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Approach to furniture design education at Purdue University

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Abstract: This article contains a brief description of furniture design educational approach at Purdue University, Wood Research Laboratory. Aesthetic design, strength design, and design for manufacturing are presented and emphasized to student as equal components of a good design. Students are trained to understand these components and use them in synergy. Product engineering, strength design, and performance testing of furniture are essential parts of the furniture design curriculum. Performance testing is a common tool used to improve the durability and safety of furniture products and to predict failure or unexpected problems associated with the proposed construction. Students are trained that product testing and evaluation are needed to obtain safe and reliable furniture products and should provide pertinent information to designers, manufacturers and customers. Encouraged hands-on experience and rapid prototyping by CNC equipment are essential components of furniture design education, and the overall teaching method leads to meritorious student designs.

Keywords: furniture design, education, strength design, performance testing, product engineering.

INTRODUCTION

The Wood Research Laboratory (WRL), in the Department of Forestry and Natural Resources (FNR), is responsible for teaching, research and extension in the area of wood products. WRL's mission is to: assist wood products manufacturers, develop new knowledge for wood products industry, add value to wood raw materials, develop new uses for wood residues and by-products, encourage innovation in wood and wood-based products, improve wood products engineering and processing technologies, also train experts for wood products field. Among others, WRL has pioneering contributions to wood science in product engineering, quality improvement, strength design of furniture and its performance. FNR department is offering undergraduate and graduate programs in Wood Products Manufacturing Technology and Wood Science, and a minor in Furniture Design.

WRL is supporting this program with courses:
Wood Products and Processing – course provides insight into the many products and processes which are used to help convert round timber into industrial products and provides student with an adequate background in order to be employable by the hardwood industry.
Wood Structure, Identification, and Properties – students study cellular structure of native woody species, learning the identifying characteristics of commercially important wood species (color, odor, cellular arrangement, grain pattern, character marks, etc.) through laboratory exercises and field trips and study the manufacturing characteristics and uses of various species.
Properties of Wood Related to Manufacturing – course familiarizes the student with the basic physical, mechanical and working properties of wood and wood composites.
Secondary Wood Products Manufacturing – course familiarizes the student with basics of secondary hardwood products manufacturing (organization, raw materials, machinery, plant layout, production methods, machining, finishing, and industrial engineering techniques).
Furniture and Cabinet Design and Manufacturing – course familiarizes the student with qualitative and quantitative principles of furniture construction, performance testing of

furniture, and computer-based application and solutions. Course also features laboratory evaluation of fasteners, furniture joints and furniture.
Furniture Design for CNC Manufacturing - course familiarizes the student with computer Aided Design (CAD), Computer Aided Manufacturing (CAM), CNC router operation, rapid prototyping and basics of secondary wood products manufacturing.

APPROACH TO FURNITURE DESIGN

Aesthetic design, strength design and design for manufacturing are presented and emphasized to the student as equal components of a good design and students are trained to understand them and use them in synergy **(**Fig.1**)**.

Figure 1. Approach to furniture design

Furniture is often considered as a work of art while the engineering aspects of furniture, such as structural integrity, is often considered to be of secondary importance. The most important aspect of product engineering of furniture is structural design. However, aesthetic needs are often favored over the structural requirements of the products. Even though, in general, fashion sells furniture, a methodical design approach should be applied that generates structurally sound, safe, and durable furniture. Design for manufacturing is also an important aspect, especially for production of economically feasible furniture.

PRODUCT ENGINEETING

Product engineering is presented to student as an application of a systematic, disciplined, quantifiable approach to design of furniture structures. Attributes the designer should emphasized in the process of product creation include: strive to create furniture pieces which are fashionable, esthetically pleasing, economically feasible, functional, ergonomically correct, easy to produce with short lead time, and should apply feasible materials and joinery in order to create structurally sound product providing safe and reliable service.

Product designer should know: properties of materials used for product, loads applied in service, rational design of joints in order to carry the service loads, how to determine the most suitable fasteners, joints connecting systems and their allowable stresses.

A Seven-step Product Engineering Design Process **(**Fig. 2**)** by Carl A. Eckelman (2003) is applied to the product development process. Steps are: determine service loads; evaluate the material properties and determine the member and joint parameters; analyze the structure by finite element analysis tools; repeat steps 2&3 if any members or joints are under – or over – stressed; construct 1/1 prototypes; conduct performance tests to simulate service action; redesign if necessary; perform joint strength tests on joint extracted from prototypes.

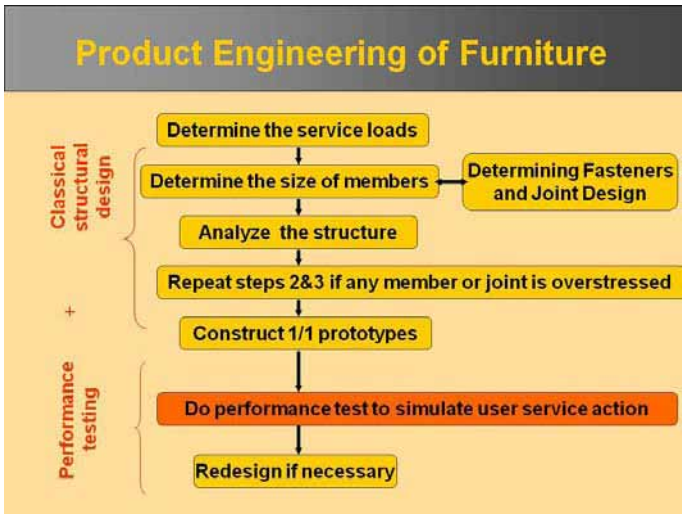

Figure 2. Seven-step product engineering design process

Strength testing of newly developed products (Fig. 3). This method has history and is based on accumulative damage theory (Fig. 4); it best simulates user service actions, has consistently accurate range, and sensitivity and number of cycles can be controlled. This type of testing is not for sale purpose, but it is testing for product engineering and research.

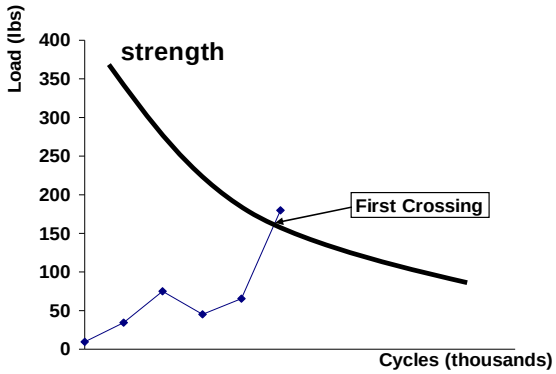

Figure 3. "First-crossing" concept of failure

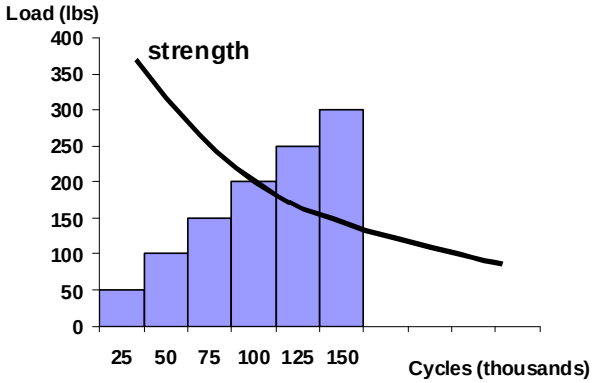

Figure 4. Cyclic stepped increasing load method

WRL performance testing laboratory with its modular equipment allows students to observe, learn and develop structurally sound prototypes (Fig. 5).

Figure 5. WRL performance testing laboratory

Student hands-on experience is encouraged though the laboratory exercises, club work and work on individual furniture projects (Fig. 6).

Figure 6. Students are involved on variety of projects

Students are encouraged to submit their work for student exhibits and contests. The program has been recognized by numerous meritorious students design projects. Examples are presented in Fig. 7a-d.

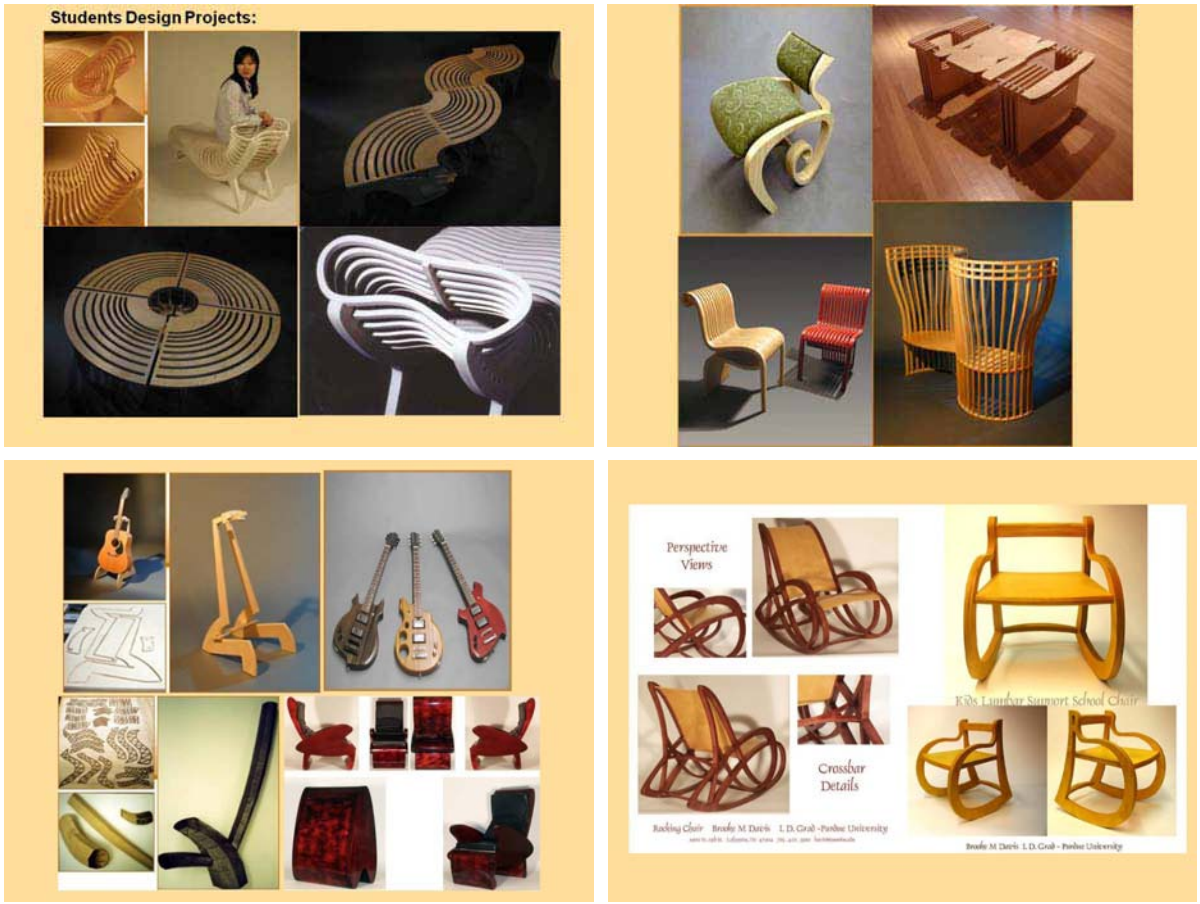

Figure 7a - d. Meritorious students designs

SYNERGY BETWEEN TEACHING AND RESEARCH

Students are also involved in ongoing research projects conducted in WRL. Best example is the product development and investigation of manufacturing capabilities for Emerging Furniture Design Challenges: Plus-size Furniture, Adjustable Furniture, Customized Furniture, Sustainable Concepts and LCA Analysis (Fig. 8a-d).

Figure 8a-d. Research projects

School furniture for the underprivileged children is a special project where involvement of graduate student was demonstrated in areas of product development and manufacturing system analysis. Undergraduate students were involved in a pilot project where they helped with building of school furniture manufacturing facility and conducted the production feasibility study (Fig. 9a-d).

Figure 9a-d. School Furniture for developing countries project

CONCLUSIONS

In conclusion, an integration of aesthetic design, strength design, and design for manufacturing as an educational approach for furniture design education at Purdue is a challenging yet successful approach for training design students. Product engineering, strength design, and performance testing of furniture are essential parts of the furniture design curriculum. Performance testing is a useful learning tool which provides the last feedback in the furniture engineering process before furniture goes into service, and therefore, provides the last opportunity for increasing the quality and reliability of furniture. Students are trained that product testing and evaluation are needed to obtain safe and reliable furniture products and should provide pertinent information to designers, manufacturers and customers. Hands on experience approach is attracting young designers, rapid prototyping by CNC equipment is essential, and is leading to meritorious student designs.

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Strzeszczenie: *Podejście do edukacji w zakresie projektowania na Purdue University.* Artykuł stanowi krótki opis stosowanego przez Wood Research Laboratory, Purdue University podejścia odnośnie edukacji w zakresie projektowania mebli. Równocennymi komponenty dobrego projektu, na które pokłada się nacisk w nauczaniu studentów są estetyka, wytrzymałość i technologiczność konstrukcji. Ważnym czynnikiem jest również szybkie prototypowanie projektowanych konstrukcji przy użyciu obrabiarek CNC.

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