INTRODUCING MECHANISM DESIGN TO PRODUCT DESIGN STUDENTS

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ABSTRACT
This paper presents a framework for incorporating the design of mechanisms into a product design program. At the Dublin Institute of Technology, School of Mechanical Engineering and Design, the theme "Mechanism Design" is taught in the Design and Manufacturing Methods module in year 3 of the program. The paper describes a model of how students can be introduced to this area. Consequently they learn to appreciate the difficulties involved initially in designing mechanisms and finally how to incorporate their designs into what can be an already complicated product. Examples of students work are shown to demonstrate the learning experience gained by the students. The discussion section of the paper reflects on the need for mechanism design curricula in general and on the challenges and improvements for the product design program at DIT in particular.

Keywords: Mechanisms, design, domestic appliances

1 INTRODUCTION

Mechanism design is an important tool in a product designer's arsenal. In an age of continually reduced lead times and compressed times to market reinventing the wheel is no longer a viable option.
In everyday consumer products, mechanisms are found performing important functions that while being an intrinsic part of a particular device could be incorporated into many other devices, therefore reducing the time a product designer spends developing their own design proposal. Another important issue with mechanisms is their relationship to the surrounding device. The means of restraining the unit while allowing it to interact with the overall product can be as important as the mechanism itself. Therefore it is imperative that the product designer both understands and appreciates not only the operation of the mechanism but how it becomes an integral part of the product.

2 THE DESIGN AND MANUFACTURING METHODS MODULE

This module is offered in semester 1, year 3 of the Product Design program at the Dublin Institute of Technology. It is a 13 week module and students gain 5 ECTS credits on successful completion. It is divided into an initial 6 and final 7 week period. In each of the first 6 weeks students are introduced to mechanisms that offer a variety of solutions to problems associated with everyday products and devices. During these weeks students propose their own solutions to supplied design problems and then investigate existing commercial solutions to the same problem. This work is carried out on an individual basis.
At the beginning of week 7, students are divided into teams and are given a design brief for a product they must complete over the last 7 weeks of the semester. The majority of this project is expected to be completed outside class contact hours.
During class contact in this 7 week period students dismantle various products that may or may not be pertinent to the on-going project. This work is carried out on a team basis.
In order to verify the students design proposals, students are given the opportunity to build virtual solid models and assemblies of their proposals during the first six weeks. This is carried out as part of another module. This module covers the areas of plastic and sheet metal design and is called Design for Tooling and Manufacture.

3 INTRODUCING MECHANISM DESIGN

The first section of the module incorporates the initial six weeks of the semester.

The students are supplied with a new design brief each week. They have a three hour class to start the design problem and a further week of self-directed learning to finalise their work for submission in class the following week.
They are described a problem in general terms. The emphasis is for the students to individually propose a solution to this problem. This is done by developing their own design concepts usually on a number of A4 sheets showing their initial design iterations. Their finalised design is sketched and rendered on the left hand side of an A2 sheet. The centre section of the sheet includes sketches and renderings of an existing commercial design already on the market and finally a descriptive section on their and the commercial design on the right hand side. To improve the layout and formalise students work a standardised template is applied.

3.1 Weekly design brief examples

The examples shown below demonstrate a variety of components that incorporate various mechanisms for which the students are expected to develop their own solutions. A commercial unit that incorporates the design is later supplied to the students for examination by means of disassembly, discovery, sketching, detailing and reassembly. Although disassembly and discovery is important, reassembly is equally so from the point of view of understanding how each component fits and is held in place within the assembly. Figures 1, 2 and 3 are some examples of the six proposals produced by students over the course of the first six weeks

Week 1 brief

The aim of this assignment is to design a device that will perform the following functions:

- Operate on the principle of reciprocating motion.
- The unit must be comfortably held in one hand
- Reciprocate at a frequency between 2000 to 3000 cycles per minute.
- Must be relatively maintenance free (simple design)

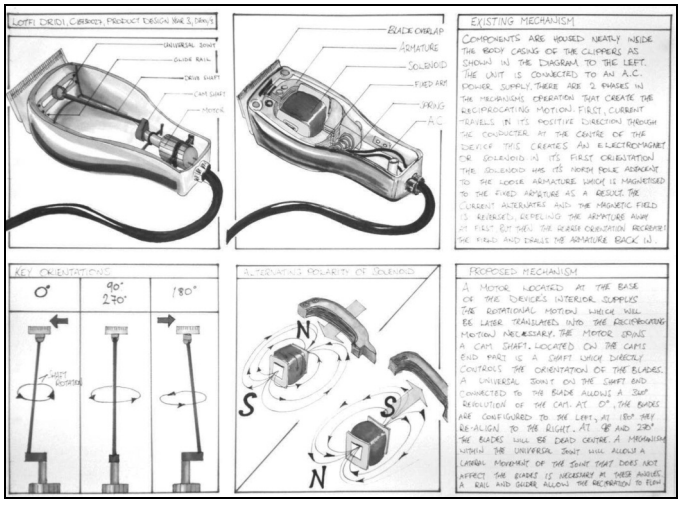

Figure 1. Reciprocating motion device

Week 3 brief

The aim of this assignment is to design a device that will perform the following functions:

- Dispense a definite quantity of liquid (e.g.) 75 cc
- Seal off the supply while dispensing the liquid
- Vent the supply vessel during operation
- Incorporate a universal fitting to cater for various supply vessel sizes
- Can be securely mounted
- Operated in the vertical position

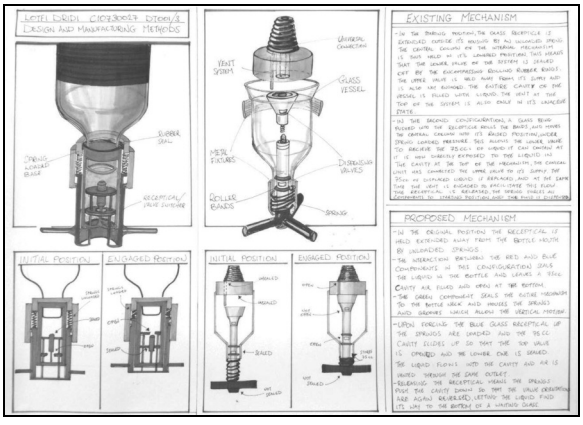

Figure 2. Volume dispensing unit

Week 5 brief
The aim of this assignment is to design a device that will propel itself in a linear direction and operate under the following conditions:

- Load mechanism by being dragged in reverse
- On release, the object will move in a forward direction
- Capable of being operated by a 3 year old child
- Method of operation, single handed

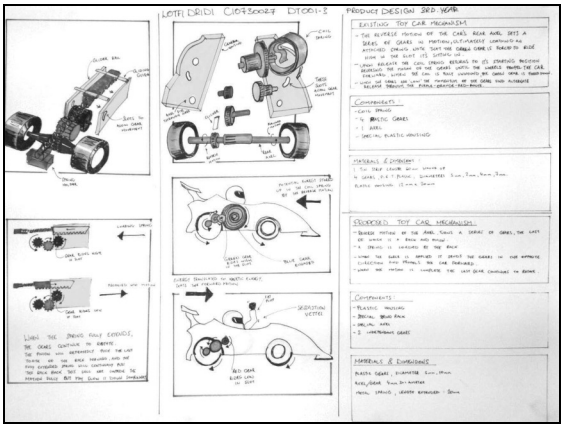

Figure 3.Self propelled device

3.2 Learning Hypothesis

The pedagogical reasoning for adopting the approach outlined in previous sections is to demonstrate that a range of possible designs are already available. Some key elements are summarised below:

- Identifying various assembly methods such as tamper proof screws, clips or living hinges.
- Students, as they disassemble the various devices ask questions such as:
  - How parts operate both on a singular and as part of an assembly
  - What makes a part move in alternative directions
  - What holds the part in a particular location while in operation or in a stationary position
  - "What if", the question that stimulates alternative ideas within the human mind.

4 INTERACTION WITH DESIGN FOR TOOLING/MANUFACTURE MODULE

This module introduces students to the design of plastic parts for moulding and sheet metal parts for press tooling. All parts and tooling are built as virtual models using a solid modelling package. As part of the module students are grouped into teams and are required to build models of a number of the mechanisms they proposed in the Design and Manufacturing Methods module. This is of great benefit to the students as it helps them to prove or disprove the feasibility of their proposal. It also allows students to understand how their design integrates into the overall product. These models force the students to confront the difficulties encountered when moving a concept from a sketched design to a manufacturable product thus closing the design circle. Shown in Figure 4 are views of the model developed from the volume dispensing unit supplied in week 3 and the reciprocating unit supplied in week 1.

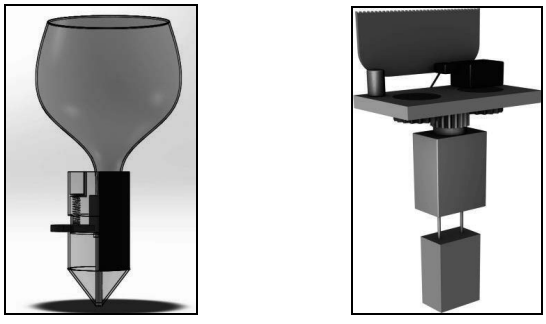

Figure 4. Volume dispensing unit

5 TEAM PROJECT

This design problem is introduced to the students in week seven of the module. They are divided into teams of three and are expected to manage all aspects of the project. During this period the students continue investigations of various products as described in section six.

Typical Team Project Brief

At present soldered copper fittings are used to seal and connect copper piping so that it can take various required pathways. When heated by means of a gas torch and allowed to cool the solder creates a water tight joint. The difficulty with using a gas torch is that it requires the installers continued attention, requires a skilled operator, can be dangerous and is difficult to operate in certain conditions.

The aim of this assignment is to design an electro mechanical device that will carry out the operation of the torch without the use of a naked flame. It is expected that the unit will be comfortable to use, safe in operation and can be used unsupervised. The overall operation of the device may require functions and designs encompassing some of the fundamental workings of products that will be examined in forthcoming lectures.

Methodology

The students are expected to use the knowledge and skills they developed across the whole of the module in order to produce the final design of the product. This approach and methodology helps to add cohesiveness to the module content and its learning outcomes. Some examples of the team project proposals are shown in Figures 5 and 6 which include a prototype and an A2 sheet depicting the design and a descriptive section explaining the designs operation.

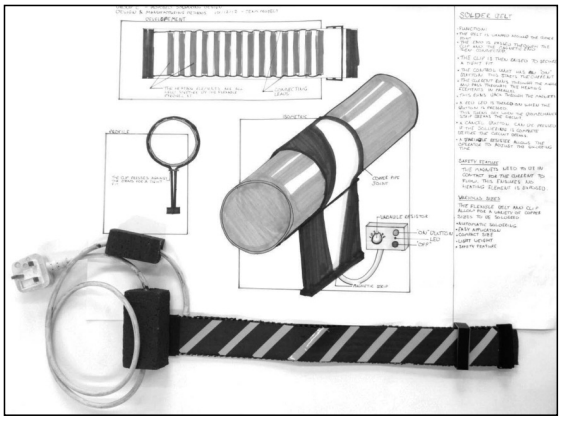

Figure 5. Rendered sketches and prototype model Team B

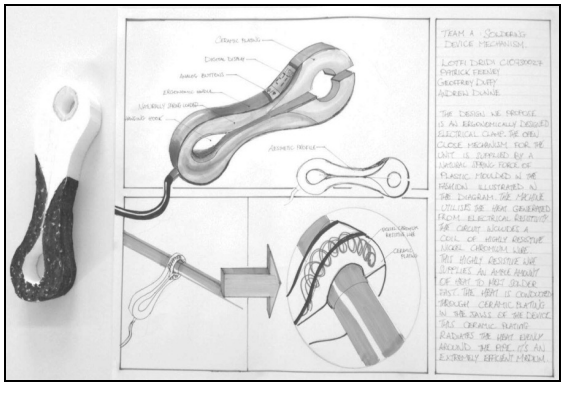

Figure 6. Rendered sketches and prototype model Team A

6 INTRODUCING PRODUCTS INCORPORATING MECHANISMS

During the final 7 weeks of the module the students are also expected to carry out investigations on mainly, small domestic appliances. During these activities the student's main focus is on:

- Application of the product.
- Materials used, and their properties.
- Safety features.
- Manufacturing methods.
- Design for assembly.
- Design for disassembly for repair, or prevention of disassembly for safety.
- Aesthetics.
- Ergonomics.

Upon completion of their research the students present their findings in report format, supported by, customer reviews of the particular product indicating suitability/unsuitability, customer satisfaction/dissatisfaction, and photographs of various mechanisms within the unit**.** Figure 7 shows some typical component photographs of a vacuum cleaner "Goblin Aztec 1500W" disassembled.

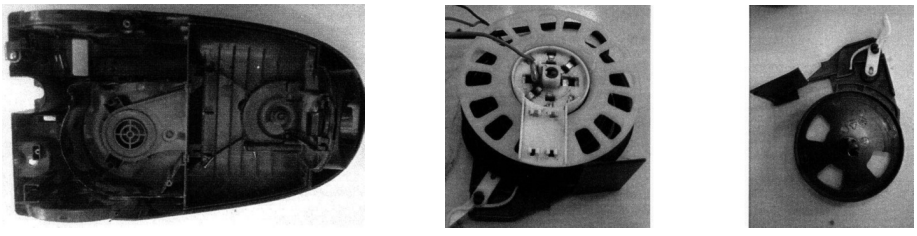

Figure 7. Recoil vacuum mechanism

6.1 Examples of small domestic appliances

Based on the product features under investigation the following units are an example of the chosen products, as they incorporate the listed features in section 6.

- Toasters
- Hairdryers
- Hair trimmers
- Vacuum cleaners
- Steam irons
- Curling tongs

7 CONCLUSIONS

The proposed designs developed by the students over the first six weeks of the module progressively improved as the module advanced. Compared to early proposals in which they designed simple solutions with no cognizance taken of the installation or retention of their device later designs showed they were endeavouring to accommodate their mechanism into the overall assembly of the product. There is still much work to be done in order to develop an approach that helps students to understand that a lot of the mechanism designs they will require in the future already exist. It is hoped that this approach will help them to see the application and potential of these designs in relation to design problems they encounter in their careers. The authors are of the opinion that by modifying the module accordingly and making changes to some of the timescales this can be achieved at some point in the modules future.