[simula . research laboratory]

Research on
Software Cost Estimation

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Agenda

- Basic information about software cost estimation research

- Experiments

- Surveys (discussion)

- If time allows :
  - Research methods in the Prepare Group at Simula

Terminology

- Software development cost estimate is understood as a prediction of the effort most likely required to implement a software development project
  - Produced by estimation processes
  - Probability of not exceeding the actual cost
  - Based on implicit/explicit assumptions
  - Contains uncertainty
  - Purpose is realism

- Software development cost estimation error is understood as a measurement of the difference between estimated and actual cost usage of a software development project

Why Study Software Cost Estimation?

- Software effort estimation is an essential part of software projects
  - Project feasibility analyses, bidding, budgeting, project steering and planning

- The consequences of inaccurate estimates can be dramatic
  - People get fired, companies fail to win contracts or loose money, products are delayed, and software of low quality

- Software projects commonly overrun their effort estimates
  - Average overrun is reported to be about 30% of estimated effort [*]

- I often encountered estimation related problems when I worked as a consultant
  - It is, e.g., often hard to know what clients want when they ask for estimates

[*] " A Review of Surveys on Software Effort Estimation", Moløkken and Jørgensen, ISESE, 2003

How Large is the Potential for Improvement of Software Cost Estimates?

- It is unrealistic to expect perfect cost estimates
  - Inherent uncertainty in software development projects
  - Complex and dynamic interaction of factors

- Still, it is likely that estimates can be improved
  - Cost estimates are overoptimistic and inconsistent

- However, even small improvements will be very valuable

Two Main Categories of Software Effort Estimation Methods

Expert estimation is typically used as a label for estimation methods in which a significant part of the estimation process (particularly the final step, i.e., the "quantification step") is based on intuition

Formal estimation model is typically used as a label for estimation methods where a substantial part of the estimation (particularly the "quantification step") is based on the use of mechanical processes, e.g., the use of a formula derived from historical data using regression analysis

Why Study Expert Estimation?

In our research, the main focus is on expert estimation

- Expert estimation is by far the most used estimation method in the software industry (70-80%) [*]

- Available evidence does not suggest that expert estimation should be replaced by formal estimation models [*]

- Most (meaningful) formal estimation models partly rely on expert judgment of input

[*] "Estimation of Software Development Work Effort: Evidence on Expert Judgment and Formal Models", Accepted for Int. J. of Forecasting, 2007.Jørgensen, 2007

Experiment:
Estimation Irrelevant Information

- Other studies show that irrelevant information in the input to forecasting processes could be an important cause of inaccuracy in forecasting processes that relies on human judgment

- Requirement specifications and other information provided in software estimation situations typically include
  - a lot of estimation irrelevant information
  - some misleading information (on purpose or accidentally)
  - much information of low importance for the estimation work

- Several studies indicate that the quality of the requirement specifications impact estimation error, but at the time when we conducted these experiments, we were not aware of any study that investigate the impact of irrelevant information

EXPERIMENTS

Estimation Irrelevant Information

We conducted two experiments with software professionals as subjects (76/92 subjects) to investigate the impact of irrelevant information

– Group A received the original programming task specification

– Group B received the same specification, with neutral estimation irrelevant information about the end users desktop applications, web design, user passwords, future systems, etc. added

– Independent experts validated that they perceived our irrelevant information as irrelevant for estimation purposes

No estimation irrelevant information (Group A, experiment 2)

Simula organizes several seminars each year. At present, participants register for the seminars by sending an email to a given contact person.

Simula wants you to develop a simple web system (one web page) for registration of participants. The system will handle registration of all Simula's seminars. The participants will register on the web by submitting their email address and a registration code that uniquely identifies the seminar (this code is sent to them by email). The only functionality in the system is to store the email address and the registration code in a database. All queries will be done manually (in sql), and there is no need for any validation of submitted data. There are no security requirements.

The system will run on a webserver that has Tomcat, Java and MySql installed and running. Assume that you are familiar with the relevant technologies. You are free to use development tools of choice.

Estimation irrelevant information (Group B, experiment 2)

Simula organizes several seminars each year. At present, participants register for the seminars by sending an email to a given contact person.

Simula has ordered a web-based registration system. This system will let participants choose seminar from a list, and then register name, company and contact information. An email that confirms the registration will be sent to the participants. The system will keep track of the number of participants for each seminar and automatically close registration when the seminar is fully booked. There will also be a management module where employees at Simula can log in and query and manipulate conferences. This system will run on a Weblogic server application server, use a Sybase database and be fully integrated with Simula's other web pages. However, due to economical priorities, this system will not be developed before the end of 2006. Simula therefore needs an intermediate system for registration. This system will be thrown away when the new system is ready.

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The system will run on a webserver that has Tomcat, Java and MySql installed and running. Assume that you are familiar with the relevant technologies. You are free to use development tools of choice.

Estimation Irrelevant Information (Paper I)

Results experiment 1:

Group	N	Mean	Median	Min	Max	Stdv
No irrelevant information	37	19.7	15.0	4	70	15.9
Irrelevant information	38	39.3	27.5	4	250	47.2

Results experiment 2:

| Group	N	Mean	Median	Min	Max	Stdv
No irrelevant information	41	16.0	8	0.5	120	22.7
Irrelevant information	47	18.7	10	1.0	100	19.8

Note that in both experiments, irrelevant information increased the estimates. However, we have done other studies have shown that irrelevant information can lead to reduced estimates as well, e.g. by choosing words "loaded" towards small tasks.

Manipulate document size

- IFI-students estimated work-effort for the same programming task
  - Group A: Received the original specification, one page long
  - Group B: Received a version that had identical text, but was seven pages long. The line spacing was increased, the margins were wirder, the font was larger and there were more space between the sections

Results
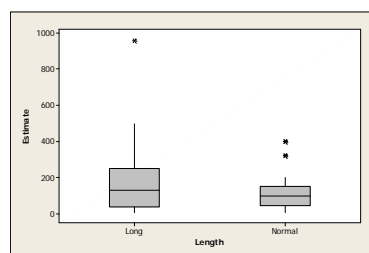
	Long	Normal	Difference
Mean	170	117	45%
StDev	173	98	77%

Information regarding client expectations

HIGH group: *"The customer has indicated that he believes that* 1000 work-hours *is a reasonable effort estimate for the specified system. However, the customer knows very little about the implications of his specification on the development effort and you shall not let the customer's expectations impact your estimate. Your task is to provide a realistic effort estimate of a system that meets the requirements specification and has a sufficient quality."*

Results
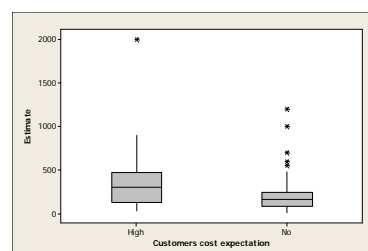
	High	None	Difference
Mean	385	233	65%
StDev	376	242	55%

SURVEYS

Excercise

- Read only the study design in the paper that I handed out
  - Identify shortcomings related to selection of participants

Our typical research method

1) Exploratory studies in the field, e.g., surveys documenting the over-optimism, over-confidence bias

2) Proposal of explanations (theories) on the reasons for these effects based on previous research from various domains

3) Laboratory experiments with a focus on validity of the explanations in software engineering contexts

4) Field experiments on the robustness and relevance of the explanations

5) Proposal of changes in software engineering processes

6) Laboratory and field experiments on the effect of the proposed changes in estimation process

• The Industry is our Lab

Multidisciplinary focus

• We make use of competence and results from several domains, e.g. software engineering, psychology and project management, to build theories

• Partners from other domains include
    – Psychology Department at the University of Oslo
    – Education Research at the University of Oslo
    – Norwegian school of management
    – Many informal collaborations

• Forms of collaboration
    – Joint supervision of students
    – Joint experiments and publications
    – Monthly seminars with the Decision-making group at UiO
    – Informal discussions

Extensive use of laboratory experiments

- Purpose: Test the validity of a theory in a software engineering context

- Typically small experiments conducted at seminars for practitioners

- Combines transfer of results and input to our research, results are presented real-time

- Applies to research question that can be addressed when software professionals solve small tasks (5-10 minutes)

- Randomized allocation to treatment

A randomized controlled laboratory experiment on irrelevant information and estimation

Purpose: Test the theory's validity in a software engineering context

Participants: 90 software developers that attended a talk on software cost estimation

Method: The software developers spent 10 minutes to estimate the required effort of a software development task. They were randomly allocated to either the original requirement specification or a manipulated version of the original specification
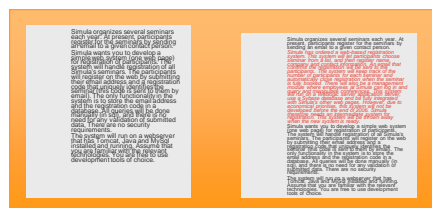
Randomized, controlled software engineering experiments in the field

- Purpose : Study the size and practical relevance of effect

- We pay for the work to ensure that this is perceived as "ordinary work" and strengthen realism and external validity

- Often conducted in outsourcing countries which reduce cost and increase robustness

A randomized controlled field experiment on irrelevant information and estimation

Purpose: Test the robustness of laboratory-results in the field

Participants: 46 companies from Europe and Asia

Method: All companies were paid to estimate the required effort of the same five software development projects. They were randomly allocated to either the original requirement specification or a manipulated version of the original specification

Proposal of changes in software engineering processes

- Publish guidelines
    - E.g. guidelines on how to avoid the negative effect of irrelevant information on cost estimates published in IEEE Software

- Improve our industrial partners estimation and planning processes and tools
    - E.g. We have recently developed an estimation model based on Bayesian analysis for one of our industrial partners

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We are currently developing an industry-strength estimation and planning tool based on our research results in software cost estimation

Transfer of results to industry

- Industry seminars
  - Annual Simula seminar for industry (typically 70-130 attendees)
  - Company specific courses and tutorials
  - Present at national and international seminars and conferences
- Web resources
  - Wikipedia pages on "Software development effort estimation"
  - Forecasting principles on Software cost estimation
  - BEST library that contains almost all research papers on software cost estimation
- Industrial magazines
- Implementation of tools

Q & A ?