CULTIVATING EXPERT SOFTWARE DESIGN DECISION-MAKING
OVERVIEW

- Introduction
- Background
- Research Approach
- Results
- Conclusions
- Future Work
INTRODUCTION

- What is Design?
The fundamental problem is that designers are obliged to use current information to predict a future state that will not come about unless their predictions are correct. The final outcome of designing has to be assumed before the means of achieving it can be explored: the designers have to work backwards in time from an assumed effect upon the world to the beginning of a chain of events that will bring the effect about.

LEARNING TO DESIGN

- Problems students face are usually
  + Compact
  + Well-formed
  + Limited number of solutions

- Real-world problems are
  + Large and complex
  + Ill-formed and poorly defined
  + Many possible solutions
SOLUTION INSIGHT

- Architecture deals with complex systems
  - Complexity within a structure
  - Complexity in a building’s environment
  - Complexity in the structure’s use

- Software systems are complex systems
  - Heterogeneous elements must work together
  - Computing environments are dynamic
  - Software is used by people
PROBLEM & SOLUTION

- Industry needs great software designers
- Students need help to learn how to think like expert designers
- Current approaches do not generally meet this need
- Principles, Patterns, and Process Framework ($P^3F$) can meet this need
BACKGROUND

- Expert Design Strategies
- Overview of the $P^3F$
EXPERT DESIGN STRATEGIES

- Maintain a view of the whole system
- Opportunistic navigation of the design problem/solution space
- Confident and grounded decision-making
SYSTEM VIEW

- Maintain the “big picture”
  - Problem & solution co-evolve
  - Problem & solution exist in some context or environment

- Abstractions & metaphors
  - Label previously solved problems
  - Placeholders for partially defined elements
  - Simplified models promote deeper understanding
OPPORTUNISTIC NAVIGATION

- High tolerance for uncertainty & ambiguity
- Able to “chunk” aspects or perspectives for closer attention
- Problem setting
  - Framed within a defined boundary
  - Can be expanded or contracted as needed
  - Can be reoriented or redefined
CONFIDENT DECISION-MAKING

- Background and domain knowledge
  - Important for problem-framing & structuring
  - Less important for actual design decision-making
- “First principles”
  - Strong basis for decision-making
  - Proven theories, formulas, etc.
  - Fundamental design principles
THE PRINCIPLES, PATTERNS, & PROCESS FRAMEWORK

- Principles
- Patterns
- Process
- The Decision Pattern
Alexander’s 15 properties of living structures
- Properties are observable attributes or qualities
- Transformations are active processes that generate these attributes
- Metaphors for visual, structural, and dynamic characteristics

Principles:
- Determining characteristic of something
- Fundamental, primary, or general law or truth
- Originating or actuating agency or force
- Rules for creating structure
- Define relationships between structures
- Chunk information under a metaphorical name
- Design Principles Pattern Language
  + Expresses & documents 15 fundamental design principles
  + Provides contextual & relational information
  + Abstract structure is a navigational aid
Alexander’s *Fundamental Differentiating Process*

- Template for identifying and iterating over design decision sequences
- Allows structure and behavior to unfold as a coherent whole
- Helps ensure solution is smoothly integrated with environment

- Whole system view is refreshed at each iteration
- Current state of system is evaluated based on design principles
- Identifies part of system needing attention next
THE DECISION PATTERN

- Documents design decisions
- Abstracts & structures key decision elements
  - Problem
  - Forces & counter forces
  - Context
  - Solution
  - Rationale
- Represents transformation moving problem closer to solution
- Supports reflection and back-tracking
RESEARCH APPROACH

- Subjects
  - Advanced undergraduate students
  - Graduate students

- Study Protocol
  - Initial design problem
  - Introduction to $P^3F$
  - Second design problem
RESEARCH APPROACH

- Data Collection
  - Artifacts from design problem solutions
  - Journals of work performed to solve problems
  - Decision Pattern use required for second problem

- Journal Coding
  - Decision Type
  - Decision Perspective
  - Basis or justification
RESEARCH APPROACH

- Coding Analysis
  - Sequences of design decisions identified larger-scale behaviors
    - Linear decomposition
    - Opportunistic differentiation
    - Fixation on a particular solution
    - Reliance on personal experience
  - Meta-coding compares with existing models of novice & expert design behavior
RESULTS

Study Goals

- Would students use the $P^3F$?
- Identify behavior changes resulting from use of the $P^3F$

Study Sample

- 38 students (out of 46) completed both assignments
- 29 determined to be usable
  - Completeness
  - Lack of backfill
  - Correlation to artifacts
# Identified Novice Design Behaviors

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<th>Problem 2</th>
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<td>G:8, U:1</td>
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<td>Fit problem to solution</td>
<td>G:7, U:8</td>
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<td>Early concretization</td>
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<td>Weak relationships</td>
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<td>Use of buzzwords</td>
<td>G:5, U:9</td>
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<td>Identification Expert Design Behaviors</td>
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<td><strong>System View</strong></td>
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<td>Maintains system view</td>
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<td>Tolerance for ambiguity</td>
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<td>G:16, U:12</td>
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DISCUSSION OF RESULTS

- Decline in novice design behaviors when using $P^3F$
- Increase in expert design behaviors after $P^3F$ introduction
- Most important increases
  - Maintaining system view
  - Problem framing
  - Opportunistic navigation
STUDY LIMITATIONS

- Extrapolations to other learning environments may not be applicable
- Results may not reflect long-term learning
- Only one problem type solved
- Journal data potentially incomplete, inaccurate, biased, and is self-reported
- Quality of design artifacts not considered for this study
CONCLUSIONS

- Would students use the $P^3F$?
  - Results indicate subjects developed some understanding of the $P^3F$
  - Subjects were also able to apply the $P^3F$ to a design problem

- Would use of the $P^3F$ cause a change in design behavior?
  - Novice behaviors reduced
  - Expert behaviors increased