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.
  (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 \textit{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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