Quantitative research

Kari Smolander

Lappeenranta University of Technology

kari.smolander@lut.fi

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- Example of a survey
  - Wolff, A., Knutas, A., & Savolainen, P. (2020). What prevents Finnish women from applying to software engineering roles? A preliminary analysis of survey data. International Conference on Software Engineering: Software Engineering Education and Training (ICSE-SEET'20), May 23-29, 2020, Seoul, Republic of Korea,

- Caveat: this is not a course of statistics
  - There are separate courses of statistics in bachelor programs

Features of quantitative research

- Quantitative research include collection of quantitative data
  - Numbers represent values and levels of theoretical constructs and concepts
  - Interpretation of the numbers as strong scientific evidence of a phenomenon
  - Statistical tools and packages an essential element
- Many sources of numerical data
  - Archival data
  - Structured interviews
  - ”Big data”
- Emphasis on positivist philosophy
  - Exact measurements
  - Formal, mathematical analyses
  - A scientific theory as one that can be falsified

Epistemology of quantitative

- Quantitative sees the world has an objective reality that can be captured and translated into testable hypotheses in the form of statistical or other numerical analyses
- Logical positivism, Vienna Circle of Positivists, 1920s and 1930s
- Later the recognition that all measurement is based on theory
  - Capturing a completely "objective" truth is impossible.
  - E.g. measuring temperature requires a theory of heat expansion
- Deduction
  - Verify that there are no internal contradictions
  - Distinguish between the logic of the theory and its empirical predictions
  - Compare with existing theory, show that the new theory advances knowledge
  - Attempt to falsify the theory with with empirical data

Type of research and methods

- Type of Research
  - Confirmatory research
    - Test (confirm) a prespecified relationship
  - Exploratory research.
    - Define possible relationships and estimate them with the method and the data
- Types of quantitative methods
  - Experiment (field and lab)
  - Simulation
  - Opinion research (**survey**)
  - Archival research
- Data collection techniques
  - Measurement
  - Interviews
  - Questionnaires (web)

Survey process (Pfleeger & Kitchenham, 2001)

1. Setting objectives
2. Planning and scheduling the survey
3. Ensuring that appropriate resources are available
4. Designing the survey
5. Preparing the data collection instrument
6. Validating the instrument
7. Selecting participants
8. Administrating and scoring the instrument = data collection
9. Analyzing the data
10. Reporting the results

Planning a survey

- Think how to reach the respondents
- Inspiring invitation and introduction motivates people to respond
- Design a short, clear and easy-to-use questionnaire
- The goal is a high response rate, because then the quality of respondents and responses are good

Data collection

- Census
  - All data is available for analysis – there is no need to take a sample
  - Examples
    - A complete project management database in a company (where the projects of the company is the population)
    - All Twitter messages
    - All user transactions in an app store
    - All metrics of the source code
- Sample
  - Often it is not possible or economical to get the full census of the population
  - Representative sampling - safely extend the conclusions from the sample to the population
  - Probability is used in statistics to describe the sampling distributions
  - Sample size is determined based on the **expense of data collection**, and the need to have sufficient **statistical power**.
  - Random sampling vs. convenience sampling

Using questionnaires

- Questionnaire is the typical tool for survey data collection
  - Several types
    - Self-administered: mailed, on-line
    - Interview-based: telephone, in person
- Self-administered
  - Can reach large geographical areas and samples
  - Requires a motivated sample and an address list of the population (either land or email addresses)
  - Online samples are possible, but their management is difficult
  - Data quality problems possible
  - Costs and resource needs relatively low
- Interview-based
  - Data quality possibly better
  - Less motivation required
  - Interviewers must be trained
  - Requires more training, resources, travel/data communications, supervision, administration, etc.

Constructing questionnaires/ survey forms

- The research terms and concepts must be clear
- The information needs and hypotheses must be clearly defined
- The survey form must be complete in light of objectives
  - Only what is asked can be analyzed!
- The sample must be able to
  - Understand the questions similarly
  - Answer to all questions
- Questions can be open-ended or closed
  - Open-ended: How successful was your first project with tool X?
  - Closed: The first project with tool X was successful. Definitely agree 1 / Agree 2 / Neutral 3 / Disagree 4 / Definitely disagree 5
- Open-ended answers require work to code and their quantification is difficult
- Closed questions are easy to analyze, but prevent exploration
- Likert scale 1-5 is not a continuous scale

Online survey

- Webropol – a tool for designing questionnaires and collecting electronic responses
- SurveyMonkey – easy and free for small questionnaires
- A link is can be sent by email
- Obligatory questions can be defined to ensure responses to the most important questions

Analyzing quantitative data

- Checking the quality of data
- In surveys: quality checking questions can be used to ensure the quality: the respondent is asked to describe the purpose of the study without being able to go back and look at earlier questions
- The quantitative data is transferred to Excel or a statistical tool (e.g. SPSS)
- Categories such as female/male are transferred to numbers
- The “direction” of the question may need to be changed, if both positive and negative wording was used

Statistical analysis

- Descriptive statistics
  - Numerical descriptors: mean and standard deviation for continuous data types
  - Frequency and percentage are more useful for describing categorical data
- Inferential statistics
  - Hypothesis testing: answering yes/no questions about the data
  - Correlation: describing associations within the data
  - Regression analysis: modeling relationships within the data

Descriptive statistics

- Types of variables
  - Continuous: temperature, heart rate
- Discrete, categorical
  - Ordinal: income class, educational experience
  - Nominal: programming language, species
  - Binomial: yes/no, absent/present
- Central tendency
  - Mean, median, mode
  - Standard deviation, percentiles

Hypothesis testing

- Null hypothesis (H0)
  - H0 is usually the hypothesis that sample observations result purely from chance
- Alternative hypothesis (H1)
  - H1 is the hypothesis that sample observations are influenced by some non-random cause
- The null hypothesis is the reverse of what the experimenter actually believes
  - It allows the data to contradict it
  - Experiment on the effect of alcohol
    - H0 = alcohol does not degrade human performance
    - H1 = alcohol degrades human performance
    - If the experimental data show a sufficiently large effect of alcohol ➔ H0 can be rejected
      - H1 is then true

Significance

- A result that is unlikely to happen by chance is **statistically significant**
- What is the probability that two random samples from the same population differ a specified amount?
  - **Level of significance**: If 1 time in 100 is an acceptable risk → $p < .01$
  - Typical levels in research
    - 95% - experimental results are 95% certain to support rejecting the null hypothesis ($p < .05$)
    - 99% ($p < .01$), 99.9% ($p < .001$)
  - If confidence level, p, is less than .05 or .01, the null hypothesis should be rejected in favor of the alternative
  - if p is greater than .05 or .01, the null should not be rejected

Correlation

- Any statistical relationship between two random variables or two sets of data
- Example: the correlation between electricity demand and weather
- Correlation coefficients
  - Pearson's product-moment coefficient - sensitive only to a linear relationship between two variables
  - Spearman's rank correlation coefficient – the relationship of two variables without linearity requirement
  - Kendall’s tau
- Remember, correlation does not imply causality
  - There is no direction (both A→B and B→A can be true)
  - There can be a common cause C
  - The correlation can be purely coincidental

Regression analysis

- A statistical process for estimating relationships among variables
- Modeling and analyzing several variables
  - Focus is on the relationship between a **dependent variable** and one or more **independent variables**
  - How the typical value of the dependent variable changes when any one of the independent variables is varied
- The result is a function of the independent variables i.e. the **regression function**
- Can be used for prediction and forecasting
- Many functions and techniques available

Example: Finnish women in software engineering roles

- Wolff, A., Knutas, A., & Savolainen, P. (2020). What prevents Finnish women from applying to software engineering roles? A preliminary analysis of survey data. *International Conference on Software Engineering: Software Engineering Education and Training (ICSE-SEET'20)*, May 23-29, 2020, Seoul, Republic of Korea,

- Watch the video in YouTube, https://youtu.be/EmA5zJ8cUH4

- My commentary of the presentation is next

What prevents Finnish women from applying to software engineering roles? A preliminary analysis of survey data

Annika Wolff, LUT University
Antti Knutas, LUT University
Paula Savolainen, Turku University of Applied Sciences

Motivation and background

- Finland has good track record in equality when it comes to representation of women in senior roles but unfortunately many professions still gendered
  - Finland is comparing unfavourably to other European countries, with only 28% of scientists and engineers being women (Eurostat, 2018)
- Therefore it is important to know what is the root cause of these issues
  - Are there deeper issues than hiring or firing policies?

Research question and methods

- What experiences may directly or indirectly affect the willingness of Finnish women to apply for SE roles?
  - Focus on women who have who have expressed an interest in technology-related careers and what might affect their willingess to put themselves forward for the role
  - Number of hypotheses and survey constructs derived from literature
- Survey conducted in cooperation with Finnish Software and E-Business association

Survey constructs

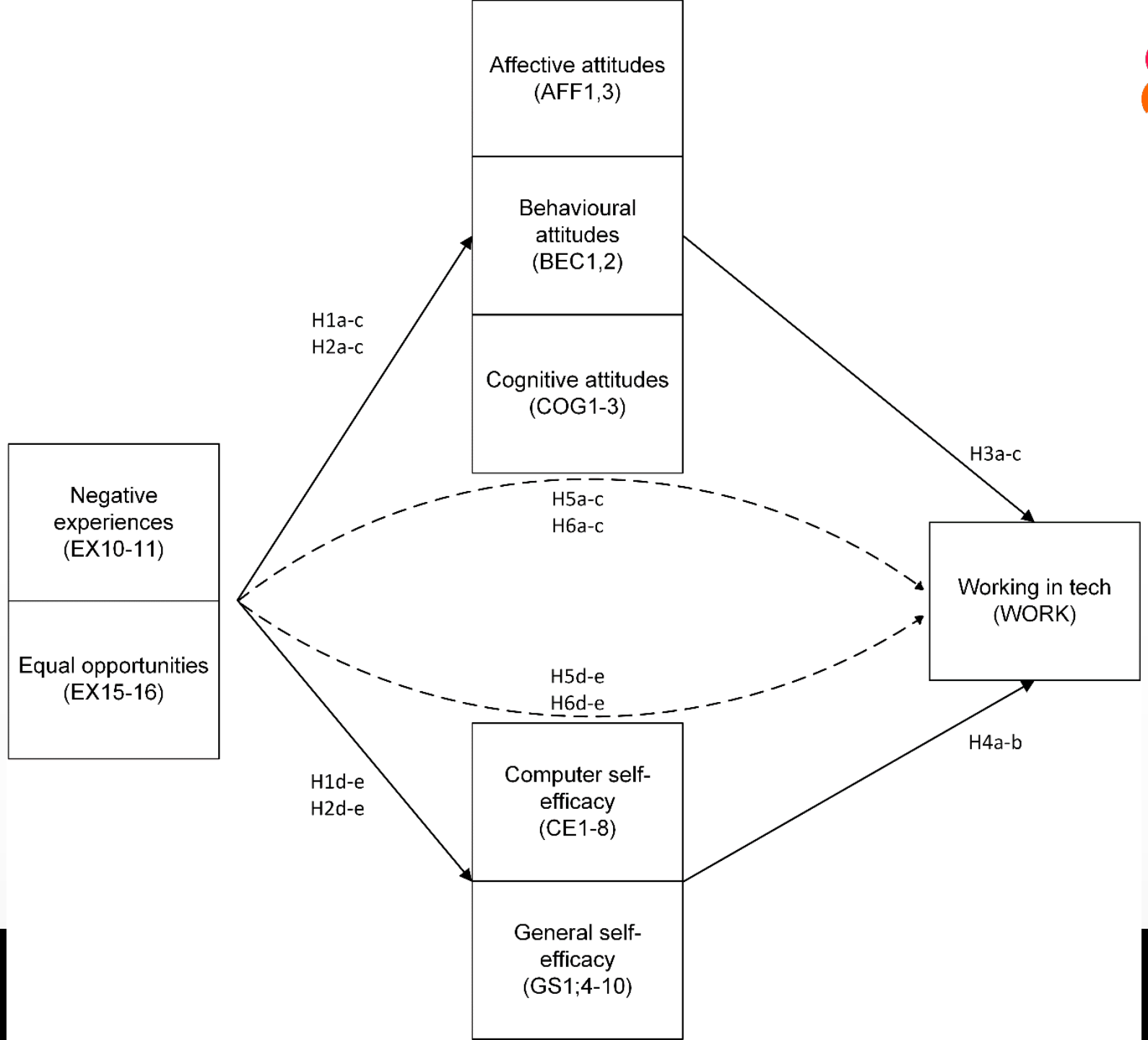
- Early school experiences
- Higher education experiences
- Working life experiences
- Affect…
  - Affective, behavioural, and cognitive attitudes
  - General and computer self-efficacy
- Which in turn have an effect on…
  - Tendency to seek work in technology careers

Research model

Each construct is specified by several survey questions.

Each line is a hypothesis about the effect of one construct on another.

Full survey available as an online appendix.

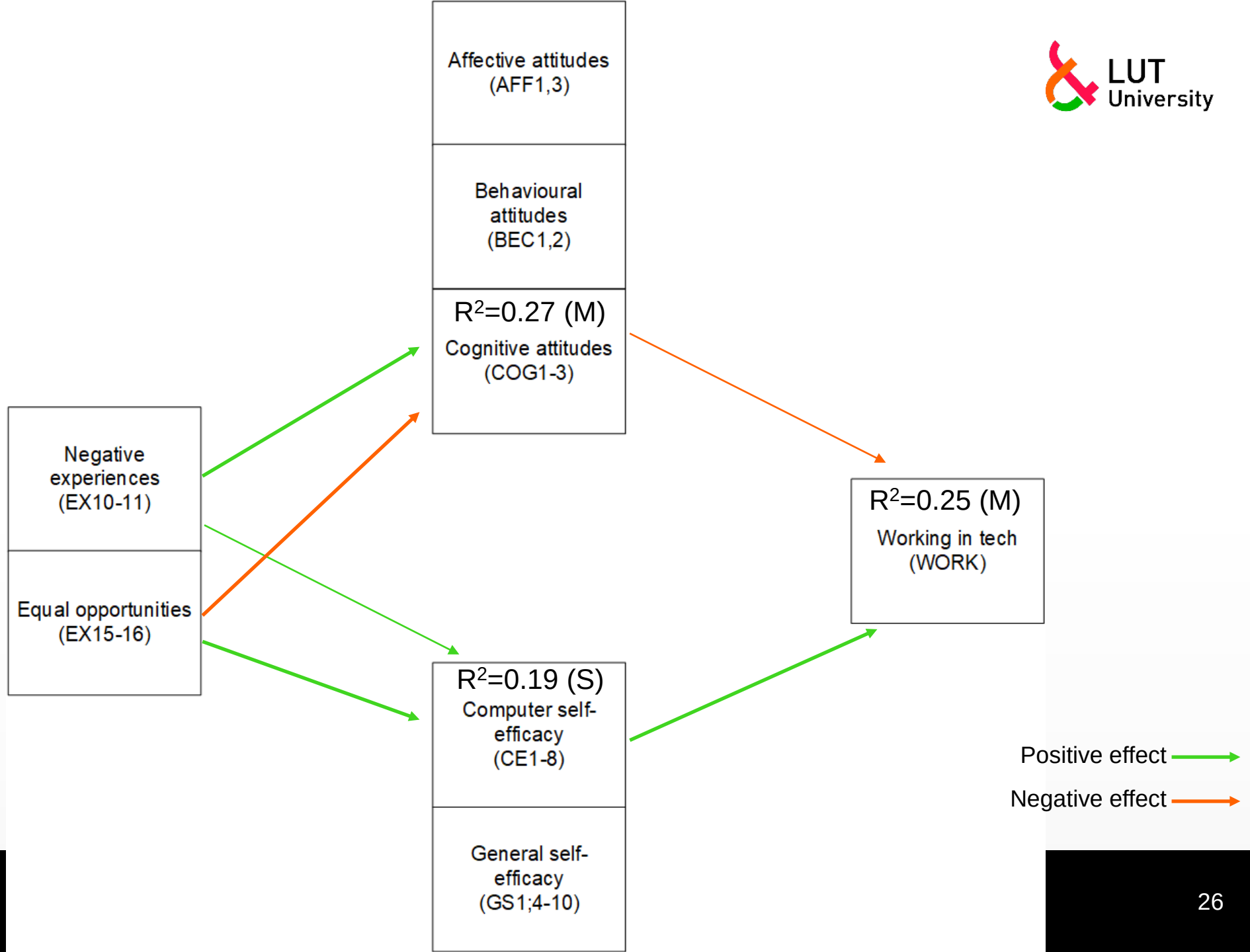


Analysis method

- Partial Least Squares Path Modeling (PLS-PM)
  - Allows connecting series of variables into a latent construct
  - Allows specifying paths of effect between the constructs, with each path in the research model representing a hypothesis
- Model validation and hypothesis testing process from Hair and Henseler; mediation analysis from Zhao et al.

Hypothesis testing results (mediated "complete" paths; H5 & H6)

Findings in a nutshell: Negative experiences and equal opportunities have an effect on working in tech through cognitive attitudes and computer self-efficacy.



Discussion and contribution

- Negative early experienced and perceived lack of equal opportunities had an impact
  - Effect was mediated through cognitive attitudes and computer self-efficacy
- Findings support many earlier studies that even in the Finnish context, gendering of specific roles exist due to negative experiences and gender stereotyping
- Two main contributions
  - Practice: Identified some of the barriers
  - Body of knowledge: Analyzed mediating constructs, in addition to direct effects (been proposed in literature, but not yet analyzed)

In conclusion

Our findings support the idea that *improving the situation for women in software engineering requires broad strategies that seek to change perceptions of society as a whole about who can and cannot participate in tech*
(supporting Cheryean et al. 2013 and Patitsas et al. 2014 & Patitsas 2019)

Preprint can be found at https://tinyurl.com/ICSE2020LUT

Thank you!

Questions? Comments?