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CREATIVITY AND IDEATION IN ENGINEERING AND INDUSTRIAL DESIGN

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1. Introduction

Imagination is the capacity to generate ideas.
Creativity is the capacity to use ideas to solve problems.

The ability to generate ideas can be developed through exposing students and teachers to a framework of creative learning strategies. This paper describes a pedagogy that encourages individuals to explore the diversity of imagery and objects from the natural and built world as the stimulus to evolve new and innovative solutions to design problems.
The learner will be introduced to skills to guide them to "deconstruct" a source of inspiration and identify key functional and aesthetic elements that will influence the development of a valid engineering outcome.
The use of traditional methods of visualisation is explored through pencil drawing and sculptural models and developed into computer aided design through using Autodesk Inventor to create three dimensional digital prototypes.

2. Inspiration

Structure and aesthetic

The human body in simple terms comprises of a skeletal structure and a framework of muscles that enable motion as a pure functional mechanical activity but also as an artistic expressive experience. The capacity of athletes and dancers to push their bodies to the extremes of physical ability offers the engineer and designer an opportunity to draw inspiration from the mechanical function and aesthetic interpretation of human movement.
The Fig.1 represents an artistic rendering of human movement captured through quickly drawn pencil sketches that emphasise an emotional interpretation of movement. These sketches initiate a design cycle that will explore the form and structure of the human body. Through "deconstructing" the sketches and identifying elements of mechanical movement in the joints

and linkages of the skeleton and forces in compression and tension observed through the reaction of muscle groups an engineer can acquire clues and direction to inspire a solution to a design problem.

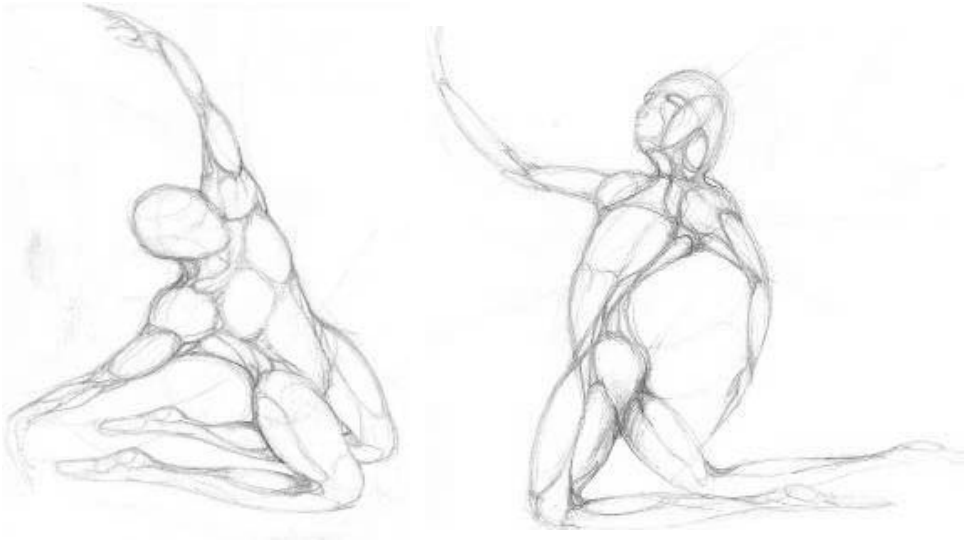

Figure 1: Pencil drawings capturing the energy and elegance of human movement

The Fig.2 illustrates how the initial inspiration of the human body can be replicated and mirrored to create a graphical image that possesses a positive and negative profile. The drawings show the outline of the body as a distinct profile and the spaces between each body and their limbs define separate shapes. The length of each element of the body in relationship to each other has been carefully considered with accurate consideration given to the ratio and proportion of all complimentary components.
This initial interpretation of the images pays little attention to mechanical functionality and gives greater emphasis to artistic and emotional interpretation of the subject matter.

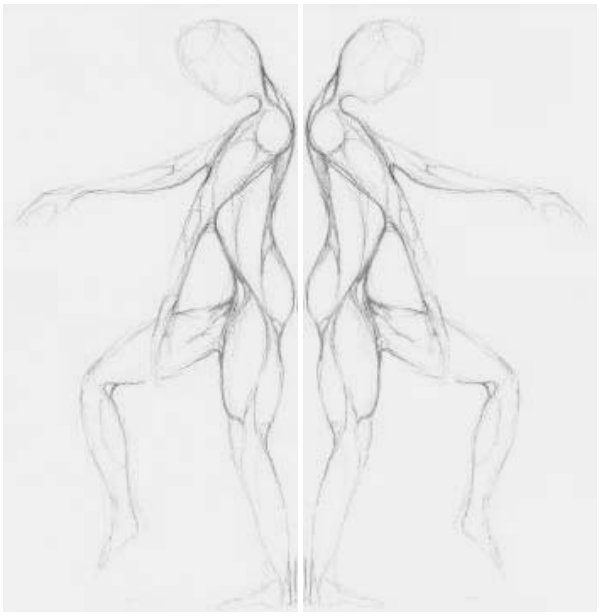

Figure 2: Pencil drawings capturing elements of symmetry, ratio and proportion

In this early phase of a design cycle that seeks to align the functionality of engineering to the aesthetic of the complimentary disciplines of art and sculpture the learner is directed to consider aspects of form, structure, colour, texture, ration and proportion. These elements of intuitive artistic design will introduce the typical engineering to a new vocabulary that has the potential to produce a design solution that will integrate an efficient FUNCTION with an elegant FORM.

3. Barriers to Creativity

The great advantage of using a simple pencil or physical sketch models to record initial ideas is the *removal of barriers to the creative design process*. A computer program demands a level of competency by the user before anything meaningful can be translated from the imagination into a shared environment where others can contribute to the design process and critique a proposal. The early ideation phase is most effectively communicated through simple sketches and three dimensional sketch models.

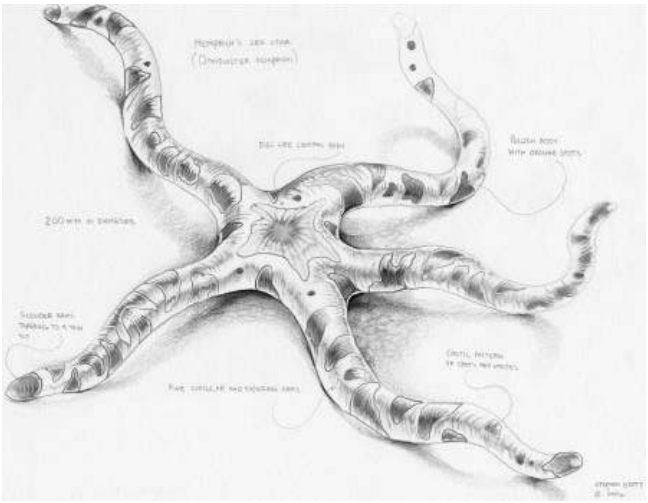

Figure 3: Observational drawing capturing colour, texture structure and form

This sketch of a starfish records aspects of colour and texture and gives an immediately understandable insight into the structure and three dimensional form of the subject. This type of communication is a direct and succinct translation of ideas from the imagination that is free of the interaction with a technical computer interface that may impede or limit the expression and free flow of ideas. The drawing is surrounded by annotations that begin to analyse the organic form and structure and are the foundations for “deconstructing” the subject in preparation for exploring opportunities to define a new engineering context.

This purely observational drawing can be criticized as being a piece of art work without any recommendation as the inspiration for an idea that will lead to a new and innovative engineering design solution. A critical stepping stone from this drawing is a series of more analytical sketches that begin to “deconstruct” the structure and explore possibilities for translation into an alternative function.

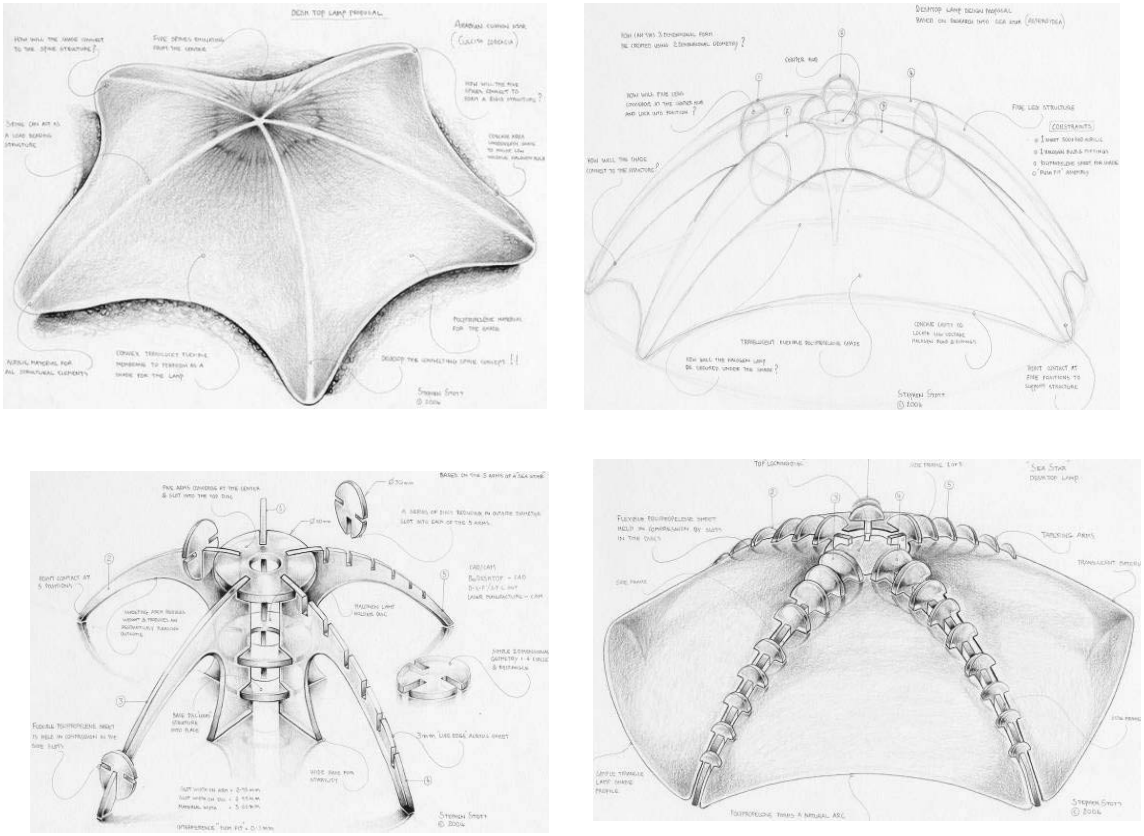

Figure 4: Ideation workflow – 2D Sketching – 3D Sketch Models

This sequence of images shows a workflow of ideas that attempt to analyse the organic form of the starfish and deconstruct it into structural elements. The translation of these “found elements” into an alternate function is in part open to individual interpretation but is often influenced by the characteristics of the shape and form of the subject matter.

It can be seen that the dominant characteristic of one of the species of starfish is a dome like structure that is supported and linked by five individual tapering limbs. These observations serve to inform the designer of the potential to translate these elements into an alternate function that reflects a sympathetic level of functionality.

4. Computer Aided Design as a creative design tool.

Autodesk Inventor offers the designer an opportunity to use a CAD tool and 3D Digital Environment with the same degree of creative freedom as using traditional drawing and sculpting materials. Figure 5 shows how the organic form of the starfish has been easily replicated as 3D Digital Solid Model and evolved into 3D Digital Prototype.

The advantage of this digital prototype is that testing and evaluation can be performed within Autodesk Inventor removing the need for many expensive physical prototypes and thus minimising the time and cost taken to move a product design to manufacture.

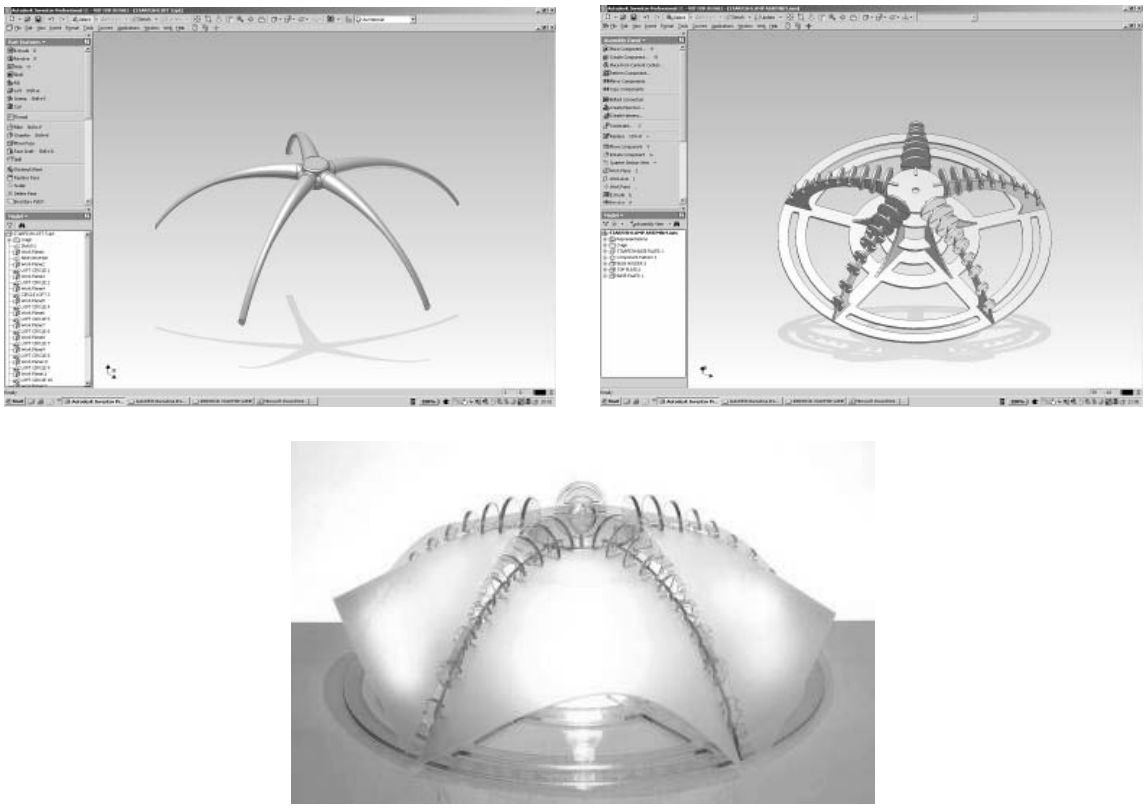

Figure 5: Sculptural Form Finding - 3D Digital Prototype – Physical Prototype

5. Conclusion

The creative design process is best supported in its early phases with tools that offer an unencumbered means of expressing ideas in a free flowing way. Simple drawing with a pencil and paper and three dimensional sculptural modelling offers the designer the freedom to express ideas without the limitations of a computer interface and the skill sets needed to drive a computer program.

Inspiration for engineering and industrial design solutions can be found in a spectacular array of organic, anthropomorphic and human made sources. These sources can be translated into an alternative function by a cycle of “deconstruction” to evolve new and innovative solution to a design problem.

As the design cycle progresses into a digital environment the designer requires a CAD tool that offers the same degree of flexibility and ease of manipulation as the traditional means of expressing ideas. Autodesk offers the designer and engineer an intuitive range of 3D Digital Solutions that support the creative design process.

Autodesk AliasStudio is a computer program that duplicates the freedom and flexibility a designer experiences using a traditional pencil by producing the same intuitive feedback from a digital pen and tablet.

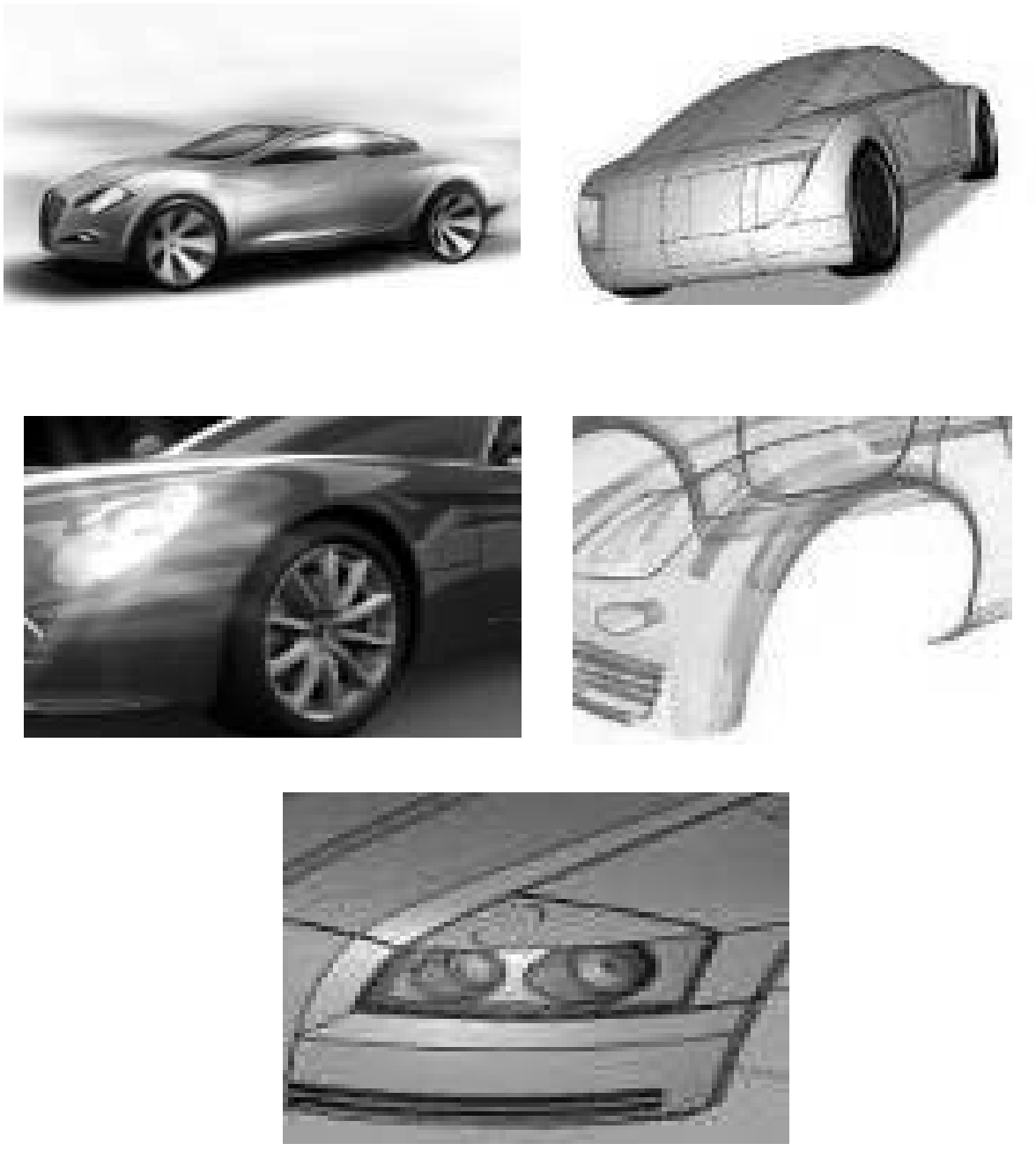

Figure 6: Complete design workflow from concept sketch to technical surfacing

Figure 7: Workflow from ideation to 3D Digital Prototype to Manufactured Design

Acknowledgement

The computer images generated in this paper were created in the Autodesk Inventor 2008 software. The pencil drawings and illustrations are all original work by the author.

The pedagogical principles described in this paper were developed in close collaboration and partnership with Mr Bill Nicholl, Head of Initial Teacher Education for Design and Technology at the University Of Cambridge, Faculty of Education.

Research Activity:
The Meaning of Design in Design & Technology
Subject Leadership in Creativity in Design and Technology, Jan 2005 - Dec 2007
Principle Investigator, Bill Nicholl.
Three year GATSBY funded research and development project (£329k) focusing on aspects of creativity and innovation in Design & Technology at KS3 (11-14 years

The teaching strategies described in his paper were conducted by the author in the capacity of an Advisory Teacher for Design and Technology in the employ and close collaboration and partnership with:
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The Community Advisory and Inspection Service
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