Empirical Software Engineering

CSE 8340 — Fall 2002

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Module Ia: ESE Overview

• ESE: Empirical Software Engineering

• About CSE 8340

• Relation to Software Measurement

• GQM and ESE
What Is ESE?

- **Empirical Software Engineering (ESE):** Applying empirical techniques/methods to solve software engineering problems.

- Objects of study:
  - Observation of SE activities.
  - Case studies in SE.
  - Controlled experiments.

- Analysis and conclusions:
  - Data from the above activities.
  - Statistical and other analyses.
  - Conclusions draw based on data/analyses.

- Typically goal driven (solve...).
Software Engineering Perspective

- Key components of S/W Eng.
  - Methods and processes
  - Formal foundations (math/theory)
  - Experimentation (scientific)

- Methods and process
  - Methods and methodologies
    - structured programming
    - OO
    - specialized methods
      - specification: formal vs informal
      - black-box/white-box/random testing
  - Process models
  - Mixing method and process
    - clean room example
  - 7313, 7314 and other MS/CS courses.
Software Engineering Perspective

- Formal foundations
  - Mathematics/logic/statistics
    - formal specifications
    - program verification
    - statistical models
  - Computer science
    - language and ADT ⇒ OO
    - systems/tools/CASE
  - Formal models on metrics: Area IV.

- Experimentation (scientific)
  - Trace/case studies
  - Controlled experiment
  - Measurement and analysis
  - Empirical validation
  - Observation-based vs. goal-oriented
  - This class 8340: Areas I, II, III.
ESE in Software Processes

• Mega-Process: Initiation, Development, Maintenance, Termination.


• Process Variations:
  ▶ Waterfall: sequence and dependencies;
  ▶ Iterative: incremental, divide & conquer;
  ▶ Spiral: risk management;
  ▶ Mixed/synthesized.

• ESE: Measurement and analysis throughout different components of the products and processes.

• Relation to CSE 7313, 7314, etc.
ESE in SE Activities

- Observational studies:
  - Passive observations of industrial practice, etc.
  - Try to draw preliminary conclusions based on observations and related data.
  - Multiple observations $\Rightarrow$ validation.

- Case studies:
  - Semi-active.
  - Pre-set study goals.
  - Conclusions need further validation.

- Controlled experiments:
  - Active design and experimentation.
  - Closest to scientific experiments.
  - Solid conclusions.
ESE in Software Measurement

- Example: testing evaluation
  - Test results and expenditure.
  - Test cases and measurement.
  - Internal measurements: size/complexity/etc.
  - Environmental data: process/people/setup
  - Evaluation results: reliability.

- Data/analysis from other phases:
  - Product: code, documents etc.
    - external: quality, cost, schedule etc.
  - Process: entities/relations/environment
  - People: experience etc.
  - Various assessment/prediction/improvement.

- Relation to CSE 8314.
ESE and Product Measurement

- Product specific (static):
  - Code, testcase, document
  - Structure vs. information flow
  - Control/data/presentation
  - Metrics and data collection
  - ESE: product quality/etc. questions?

- Execution specific (dynamic):
  - Path verification (white-box)
  - Usage to component mapping (black-box)
  - Measurement along the path
  - Usage of the measurement data
  - ESE: performance/reliability/etc.?
ESE and Other Measurement

- Process characteristics
  - Entities, relationships, and integration
  - Preparation, execution and followup

- People characteristics
  - Skills and experience
  - Roles: planners/developers/testers
  - Process management and teams

- Environmental characteristics
  - Hardware/software environment
  - Product/market environment

- ESE: based on above measurements.
How Does CSE 8340 Fit In?

• (Area I) ESE fundamentals:
  ▶ Generic activities and steps.
  ▶ Overall framework.

• (Areas II&III) ESE studies:
  ▶ Assessment/prediction focus:
    – hypothesis testing related studies.
  ▶ Improvement focus:
    – risk id./analysis related studies
  ▶ Other empirical studies.

• (Area IV) Metrics evaluation:
  ▶ Empirical ⇒ formal model.
  ▶ As extensions to hypothesis testing etc.
  ▶ Formal models for metrics evaluation.
**ESE Framework: GQM**

- **Background:**
  - Software Engineering Laboratory
  - TAME projects
  - Key personal: Basili et al.

- **Software Engineering Laboratory**
  - NASA/GSFC
  - University of Maryland
  - Computer Sciences Corp.
  - 1st SEI process award recipient
  - Software measurement and ESE:
    - among the first ESE studies
    - software measurement and analysis
    - goal-question-metric (GQM) paradigm
    - experience factory (EF)
ESE and GQM

- GQM: what is it?
  - Goal: goal of the (measurement) study.
  - Questions: questions related to goals.
  - Metrics: metrics answering questions.

- GQM background/foundations:
  - Goal oriented approach.
  - Measurement based.
  - Scientific experimentation.
  - Hierarchy or paradigm: diagram.

- Relation to ESE:
  - Can serve as general guidelines for ESE.
  - Related EF: similar to scientific labs in ESE.
ESE and EF

● EF: What is it?
  ▶ Experience Factory
  ▶ Separation of concerns
  ▶ In connection with GQM/TAME
  ▶ In ESE: Similar to scientific labs that conducts scientific experiments.

● Experience Factory
  ▶ Input from product organization
  ▶ Output to product development
  ▶ Internal organization
  ▶ Implementation in NASA/SEL
GQM/EF Recent Development

- Research activities:
  - New NSF-funded Center:
    - Univ. Maryland and USC (Boehm)
    - GMQM and other activities
  - Fraunhofer Institute and Centers
  - Others

- GQM extensions:
  - GMQM: success model
  - Specialized guidelines
    - Kitchenham et al.
    - Tian measurement/model, etc.
  - More emphasis on scientific experimentation

- EF beyond NASA/SEL.