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A Web-based Course for Practicing Engineers on Axiomatic Design Principles

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Outline

- Introduction
- Original course design for campus students
- Televised instruction
- Web-based instruction
- Concluding remarks

Introduction

- A bold hypothesis (Suh, Bell and Gossard, 1978)

" There exists a small set of global principles, or axioms, which can be applied to decisions made throughout the synthesis of a manufacturing system. These axioms constitute guidelines or decision rules which lead to 'correct' decisions, i.e., those which maximize the productivity of the total manufacturing system, in all cases"

Hypothetical Axioms

- Minimize the number of FR's and constraints
- Satisfy the primary FRs first
- Minimize information content
- Decouple aspects of a solution if FRs become coupled…..
- Integrate FRs in a single part if can be satisfied independently

(Suh, Bell and Gossard, 1978)

Design Axioms

Rinderle and Suh, 1982:

- *Independence Axiom*: Maintain the independence of Functional Requirements
- *Information Axiom*: Minimize information Content

Course Goals

- learn to think in terms of functional requirements and the idea of functional independence.
- learn the importance of seeking to minimize the functional coupling in their design solutions.
- learn to qualitatively compare design solutions in terms of information content.

Original Course Design

- Challenge of teaching axiomatic ideas
  - Design problem formulation
  - The idea of functional independence
  - functional versus physical coupling
  - Tolerance on a functional requirement
  - Qualitative assessment of functional coupling
  - Design matrix as a tool for design evaluation

A Discussion-Based Approach

- Alternative to the traditional lecture

Working Hypothesis:

" The ideas will 'sink-in' better if they are generated via student discussions and are anchored in the student's own design related experience."

Basic course elements

- Lectures : used largely for discussion moderated by instructor
- Homework: A “linked” set of homework
- Case studies: Product/Process/Software
- Design Project: Self-selected by student
- Class presentation of project

Linked Homework

Designed to introduce by week 4 the axiomatic language and principles that the student will use in his/her project

Homework # 1

- Some examples of “good” and “bad” designs from everyday experience

‘good’ design examples

- Tooth brush
- Zipper
- Helical screw wine bottle opener
- Bread machine
- Pontiac Grand Prix Stereo
- Boeing 777 stow bins
- Bicycle

‘bad’ design examples

- Keyboard hiding tray under desk
- Push button remote trunk latch mechanism
- Mechanical pencil (frequent lead break)
- Head-light assembly for 1985 Ford Ranger
- 1991 Mercury Tracer Stereo
- Bath tub (too shallow)

Homework # 2

- Design problem definition
- Functional requirements
- Constraints
- Tolerances on FR’s

Homework# 3

- Develop several independent solutions that satisfy the FR's

Homework # 4

- Use design-matrix as a tool to evaluate functional coupling in the proposed designs
- Develop strategies to minimize coupling
- Select the best design concepts for further consideration

Homework Postscript

- Students choose a ‘bad’ design example from their own experience and set out to improve the design
- The linked homework progressively introduces axiomatic ideas and tools

Case study: Product Design

- Design of a transport rig for Boeing 777 stowage bins from manufacturing plant to inside the airplane. (Steve Kirchmeyer, 1994 course project)
- Design was implemented at Boeing

Case Study: Process Design

- Synthesis of a process to produce 3-D microcellular thermoplastic parts

  Kumar, PhD dissertation, MIT 1988

Case Study: Software Design

- The design and development of Microsoft *Front-Page.*

  Michael Angiulo, MS thesis, U of Washington, 1996.

  (Currently General Manager of Microsoft *Project.)*

Course Project

- Goal is to *reinforce* the axiomatic design ideas and principles
- Help the student get insights into his *own* design from axiomatic approach

Course Project

- Self-selected by student teams
- New design OR redesign
- Report required
- Class presentation required

Televised Instruction (1994-1999)

- The class lecture was to be televised *live*.
- New Challenge: how to preserve the unique discussion format of the lectures?
  - Email helped integrate the distant students
  - Working engineers a big asset
  - Lectures and discussions were taped

Web-Based Course (2001-Present)

- Asynchronous delivery around the country
- Pre-taped lectures on CD's and web
- New challenges:
  - How to preserve class discussion?
  - How to form project teams?
  - How to conduct class presentation?

Web-Based Course (cont'd)

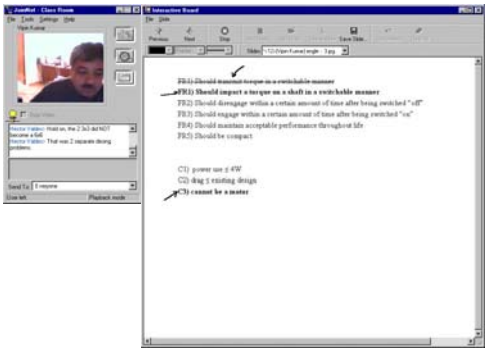
- Online and campus students separated in different communities
- Intimate discussion was restored for the campus class
- Online course can be offered independently at any time

Course Website

- Course management via a calendar
- Web-based discussion tools [E-Post]
  - Instructor-prompted and moderated web-discussion

Course Website (cont'd)

- Instructor-student interaction via conference calls
- Class presentation via web conferencing tools
  - Multi-point audio, video, text, whiteboard



Web-Course Pilot

- Students from Texas, Los Angeles, Oregon, and Puget-Sound area
- Student projects and evaluations show successful delivery

Future Development

- Incorporate state-of-the-art web conferencing tools
- Update interface for pre-taped lecture materials
- Create course variations for in-house education in industry

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