AC 2008-1625: A NON-TRADITIONAL AND MULTI-DISCIPLINARY APPROACH TO TEACHING MECHANISMS AND MORE

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A Non-Traditional and Multi-Disciplinary Approach to Teaching Mechanisms and More

Introduction

This paper presents a non-traditional approach of teaching mechanisms to a multi-disciplinary group of college students that included engineering, industrial technology, and art majors. The author used automata, mechanized sculptures, to teach mechanisms in his honors course (HONR 218: Animatronics[1]) at his previous teaching assignment. The course was designed to attract students from various backgrounds. It was intended to give students a cross-disciplinary learning experience while dealing with integration of art, engineering theory, and fabrication elements.

The approach utilized various means of teaching mechanisms, consequently addressing various types of learners. These means, presented in the following sequence, were:

1. Study of theory of machines including kinematics and dynamics[2]
2. Observation of working mechanisms and computer animations
3. Reverse engineering of mechanisms found in animated toys
4. Assembly and successful operation of commercially available automata kits
5. An open-ended design project where a group of students had to design and build automata.

During the course, students learned the theory governing mechanisms and their uses in the real-world. The students followed a practical path to learn about joint, element, and mechanism types as well as functions of joints and elements, and mechanism as a whole. Following the sequence mentioned above did allow each student to build a knowledge base leading to the open-ended design project assignment. Groups of two or three students designed and presented various mechanisms that included eccentric and lobed cams, ordinary cranks, crank sliders, and some bar mechanisms. During the projects, groups were also exposed to concepts such as materials and process selection, tolerances, clearances and assembly, fasteners, adhesives and joining. NC (Numerically Controlled) laser cutter hardware allowed students to cut and engrave various types of materials with minimal design effort in AutoCAD or Corel Draw.

Student response and feedback to the course and especially to the mechanism development section was extremely positive. 90% of the students were satisfied with the experience and they were in favor of further development of the course. The cross-disciplinary make-up of the class enhanced the learning experience as the art and technical majors generated a nice blend of students that worked well. All the students were hungry for practical or experiential learning, and stayed heavily engaged throughout the course. There were some drawbacks such as not having a separate laboratory session. However, students were able to work additional hours to complete their work and assignments.

Study of Theory of Machines

The students were given background on the theory of machines and especially mechanisms[1]. The relationships between the geometry and motions of mechanisms, and the forces that produce those motions were presented[2]. Background information was comprised of two main components:

- Mechanisms and Kinematics of mechanisms: Basic terminologies, classification of mechanisms and concepts such as kinematic inversion, Grashof's Law, and mechanical advantage were covered. Examples of position, velocity, and acceleration analyses were also shown.
- Kinetics, the time-varying forces in the machines and the resulting dynamic phenomena: A wide variety of subjects including static and dynamic force and vibration analyses were included here as well as balancing and cam dynamics.

Some of the subjects mentioned above were covered with simple examples due to presence of non-engineering or non-technical students within the class. However, basic but simple concepts like kinematic pair types, classification of mechanisms, machine elements, or graphical based analyses are covered in greater detail. The focus was given to a variety of elements including:

- Levers
- Shafts/Axles
- Cranks
- Cams
- Linkages
- Springs
- Ratchets
- Drives
- Gearing

Observations of Working Mechanisms

As the students progressed through the subjects and elements that constituted the background portion of the course, they were exposed to various physical and virtual examples. Two- and four-stroke engine models (Figure 1), various animated and walking toys, other mechanisms utilized in daily human life as in a stapler or automobile window crank were studied. The students operated each tool or toy and were asked to associate them with the theoretical content they were learning. Computer animations were also utilized as visual aids. Example computer animation of a Geneva mechanism is shown in Figure 2.

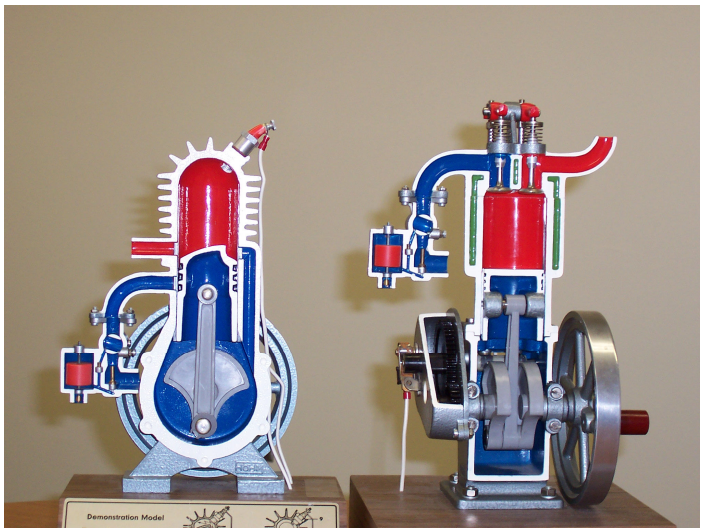

Figure 1: Two and four-Stroke engine models with working mechanisms

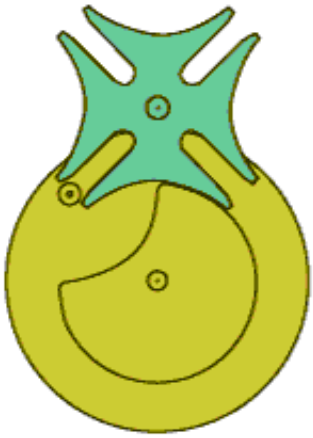

Figure 2: Computer animation of a Geneva mechanism

Reverse Engineering a Toy

Reverse engineering methodology and exercises were used to reinforce background section of the course. In the previous step, students were able touch and feel the mechanisms, see them working, and watch the visual aids. The very next step was about them getting into the mechanisms for a learning experience that was based on close contact and practical. Animated toys were selected as the target products since the course was based on Animatronics. An example activity is given below in Figure 3. After experimenting with and dissecting the toys, students were asked to generate reports that included:

- Function(s) of the toy or the mechanism including motions generated
- Structure of the toy and its subassemblies (mechanisms present within)

- Materials utilized in the parts
- Supporting evidence including sketches and photographs

Figure 3: Reverse engineering toys

Automata

After successfully completing the reverse engineering laboratory, students were required to assemble commercially available automata sets[3,4]. Automata are the mechanized sculptures that have been around since ancient Greece and Egypt. They existed in the forms of water driven sculptures in ancient gardens or in clocks or clock towers as animated clock figurines. Automata can be referred to as the predecessors of modern day robots. Examples of assembled automata sets are presented in Figures 4 and 5. While Figure 4 is showing various mechanism examples, Figure 5 is about an automaton portraying a mad computer user. The interesting factor here that drove student interest was that most of the automata had humor built in them. Students had to demonstrate their working automata in order to move on the next step with a good grade.

Figure 4: Assembled automata representing various mechanism types[3]

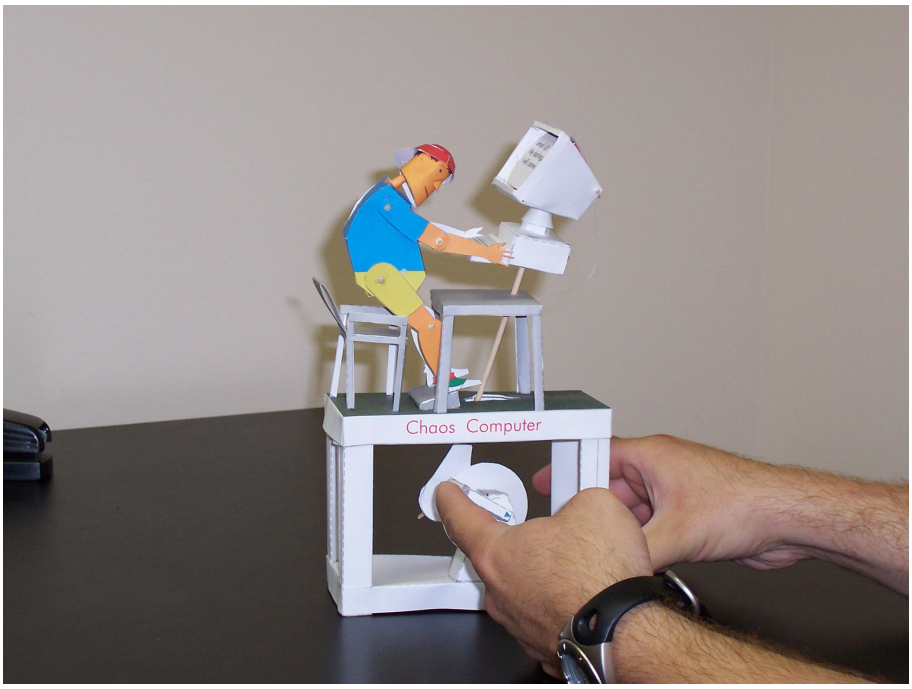

Figure 5: A mad computer user – driven by a slider-crank[3]

Groups of two students designed and presented their own automata products after going through a rigorous design process. Their designs included various mechanisms such as eccentric and lobed cams, ordinary cranks, crank sliders, and some bar mechanisms. During the projects, groups were also experienced the

concepts such as materials and process selection, tolerances, clearances and assembly, fasteners, adhesives and joining at first hand. NC (Numerically Controlled) laser cutter hardware allowed students to cut and engrave various types of materials with minimal design effort in AutoCAD or Corel Draw software tools. Two examples are presented at this section. The very first one is the Jolly Roger. Figure 6 is the product of the concept development as Figure 7 portrays the end-product near completion. A slithering snake is also added to this paper at Figure 8.

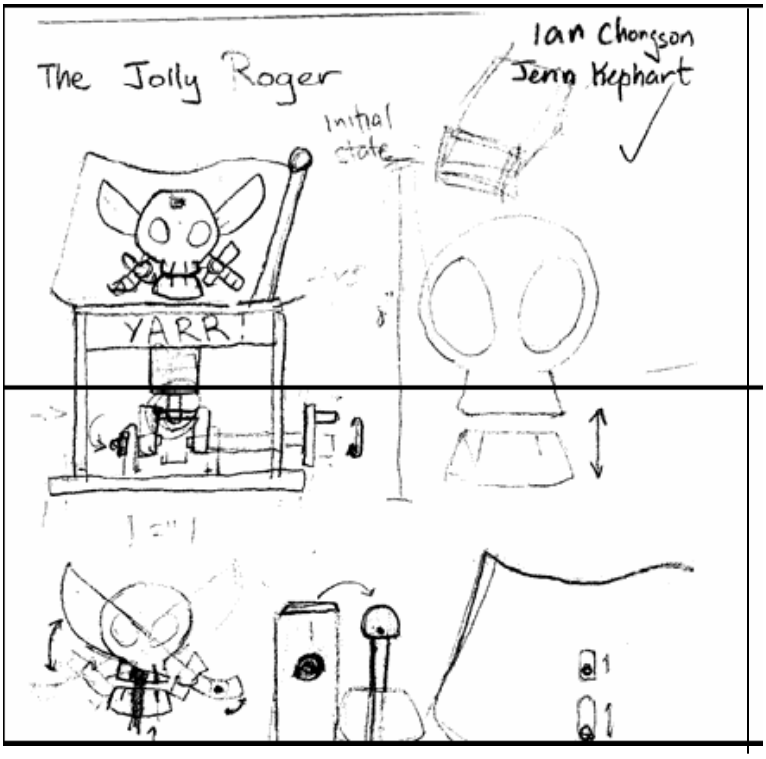

Figure 6: The concept drawing of the Jolly Roger

Figure 7: The Jolly Roger (near completion)

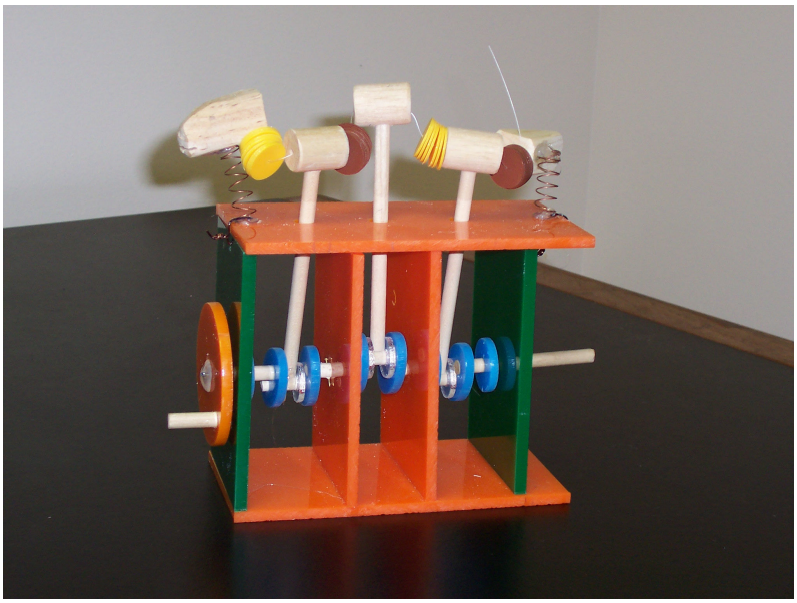

Figure 8: Inner-workings of the Slithering Snake

Conclusions and Future Work

Student response and feedback to the course and especially to the mechanism development (automaton design) section was extremely positive. 90% of the students were satisfied with the overall experience and they were in favor of further development of the course. Art and technical majors generated a nice blend of students that worked well in learning animatronics. Both groups were hungry for practical or experiential learning, and stayed heavily engaged throughout the course. Since the course met only four hours a week and the meetings happened only in one-hour blocks, students had to meet after hours and spent some additional time in accomplishing the project work. That was the main drawback of the course, yet it did not generate any major complaints. Some minor issues experienced by some of the non-technical students handled accordingly can be listed as working with clearances and tolerances and associated assembly issues, and adhesive problems.

The author is currently utilizing a similar method in his (ENGR 2160) Engineering Graphics course. Some students are using cardboard automata models cut out from the templates supplied by him while others are using balsa wood models they generated from the templates given. The near future assignment is to design humorous automata models inside Solidworks software. These models will be assemblies that will include 2-3 different mechanisms. Each mechanism will be made of multiple components. At the end, a few of the selected designs will be realized using Rapid Prototyping technologies. With this assignment, the author is planning to present students with a solid modeling and assembly challenge that is meaningful and fun.

References

[1] Syllabus for HONR 218: Animatronics, Ohio Northern University, 2003.

[2] Uicker J.J.et al, Theory of Machines and Mechanisms (3rd Edition), Oxford University Press, NY, NY, 2003.

[3] http://www.cabaret.co.uk/

[4] http://www.flying-pig.co.uk/