivated in companies known for innovation and market leadership. These companies realise that competitive advantage lies beyond customer expectation in the realm of possibility. There are a great number of companies successfully implementing design thinking approaches and reaping great rewards of which GE, Proctor & Gamble, Fisher & Paykel, National Australia Bank (NAB) and Maytag are but a few (Beverland and Farrelly [2]; Hyer [8]).

The question is no longer *whether* design thinking can add value to an organisation but rather *how* it can add value. In the case of OR/MS there are specific problem areas that have to be addressed. The next section discusses the concepts and approaches of design thinking that are relevant to these areas.

4. DESIGN THINKING CONCEPTS APPLIED TO OR/MS

4.1 Engaging reality

The first step in the OR/MS problem-solving approach (see Figure 1), is representing reality as a quantifiable problem. In order to do this, enough information must be gleaned from reality so that, once reduced to a quantified problem, the problem still represents reality sufficiently enough to yield useful results. There are plenty of tools in the OR/MS toolbox with which such fieldwork can be done. Data mining and statistical analysis are the obvious choices when sufficient quantitative data is available; while interviews and work, time and motion studies are used to obtain information regarding business processes and interactions between components of the problem. In theory these techniques, when applied correctly, should enable the operations researcher to fully understand the reality - even the finer nuances of how human behaviour affects this reality. Unfortunately, in practice these techniques are placed in the hands of textbook trained practitioners with a predisposition to mathematical equations, computing power and the safety of their five foot cubicle dividers. Whether by nature or nurture, OR/MS practitioners generally do not possess the skills required to ask the *"interactional what"* Button[5] believes is essential in understanding the complexes of action within a system.

Button[5] uses an example of a production print shop to highlight what he believes to be the difference between fieldwork and the *"interactional what"* of ethnography. Fieldwork-based studies of a production print shop reveal that production is enabled by the interactive effort of a number of people using objects such as production lists, scheduling boards, work tickets and so on. Fieldwork would describe that these objects are used, and perhaps even how they are used. If this fieldwork were then used to formulate a system that could improve the efficiency of the production print shop, an obvious solution would be the automation of the scheduling and track-keeping processes, to take some load off the managers. Button[5] comments on this approach:

> *"… fieldwork that only describes what relevant persons do may well be missing out on the constitutive practices of how they do what they do, the 'interactional what' of their complexes of action".*

What you would be missing out on, is that the primary purpose of the scheduling board is not the manipulation of data and calculation of start and finish times. Instead, it exists so that personnel can get a picture of what is happening on the production floor with one glance. If a machine were to go down, one look at the scheduling board can immediately allude to a number of different possibilities to solve the problem. This small insight will have a monumental effect on the development of a system for the print shop, the solution being much more effective than a mere automation of calculations.

Ethnography tells the story of what is happening in the environment. According to Sanjek, as cited by Macaulay, Benyon, and Crerar[12], ethnography differs from journalism in that it not only *reports* but also *interprets*. Macaulay et al.[12] further differentiate between a "traditional" ethnographer and a design ethnographer by saying that while the former describes and interprets cultures, the latter describes and interprets cultures with the express aim of developing a future tool that will change the culture that is being studied. Having design ethnography as part of the initial problem formulation process would have obvious benefits. Firstly, practitioners would get a more thorough grasp of the elements affected by, or influencing, the situation. This would result in a more accurate representation of reality. Secondly, there would be a deeper understanding of the client's need, and this will ensure that the practitioner sets out to solve the *right* problem. Lastly, when the people involved realise that the practitioner is really interested "in getting to the bottom of a thing", they would be more than likely to suggest solutions that would not necessarily be obvious to the practitioner, but invaluable nonetheless.

Beverland and Farrely[2] take it one step further and speak of the designer's role as *constant ethnographer* in an organisation that is design-led. What this means is that designers are constantly seeking new inspiration from their wider environment. This uninterrupted orientation towards the wider goal makes them sensitive to changes in client need and therefore adaptive in their solution approach. Cultivating a culture of constant ethnography within an operations researcher would ensure that there is a link between the solution being developed, and reality. It often happens that during the period that it takes the OR/MS team to develop and create the model, the client's need changes, or even elements of reality change. This results in a product-need mismatch that could have been avoided if the operations researcher was constantly in tune with reality - alert to changes and seeking out opportunities.

In addition to fully understanding the problem at hand, maintaining a client-centred focus throughout the OR/MS process is necessary if the end product is to successfully address the client's need. When referring back to Owen's[15] definition of scientific thinking, we see that

> *"[s]cience and, to a lesser extent, technology have few built-in governors. That is to say, as in the arts, exploration proceeds where discoveries direct".*

In contrast, the discipline of design is client-centred by nature.

The Swedish Design Ladder, as explained by Microgiants Design Research[14], outlines four levels of design integration in a company. As an organisation increasingly embeds more design thinking into its corporate culture (progressing through the four levels), it becomes more strategic and client-centred not only with its products, but with every aspect of the business.

- **Level 1: Non-Design**. Design is seen as an unimportant task and the perspective of the end-user is disregarded.
- **Level 2: Design as styling.** In such companies, design is seen as the final "glitter dust" meant to make the product more appealing. A designer may be the one

actually performing the final styling, but often the initial designing is done by someone with no design training.

- **Level 3: Design as a process.** This is a multidisciplinary approach where the design process influences the product from conceptualisation to delivery, keeping the end-user in mind at all times.
- **Level 4: Design as strategy.** In such companies designers work with managers to spear-head innovation in all major business areas. The design process is not limited to products but addresses aspects of company vision and position in the value chain.

When design is the strategy, the entire company becomes geared to fulfilling the client need. OR/MS needs to deliberately increase the client focus in its process. Not only would this ensure client satisfaction and return business, but it will also enhance the relationship with the client, which is the next critical point.

4.2 Friendly OR/MS

Corbett and Van Wassenhove[6] examine the perceived communication barrier between OR/MS practitioners and businessmen, by studying articles related to the subject that were published in the Harvard Business Review over the last six decades. The communication barrier was identified as a serious problem in the 1950's. The opinion then was that the responsibility to overcome the barrier lay within both camps. A few years later, the opinion changed to one where the OR/MS practitioner is primarily responsible for taking the first step. Jones, as cited by the authors, stated in 1966 that the accessibility of OR/MS publications for the business world was deteriorating, as the connection between the business problem and the mathematical technique was becoming more vague, and specialised jargon was starting to creep in. Not much has changed since then, with less OR/MS papers being published in management journals. OR/MS is definitely not the only player seeking the favour of managers. Viewed as just another potential value adding tool on management's shelf OR/MS needs to become more personalised and accessible so that managers can identify with it more.

Bruce and Docherty[4] in their comparative study of client - design consultant relationships, describe design as a personalised business. They focus on design consultancies instead of in-house design departments in their study, and delineate a taxonomy of different client - design consultant relationships. Citing Dawes' research of clients' reasons for choosing management consultants, they state that the three most important criteria for contracting consultants were the reputation of the consultancy, its reputation within its specialist area, and personally knowing the consultant that would work on the project. Another study by Horn, as cited by the authors, stated that personality was the most common criteria considered when choosing a design consultancy. They attribute the intensely personal nature of design projects to the inherent characteristics of a designer. Apart from their professional competency, designers immerse themselves in a problem so that they do not just understand the problem on an abstracted intellectual level, but on a deeply intuitive level. Considering the diverse fields within which designers often work, it stands to reason that they are regularly faced with communication barriers where the language of their client sounds nothing like the design language they understand. In such cases it is usually the *designer* that goes to great lengths to understand the language and environment of the client, not visa versa.

According to Brown[3], one of the five main characteristics of a design thinker's personality profile is empathy. Empathy, in this regard, is the ability to observe reality from multiple perspectives. This empathy is essential in building healthy client relations. Unfortunately, empathy is not a textbook concept that can be *taught* to operations researchers in the lecture hall, instead it needs to be *caught* in the client's boardroom.

Adding insult to injury is the particularly bad image that OR/MS has, not only amongst managers, but even within its own community. Studying OR/MS literature pertaining to this crisis, the disdain felt by individuals in the OR/MS community itself is clear. To put it in

design terms, it is the *brand* of OR/MS that has come into question. What is the value proposition offered by OR/MS and its products? In discussing brand as a physical manifestation of design, Beverland and Farrelly[2] quote Michael Smythe who says that

> *"[a]n organization is known by the way it manifests itself through its products and services, its visual communications and its operational environment".*

The discipline of OR/MS is widely dispersed in just about every industry all over the world, so that finding one brand to unify the entire discipline is indeed impossible. However, the question of brand *is* critical and must be asked wherever OR/MS is practiced, but more importantly wherever OR/MS is taught. This once again points to moving towards the fourth level of design integration as discussed in Section 4.1.

4.3 Visual thinking and communication

Much (if not most) of the value that is added by using OR/MS approaches to solve real life problems, does not lie in the actual solution, but in the process of ordering reality and representing it as a quantified problem. However, most OR/MS practitioners are so numb to the potential value that could be added by involving the client that they simply do not. Once satisfied that enough data regarding the reality has been gathered through whichever technique, they retreat into a back room where raw data is transformed into a conceptual model, then a working model and eventually (once some niggling errors have been ironed out) a final model. Depending on the project, the OR/MS practitioner, and the client, there may be varying degrees of interaction at critical points, with one or two key client representatives during the model development, but usually OR/MS practitioners work on a need to know basis. This is tragic, as there are many small steps within the quantification process that could offer great insight to a manager if he had been involved, or at least informed. For example, determining which organisational decisions have bearing on a certain real life problem might be something a manager never stops to think about, yet it is one of the first things considered when formulating an OR/MS problem from reality. The crux of the matter is that a lot of the potential value that could have been added to the client is lost, due to the low level of involvement and interaction.

Remembering the very real communication barrier, the question is how does one manage these interactions so that mutual insights are attained without wasting precious hours where both parties could potentially be lost in translation? Dziersk[7] discusses the importance of visual thinking when designers try to explain strategic concepts to managers. Visual thinking has the potential to overcome communication barriers through storytelling and intuitive association. In the same way, visual thinking can be used by OR/MS practitioners to translate complex quantitative equations into accessible management scenarios. Unfortunately, visual thinking is not a skill the average OR/MS practitioner has at his disposal. Training and experience in the art of visual thinking is required so that OR/MS can more successfully include clients in the modelling process. This inclusion will increase the value added to the client, and possibly even the popularity of OR/MS.

4.4 Solving the bigger picture

It is clear that the world has long since progressed from the machine age to a systems age. Kirby[9] cites Ackoff who stated that

> *"[a] system is more than the sum of its parts; it is an indivisible whole. It loses its essential properties when it is taken apart. The elements of a system may themselves be systems, and every system may be part of a larger system".*

So the real life problems faced by managers can hardly ever be separated into independent components. For OR/MS to be a strategic tool, it must look at the bigger picture and create all solutions with that in mind.

The words *top-down* and *systems approach* are not foreign to the field of OR/MS. It is common sense to any operations researcher that obtaining optimality for one component within a system may render the entire system's performance suboptimal. What then explains the opinion that OR/MS is primarily a tactical or operational tool, unable to adequately handle entire systems and therefore unable to handle strategic problems? Quite simply, this comes back to the mindset of the operations researcher. As soon as the human element is added to a system (which inevitably happens as one progresses from the tactical, to the operational, and finally strategic level) an enormous amount of complexity and variability is added in the form of human behaviour. At this point, if left to himself, the operations researcher would either murder the reality by reducing human behaviour to binary logic, or proclaim that the problem is too complex to solve. Special skills are required to find ways to incorporate human behaviour into models. Such skills can be found in design thinkers who have an ability to work systematically with qualitative information.

However, solving the bigger picture means more than just solving the model that represents the current strategic system, but actually includes solving the models that represent future scenarios of the system as well. Solutions must be both adaptive and multifunctional. It is important that a solution be adaptive so that under various possible future scenarios, it will still be able to solve a client's problem uniquely. A major trend that illustrates this is in the motor industry, where customisation is pushed as far forward as possible in the manufacturing pipeline, to both save costs and improve client satisfaction. According to Owen[15], a "bias for adaptivity" is one of the characteristics of design thinking. Multifunctionality is really just the concept of killing more than one bird with only one stone. Due to their predisposition to strive to amass multiple benefits from a solution, designers often succeed in this objective. It is clear that designers, or at least design thinkers, possess a great number of skills required to effectively solve larger, dynamic systems.

It is clear from this section that collaboration between design thinkers and operations researchers could hold obvious advantages for OR/MS. Unfortunately, even in its approach towards interdisciplinarity OR/MS and design thinking do not see eye to eye.

5. CONFLICTING PERCEPTIONS OF INTERDISCIPLINARITY

Interdisciplinary is a word easily tossed around in OR/MS, as OR/MS can (and is) applied in just about every industry. When approaching a problem in an industry where the operations researcher has little or no experience, experts from other disciplines, or perhaps even the industry itself, must be involved in "understanding" the reality that is to be solved. However, merely soliciting expert opinions from other disciplines in order to paint a backdrop should rather be termed *multidisciplinary* work, instead of *interdisciplinary* work. In multidisciplinary work, inputs are received from many diverse disciplines, and then taken into account in developing a product. Interdisciplinary work requires a more intimate involvement from the players. It requires, to some extent, surrendering the ingrained paradigms and modus operandi of the different disciplines, in favour of a more synergistic problem solving approach. Multidisciplinarity can be likened to each discipline slapping their uniquely shaped and coloured ball of clay onto the table and then taking a picture of all the clay shapes together. Interdisciplinarity, on the other hand, is when each piece of clay is moulded with the others so that colour and shape become hard to differentiate. Such interdisciplinarity is essential when working in the area of management engineering, where theory meets application.

The OR/MS problem solving process stresses the assimilation of information from other disciplines, as far as such information is necessary to understand the reality of the problem and the variables that affect it. This can be seen as the multidisciplinary facet in OR/MS. However, once the problem has been quantified, the involvement of other disciplines usually stops, as it is taught that the problem solving model should be developed only using the characteristics of the quantified problem and the tools available in the operations

researcher's toolkit. It is taught that it is not always necessary to take into account paradigms and approaches of other disciplines after the problem has been quantified. Very rarely are problem solving approaches from other disciplines moulded into an OR/MS model because then, of course, it would no longer resemble a distinguishable OR/MS model, would it?

Conversely, designers are either born or bred (or both) for interdisciplinary teamwork. According to Owen[15], an affinity for teamwork is one of the indispensable characteristics of design thinking. The client-based nature of the design profession requires good interpersonal skills, making the ability to work with many people from diverse backgrounds a cultivated tool in the designer's toolbox and not just another "soft skill". Owen comments that industry has moved towards team based product design over the last few decades and this has spurred the affinity for interdisciplinary cooperation even more. He notes that in teams, designers are

> *"a highly valuable asset because of their characteristic abilities to generalize, communicate across disciplines, work systematically with qualitative information, and visualize concepts"*[15].

Brown[3] states that

> *"[t]he best design thinkers do not simply work alongside other disciplines; many of them have significant experience in more than one",*

implying that the design thinker's nature is predisposed towards interdisciplinarity.

Apart from being able to work across disciplines when developing a solution, designers are also aware that for a product to survive in the market place, its design must satisfy many, often opposing, functional objectives within an organisation. Beverland and Farrelly[2] call this juggling of objectives cross-functional empathy and say that it is essential in design-led companies. Designers who understand the impact of their design on other functions within the organisation, and are able to find solutions to cost, legislative or other constraints, are invaluable.

The juxtaposition of the diverging perceptions of interdisciplinarity of the two approaches draws attention to the obvious chasm between practising collaboration and preaching it. Initial contemplation proffers two bridges over the chasm. The first is the purposeful incorporation of design thinkers into OR/MS teams with the express purpose of "disrupting" the status quo with their design thinking ways. The second is the incorporation of design thinking concepts into traditional OR/MS education. The former may be likened to locking cats and dogs in one room while the latter is like genetically manipulating the dogs over many generations. Finding a mediating agent may be less confrontational and more efficient.

6. INDUSTRIAL ENGINEERS AS MEDIATORS

Lister and Donaldson[11] quote the American Institute of Industrial Engineers that defines industrial engineering as

> *"the branch of engineering concerned with the design, improvement, and installation of integrated systems of people, material, information, equipment and energy. It draws upon specialised knowledge and skills in the mathematical, physical, and social sciences, together with the principles of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems."*

Kruger[10] explains industrial engineering as being primarily rooted in determinism and stochastism with the disciplines of engineering, science, economics, management and

humanities constituting the five lesser roots. It is clear from these definitions that industrial engineers are trained "interdisciplinarians", possessing cross-functional empathy as a result of theoretical and practical exposure.

The industrial engineer is able to speak the language of the engineer, the business man and the users of systems. With a firm footing in mathematics, augmented by formal OR/MS training, the industrial engineer is fully capable of developing OR/MS models and solution procedures. However, their predisposition is towards the client and addressing his need in a practicable manner, akin to the predisposition of design thinkers. Often in practise they are the mediators between the business client and the other engineers and scientists.

7. CONCLUSION

The debate within OR/MS can, to some degree, be seen as part of the natural progression or evolution of the discipline. It has been argued, however, that the crisis that the discipline has experienced has become so pronounced that the relevance of the discipline in industry must be questioned. This paper has taken a new approach to solving a few identified problem areas by considering design thinking as a remedy. Accepting that design thinking is opposite and at the same time complementary to science thinking (which is the foundation upon which OR/MS is built) the paper considers the intersecting points between design thinking and OR/MS. A discussion of the conflicting perceptions of interdisciplinarity held by OR/MS and design thinking exposes the chasm between preaching interdisciplinary collaboration and actually practising it. The paper concludes by suggesting that industrial engineers are ideally positioned to act as mediators in the collaboration process as they are "interdisciplinarian" by nature. They empathise with both fields as they have a predisposition towards practicable, client focused solutions cemented on a firm scientific foundation. This paper has introduced the idea of collaboration between OR/MS and design thinking, enabled by the mediation of industrial engineering. Future discussion should develop the idea more fully to propose *how* this collaboration could be achieved.

8. REFERENCES

[1] **Ackoff, R.** 1979. The Future of Operational Research is Past. *The Journal of the Operational Research Society*, 30(2), pp 93 – 104.

[2] **Beverland, M., and Farrelly, F.** 2007. What does it mean to be design-led? *Design Management Review*, 18(4), pp 10 – 17.

[3] **Brown, T**. 2008. Design Thinking. *Harvard Business Review*, June, pp 84 – 92.

[4] **Bruce, M., and Docherty, C.** 1993. It's all in a relationship: a comparative study of client-design consultant relationships. *Design Studies*, 14(4), pp 402 – 422.

[5] **Button, G.** 2000. The ethnographic tradition and design. *Design Studies*, 21(4), pp 319 – 332.

[6] **Corbett, C., and Van Wassenhove, L.** 1993. The natural drift: what happened to Operations Research? *Operations Research*, 41(4), pp 625 – 640.

[7] **Dziersk, M.** 2007. Visual Thinking: A Leadership Strategy. *Design Management Review*, 18(4), pp 42 – 49.

[8] **Hyer, T.** 2006. Intro to Design Thinking. *Red Hat Magazine*. [O]. Available: http://www.redhat.com/magazine/019may06/features/burney/ Accessed 28 April 2009.

[9] **Kirby, M**. 2007. Paradigm Change in Operations Research: Thirty Years of Debate. *Operations Research*, 55(1), pp 1 – 13.

[10] **Kruger, P.S**. 2003. Industrial Engineering: Rooting for roots, hankering for heroes. *South African Journal of Industrial Engineering*, 14(1), pp 137 - 147.

[11] **Lister, G., and Donaldson, K.** 2003. New roles for industrial engineers in developing countries. *South African Journal of Industrial Engineering*, 15(1), pp 43 – 52.

[12] **Macaulay, C., Benyon, D., and Crerar, A.** 2000. Ethnography, theory and systems design: from intuition to insight. *International Journal of Human-Computer Studies*, 53(1), pp 35 – 60.
[13] **Macdonald, A., and Scott, B.** 1994. Creating an integrated learning Environment. Experiences in Product Engineering Education. *Colloquium on Design Education - Bridging the Gap Between Industrial and Engineering Design*, 6, pp 1 – 4.
[14] **Microgiants Design Research.** 2006. The Austrian Design Ladder. Microgiants Industrial Design GMBH.
[15] **Owen, C**. 2007. Design Thinking: Notes on its Nature and Use. *Design Research Quarterly*, 1(2), pp 16 – 27.
[16] **Pierskalla, W.** 1987. President's Symposium: Creating Growth in OR/MS. *Operations Research*, 35(1), pp 153 – 156.
[17] **Rardin, R.** 1998. *Optimization in Operations Research*, Prentice Hall.