# SEI IPA/SEC Research Status

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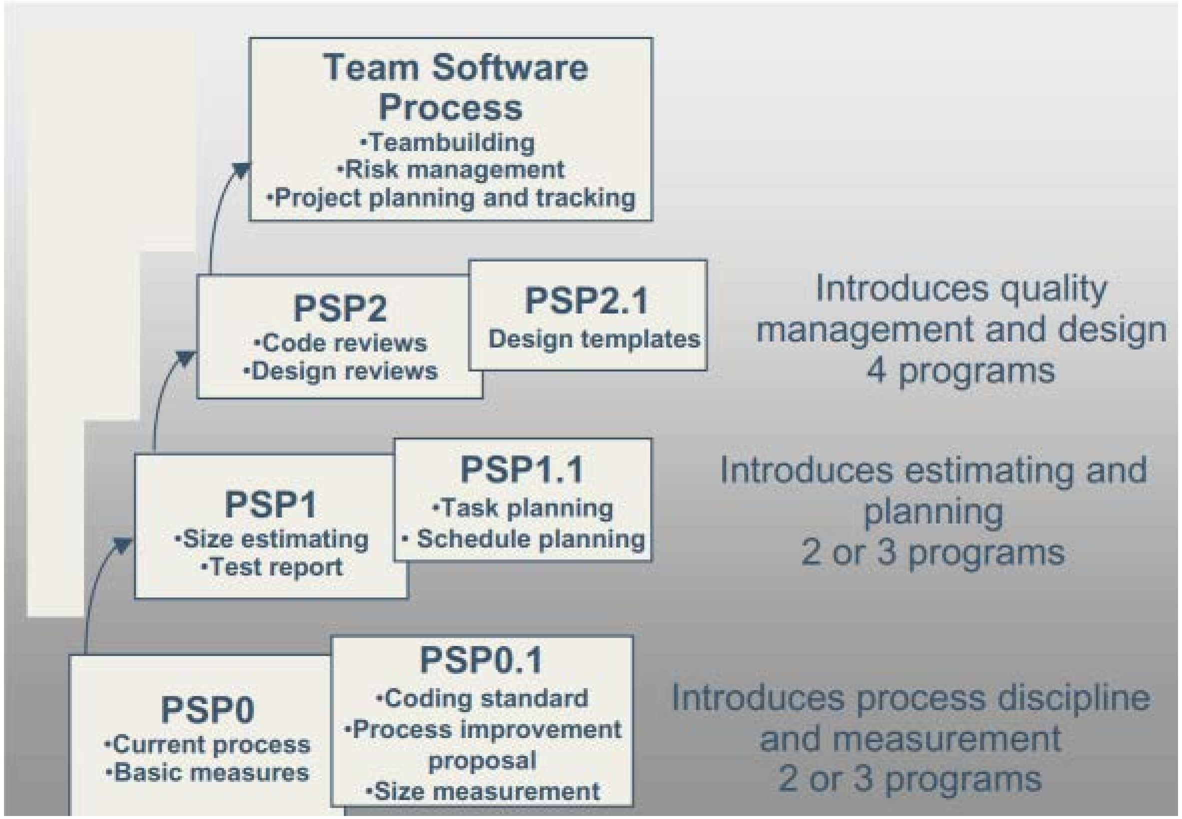
# PSP database

Suitable  for Quasi-expermiental methods.





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# PSP Data Overview

When using the PSP, developers gather and use data.

- Time data
  - The time in minutes spent by development task
  - Interruption time is not counted.
- Size data
  - Product size in db elements, pages, LOC, etc.
  - Categories: base, added, deleted, modified, reused
- Defect data
  - All defects removed in compile, test, review, Type, phases injected & removed, fix time, description


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# PSP Data by Language

| Language | Programs | LOC | Hours | Defects |
|---|---|---|---|---|
| C | 4,984 | 532,529 | 21,460.80 | 36,426 |
| C++ | 3,255 | 448,517 | 14,913.40 | 30,785 |
| C# | 1,213 | 163,233 | 3,696.60 | 6,661 |
| VB | 1,353 | 144,621 | 5,108.50 | 7,405 |
| Java | 1,383 | 199,493 | 6,311.00 | 11,131 |
| Ada | 286 | 33,060 | 1,869.00 | 3,477 |
| Total | **12,474** | **1,521,453** | **53,359.20** | **95,885** |


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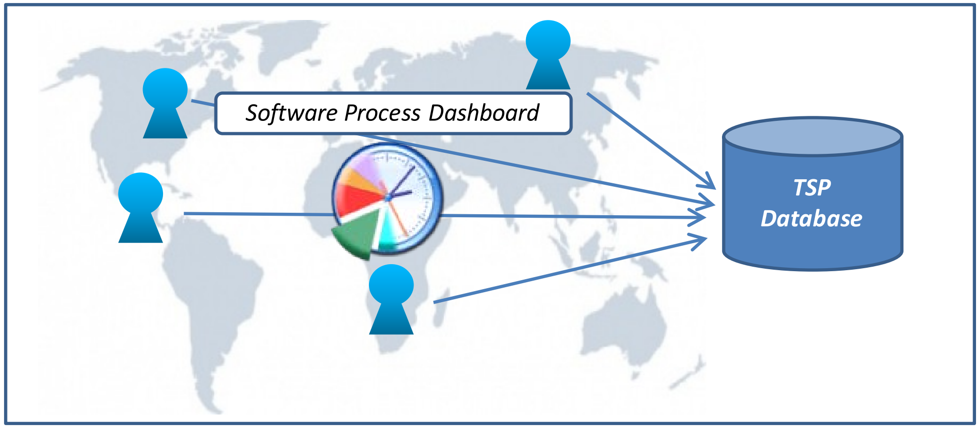
# The TSP SEMPR Database

## Stores project data

- >900 projects launched after 2009
- used the Software Process Dashboard
- In a relational database (MySQL 5.6) via SQL



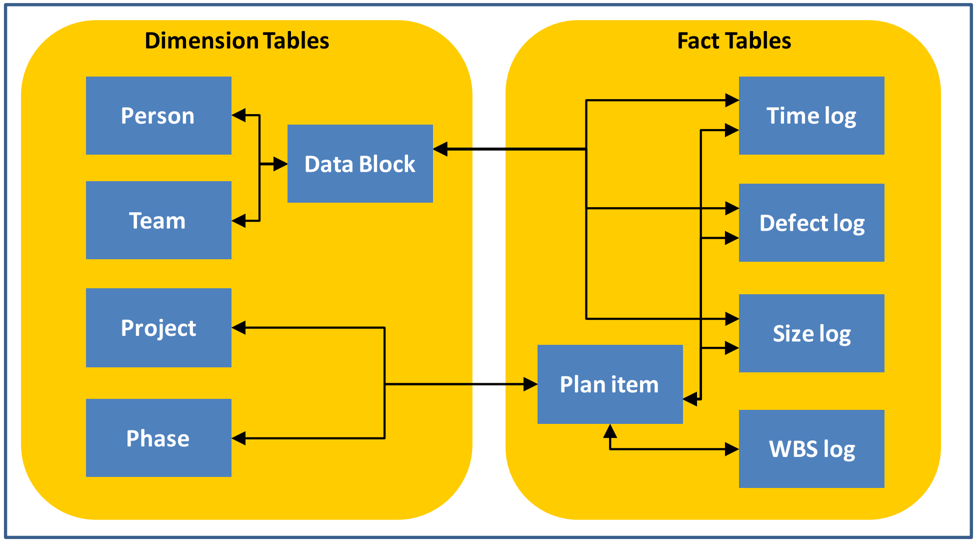
# The TSP Database

*Follows the schema of the Team Process Data Warehouse.*

*Includes Fact Tables and Dimension Tables.*

*Connects Dimension Tables to Fact Tables for data analysis from many perspectives.*

**http://www.processdash.com/**



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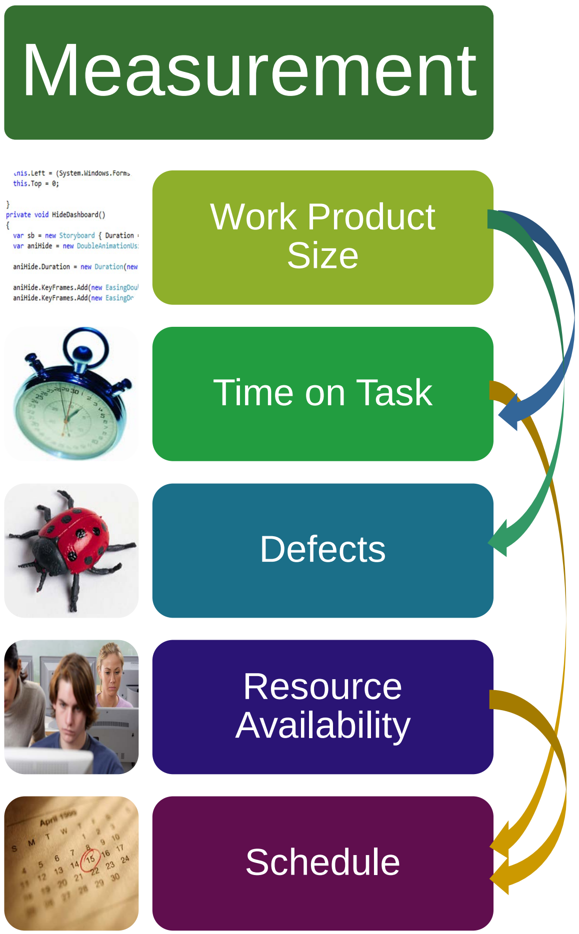
# Team Software Process (TSP$_{SM}$) measurement framework




Five direct measures

Team and team member data

Estimated during planning

Measured while working

Evaluated weekly or when a

- task is completed
- process phase is completed
- component is completed
- cycle is completed
- project is completed



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# Types of Data, Individual

Planned total effort per period

Actual total effort per period

Planned task effort for each work item

Actual task effort actual task effort for each work item,

Defects found

Defects removed


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# Types of Data, Component

Planned component size

Actual component size,

Planned effort in each development phase

Actual effort in each development phase

Planned completion date for each task

Actual completion date for each task

Defects injected in each development phase

Defects removed in each development phase

Number of individuals who worked on each component


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# Types of data, Project Context

Project Characteristics and Site Charactistics

See PACE Application Forms

Data includes (not limited to)

- Programming Language
- Organization size
- Goals priority
- Business category
- Application category
- Project Lifecycle Stage
- Tools used


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# Types of data, Project outcomes

Planned effort

Actual effort

Number of developers

Planned delivery date

Actual delivery date

Customer Satisfaction results (for PACE projects)

Planned and actual effort in each development phase


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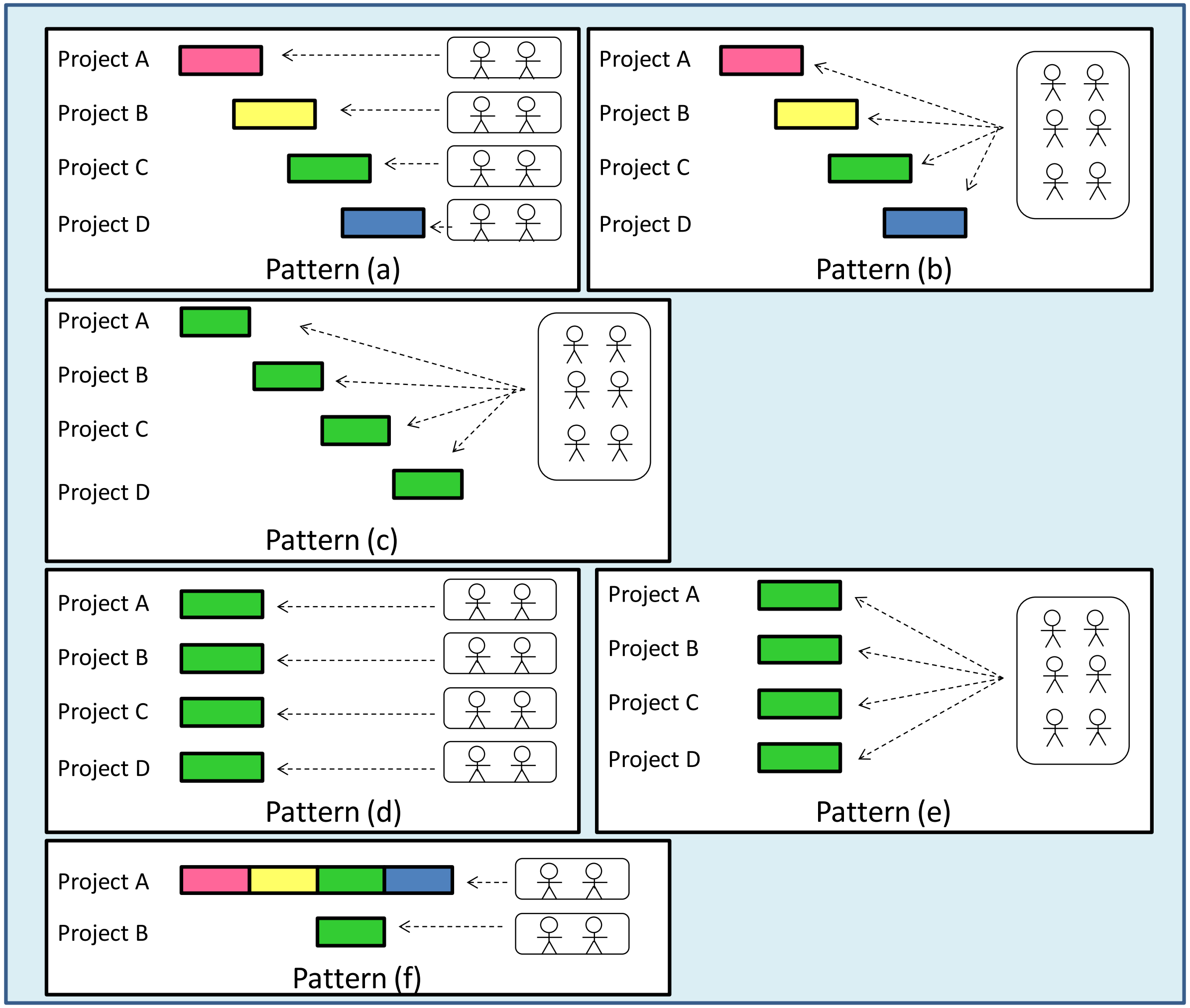
# Patterns of Project Organization



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# TSP IPA/SEC Research Questions

Are the correlations identified in IPA/SEC data also observed in other data sets?

Which development measures have the highest correlation with external, fielded measures of quality?

Which measures of quality are candidates for causes of product quality-in-use?

Which internal, development measures have the highest correlation with external, schedule performance?

Does performance differ with  project organizational structure?


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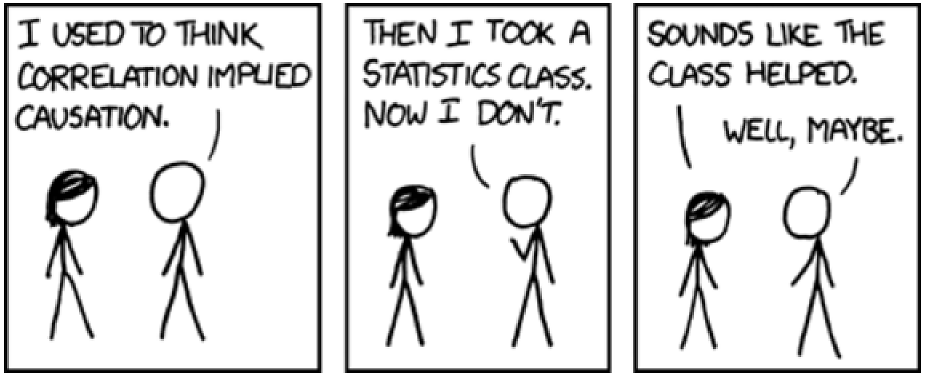
# Investigating Project Success Factors Correlation and Inferring Causation





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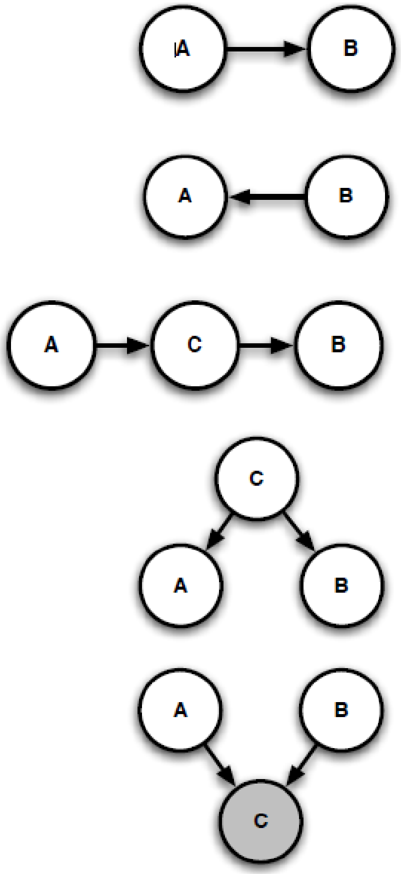
# Types of association




**Direct causation** — A causes B in the expected direction.

**Reverse causation** — A causes B in the reverse direction.

**Causal chain** —A indirectly causes B through C.

**Common cause** —The variable C causes both A and B, thus inducing a dependence between A and B.

**Conditioning on common effect** — A and B share a common effect C,and conditioning on this variable can Induce a dependence between A and B.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# Analysis approach

Begin with correlational studies (R, Minitab)

Include Quasi-expermental analysis

Apply tools to infer causation

- Tetrad.
  - ❑ Useful for large data samples.
  - ❑ Applied to observational data.
  - ❑ Useful where unobserved confounders are present.
  - ❑ Uses Categorical Data

- Strata and BayesiaLab
  - ❑ Evaluate a causal model
  - ❑ Quantify degree of cause and effect between factors


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# Initial Results

Data preparation

Cuts on data

Include only

- New development
- LOC measured (Added and Modified)
- Blank lines and comments not included
- Defects (5269 (released) OR 5253, 5254 (int and sys test) )
- Phased efforts reported

Remove all production rates > 30 LOC/Hr (data went to 600LOC/Hr!)

Normalize data by product size


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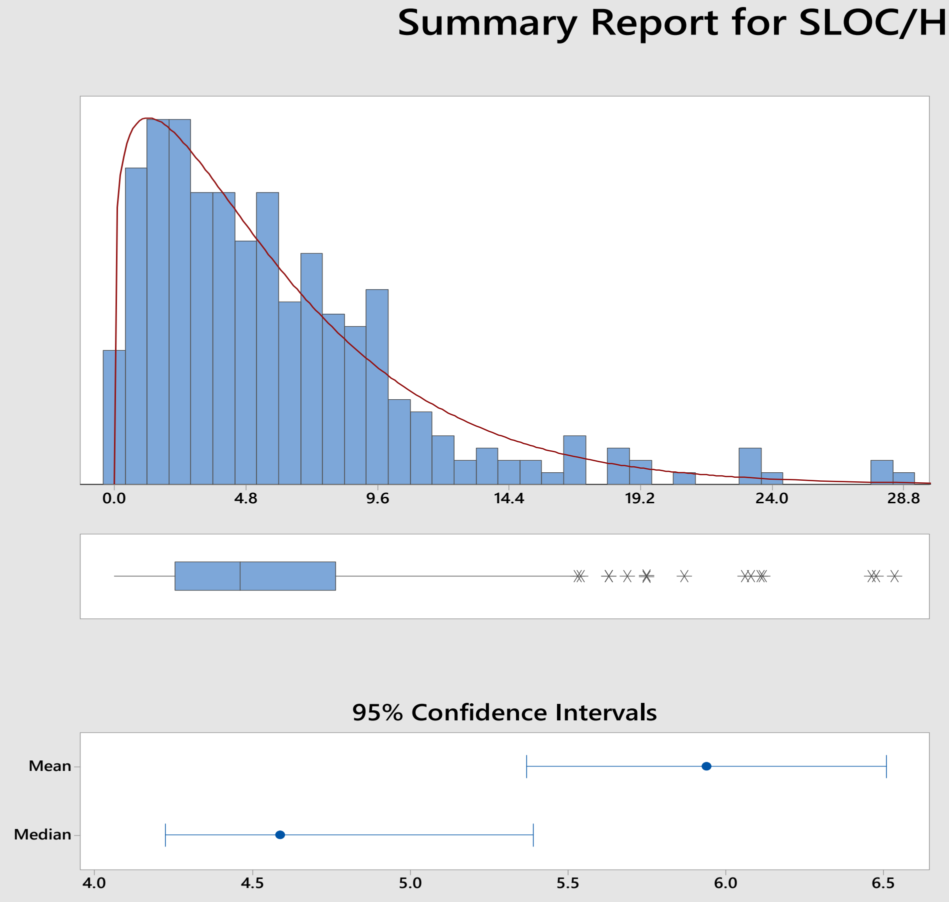
# Code Production Rates

50% of the data is between 4.5 and 8 LOC/Hr

But a substantial number are well outside of this range.




| | |
|---|---|
| **Anderson-Darling Normality Test** | |
| A-Squared | 10.55 |
| P-Value | <0.005 |
| Mean | 5.9390 |
| StDev | 5.0999 |
| Variance | 26.0092 |
| Skewness | 1.74541 |
| Kurtosis | 3.93287 |
| N | 310 |
| Minimum | 0.0065 |
| 1st Quartile | 2.2241 |
| Median | 4.5867 |
| 3rd Quartile | 8.0819 |
| Maximum | 28.4598 |
| **95% Confidence Interval for Mean** | |
| 5.3691 | 6.5090 |
| **95% Confidence Interval for Median** | |
| 4.2240 | 5.3894 |
| **95% Confidence Interval for StDev** | |
| 4.7276 | 5.5364 |



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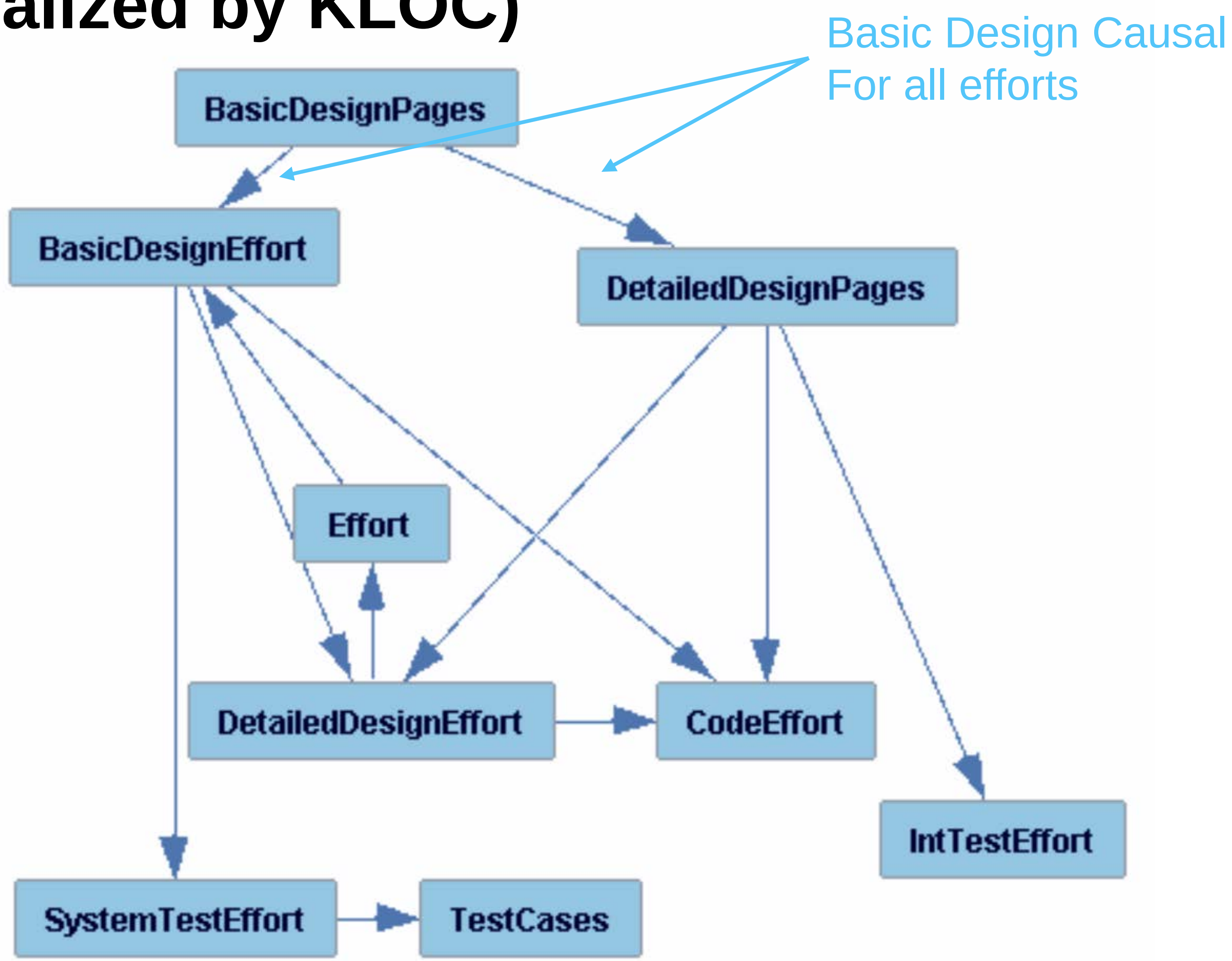
# Results of a causal search (normalized by KLOC)





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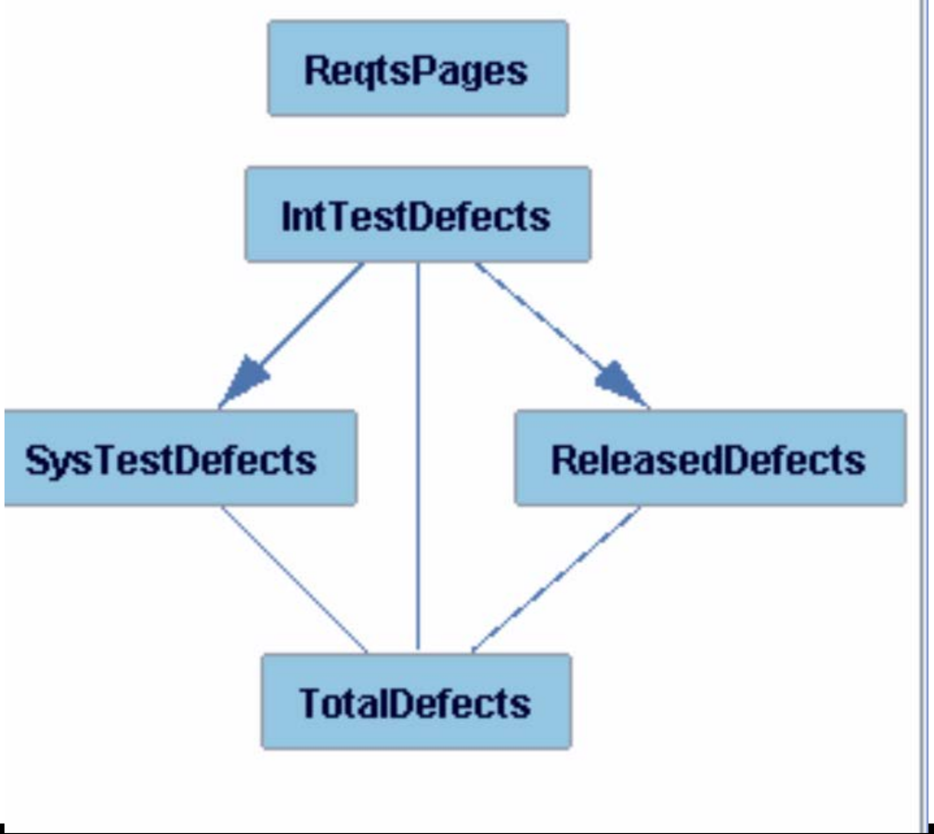
# Surprisingly, other factors were isolated

In what dense to Integration Test defects “cause” later defects?

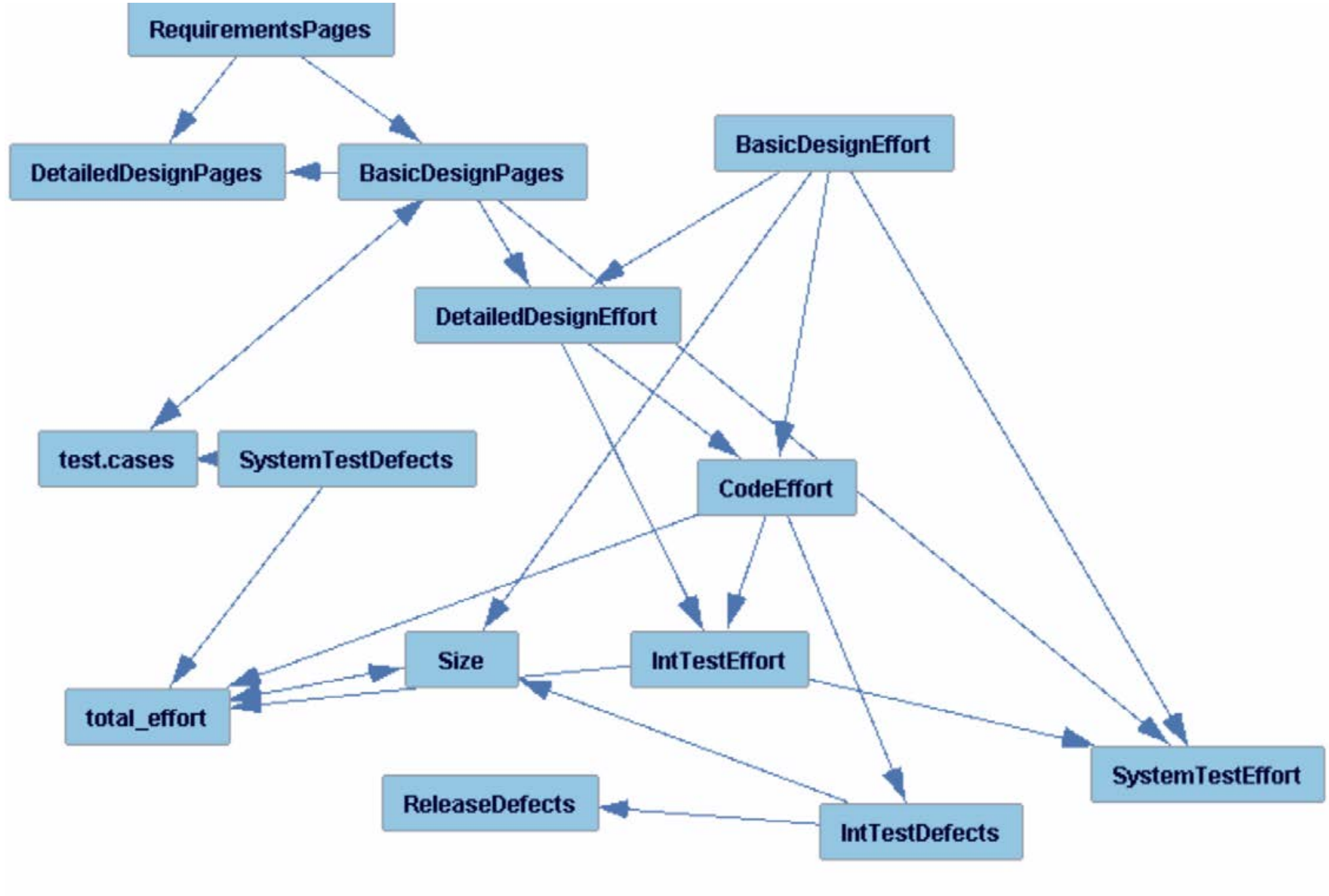
Why is requirements documentation isolated?

Defects are caused by document pages using FGRES algorighm



# Causal search (unnormalized factors)

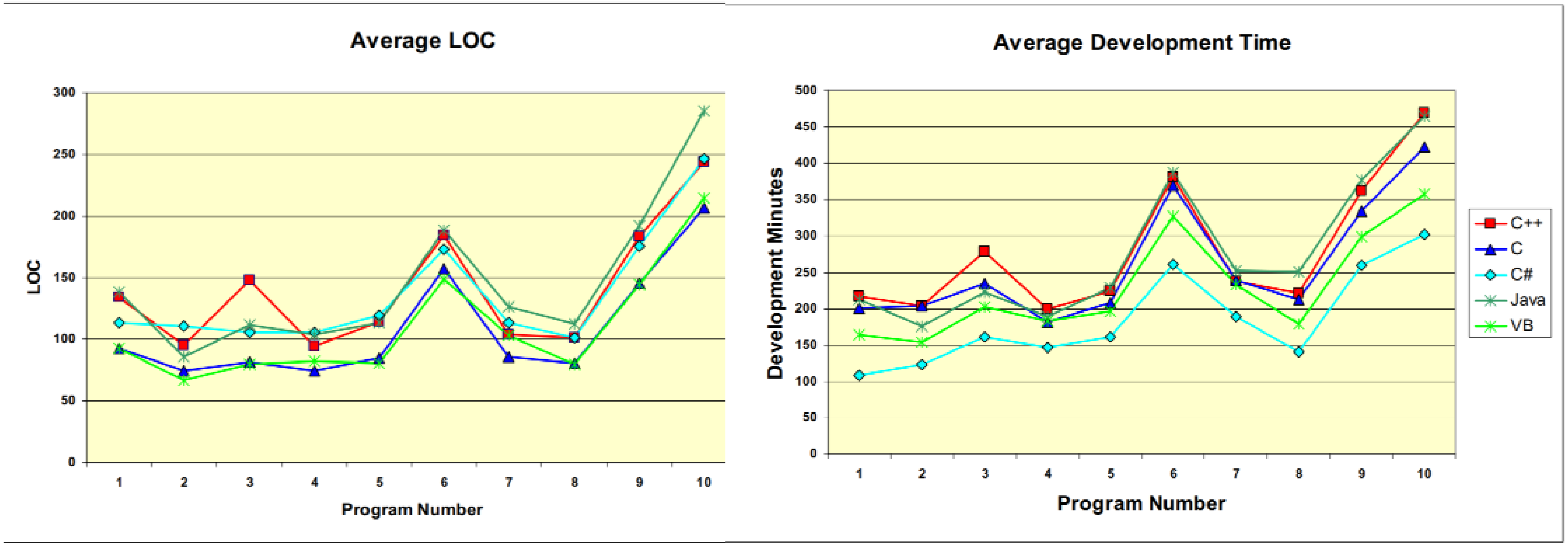
Spearman correlation with Effort and Size (KSLOC) is 0.83



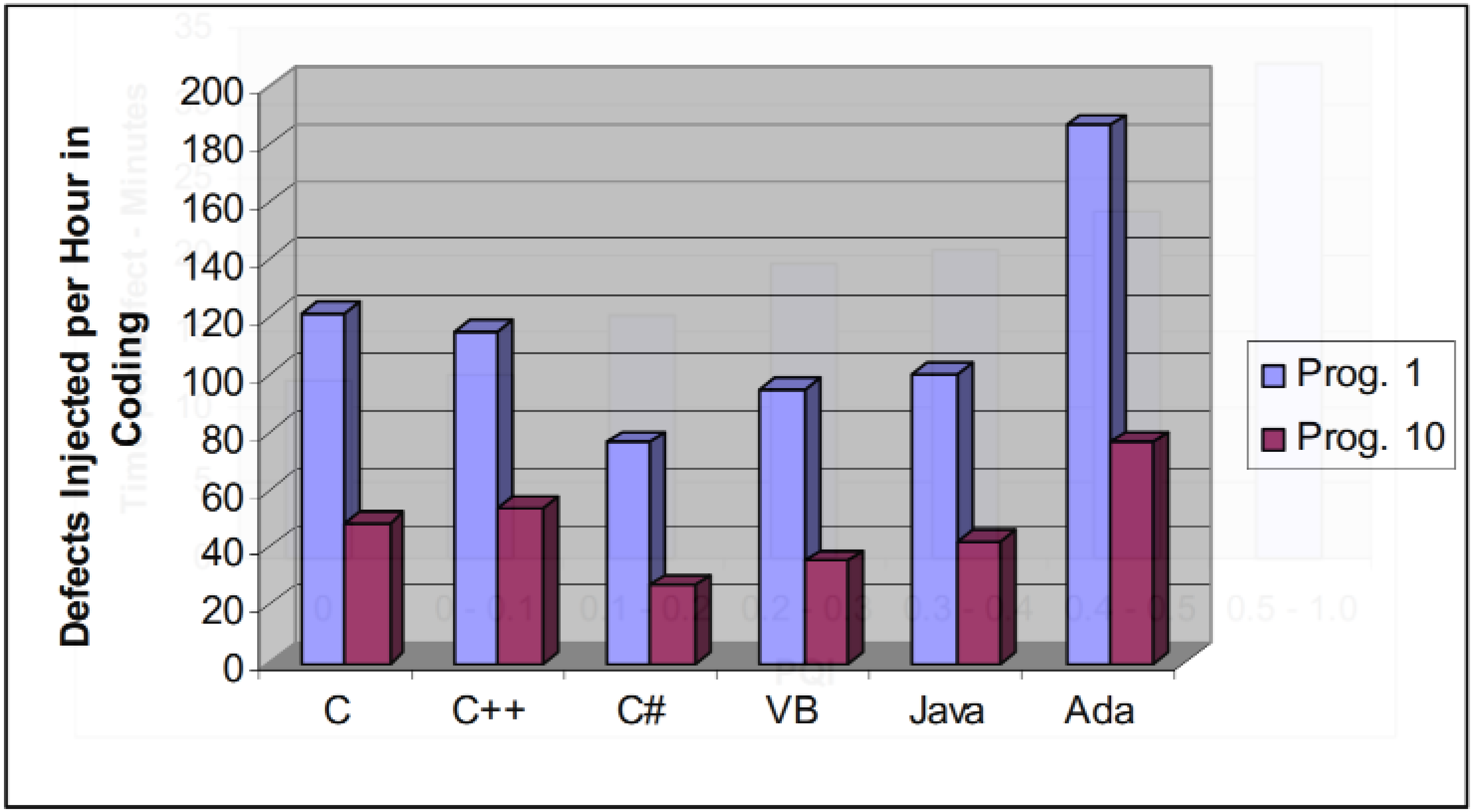
# Effect of programming language:

PSP data can help adjust for language factors for size/effort.

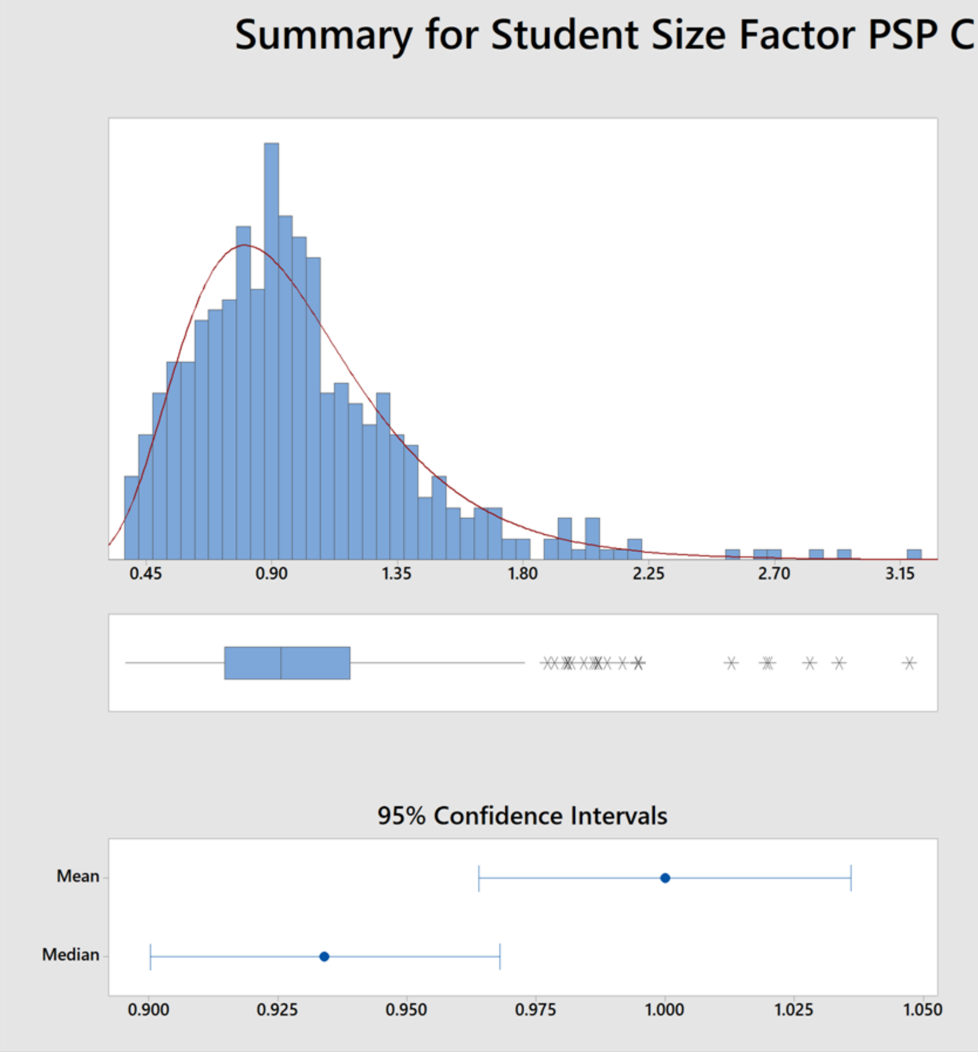
The size factor can supplement benchmarks for KLOC/FP



# Languages have different defect proneness



# Size of the programs varied by students!




| Anderson-Darling Normality Test | |
|---|---|
| A-Squared | 10.28 |
| P-Value | <0.005 |
| Mean | 1.0000 |
| StDev | 0.4081 |
| Variance | 0.1665 |
| Skewness | 1.59384 |
| Kurtosis | 4.27344 |
| N | 495 |
| Minimum | 0.3769 |
| 1st Quartile | 0.7327 |
| Median | 0.9341 |
| 3rd Quartile | 1.1814 |
| Maximum | 3.1819 |
| 95% Confidence Interval for Mean | |
| 0.9640 | 1.0360 |
| 95% Confidence Interval for Median | |
| 0.9004 | 0.9681 |
| 95% Confidence Interval for StDev | |
| 0.3841 | 0.4352 |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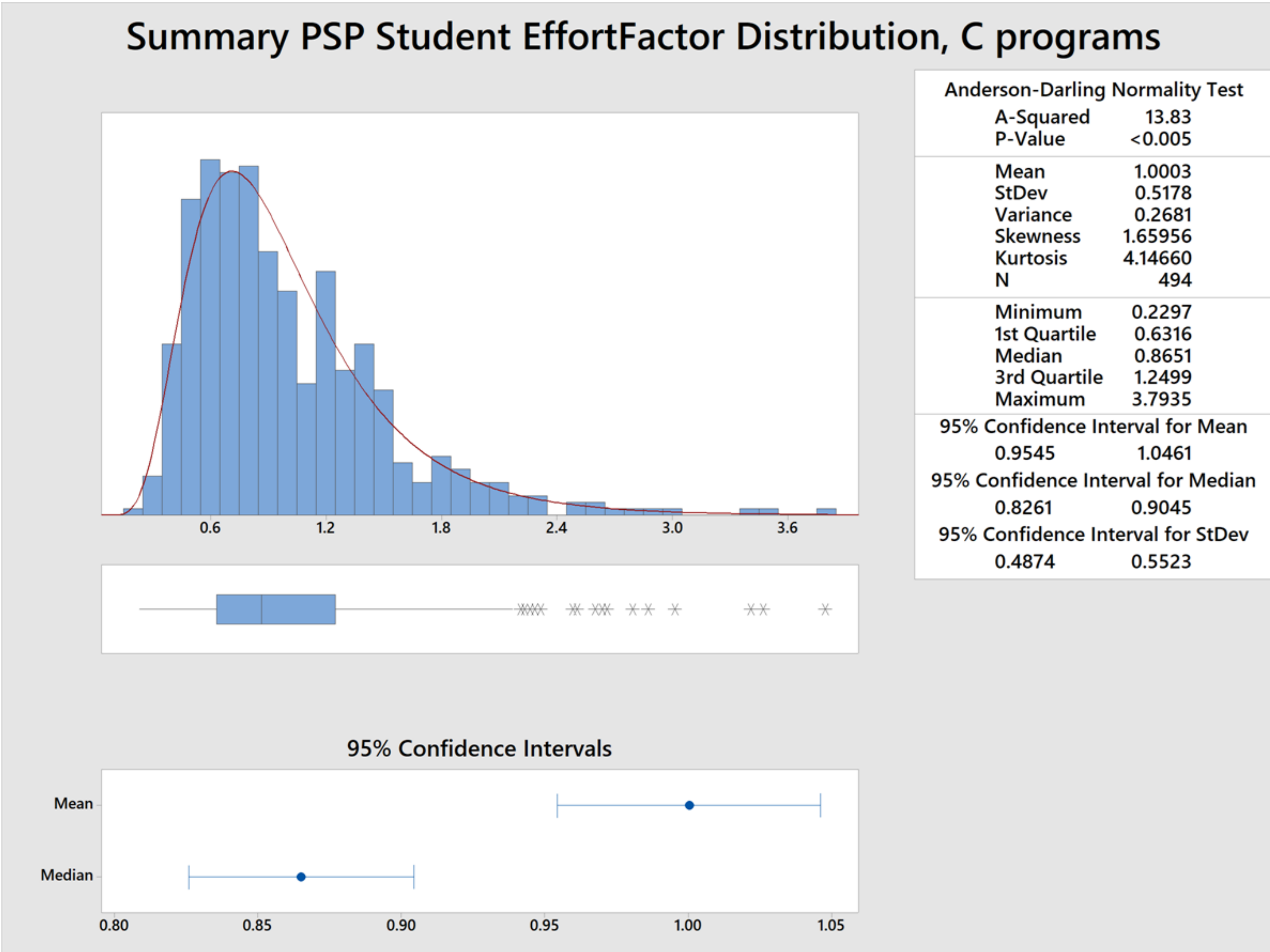
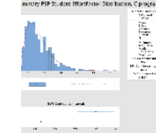
# Student total effort also varies





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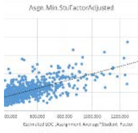
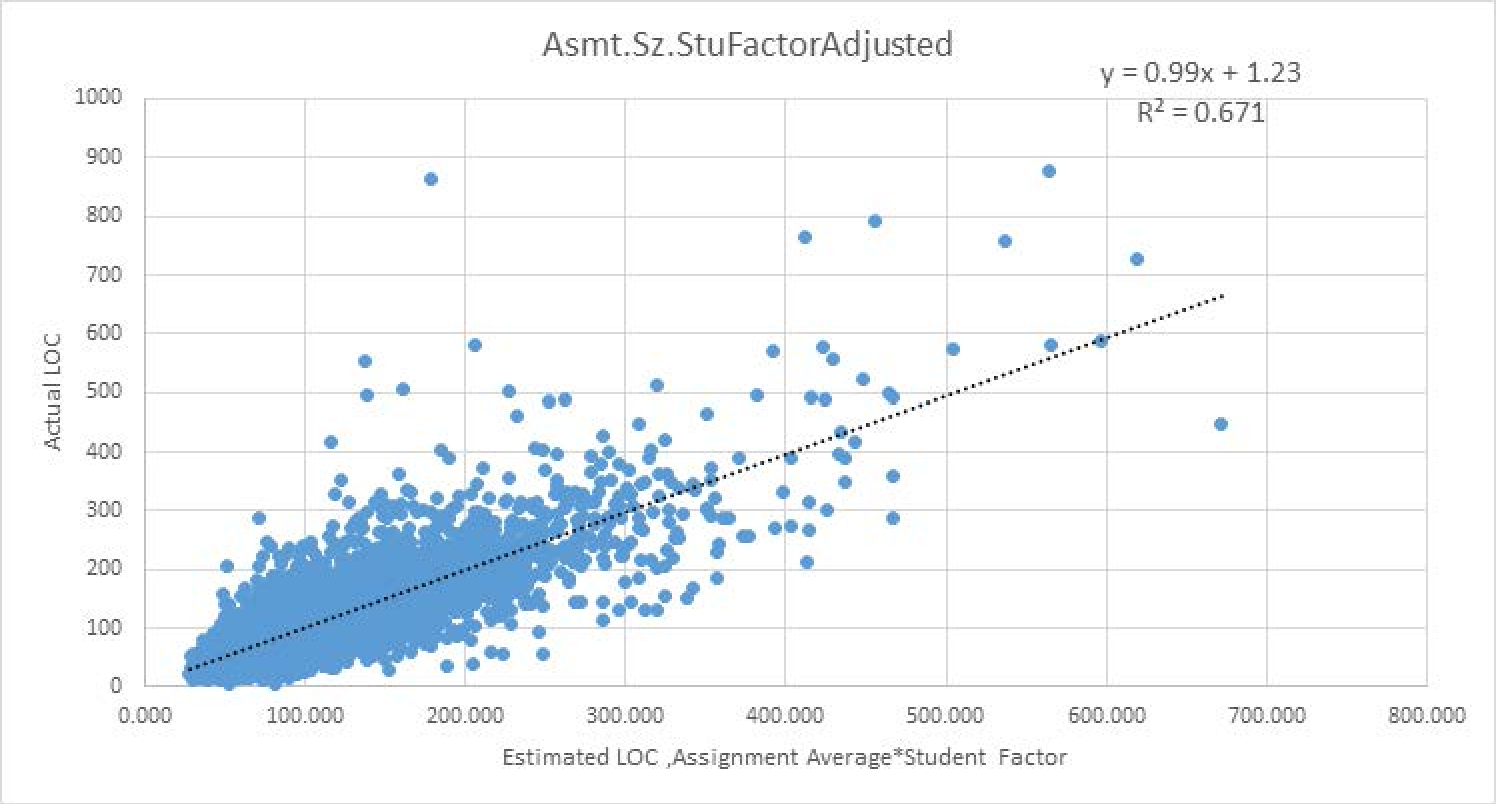
# Adding individual size factors accounts for 67% of the variation





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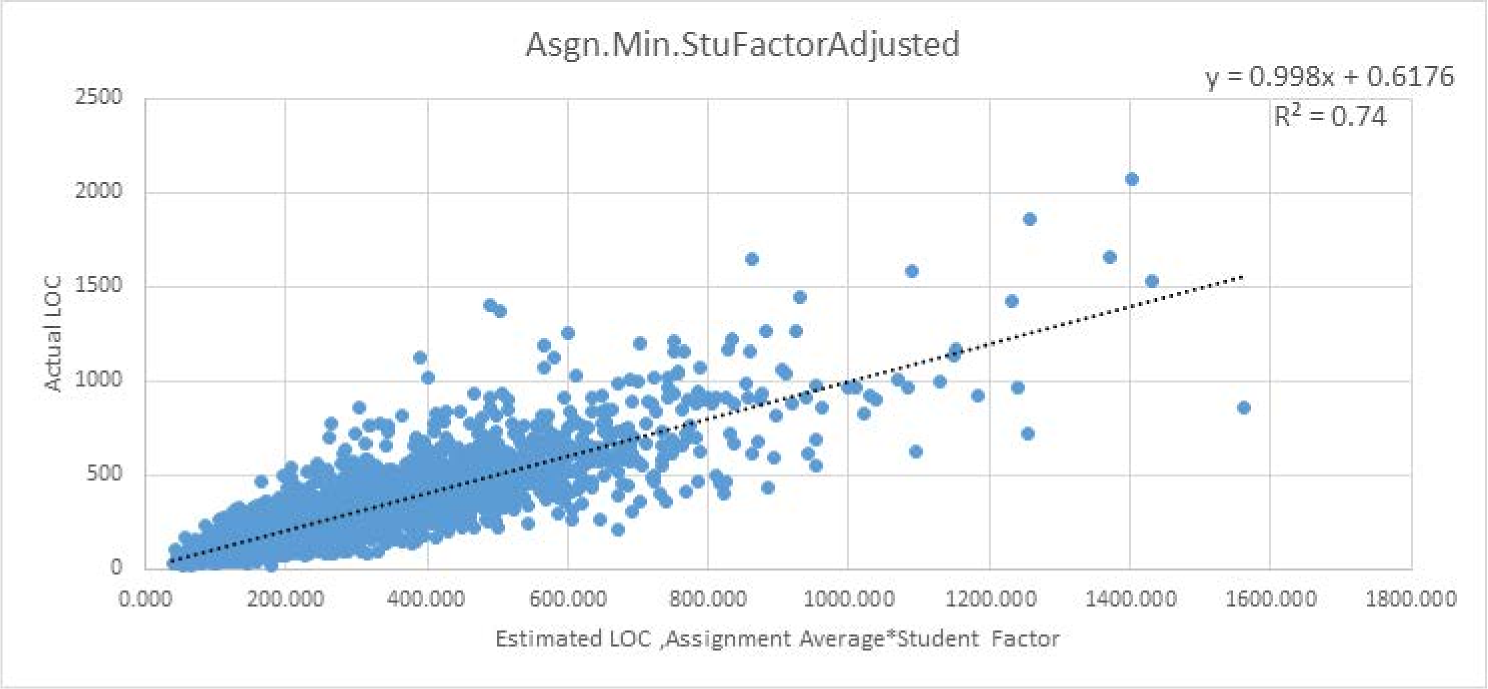
# Student effort factor predicts 74% of variation in program effort





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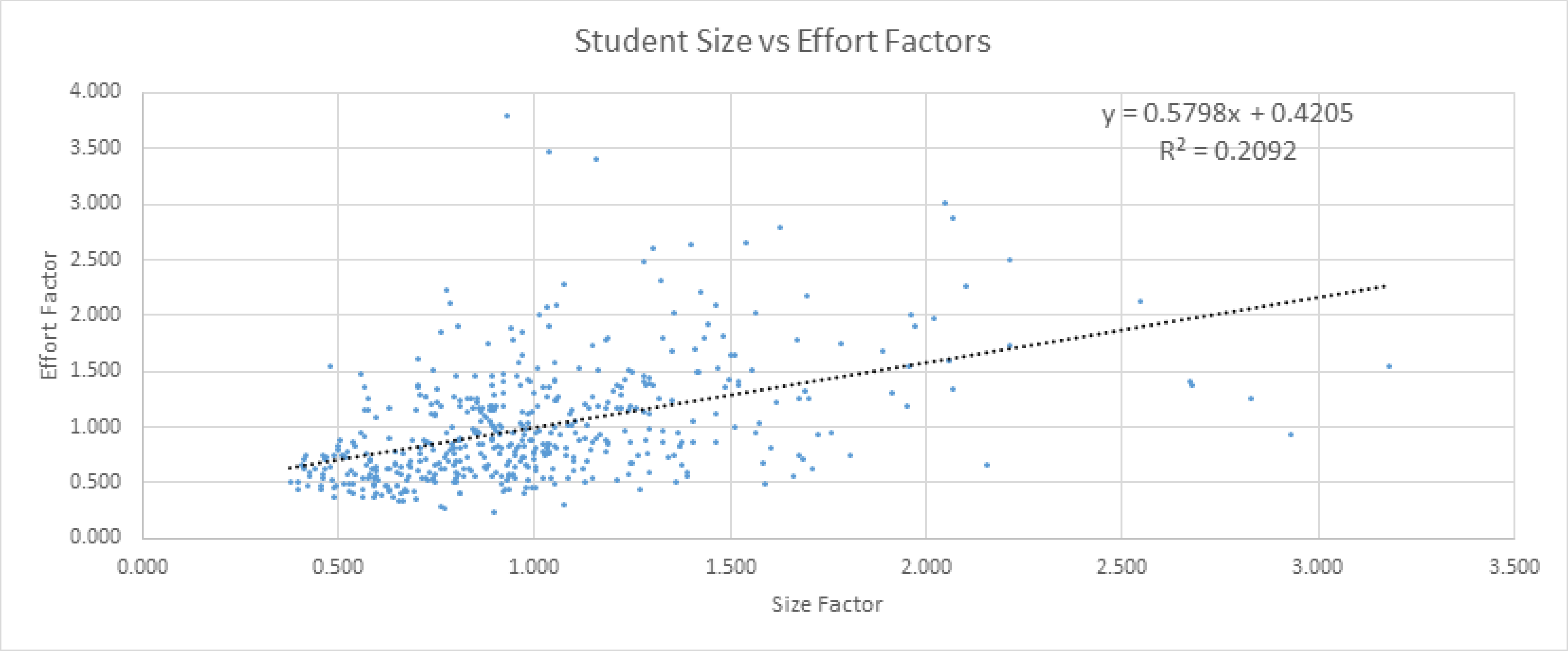
# Effort and size factors do NOT correlate strongly for the overall group.

Size is highly predictive for individual students, but the individual rates vary widely.  Factors are highly local and do not generalize.





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# Summary

We have some evidence of causal influence from Design documents and effort

While size appears to be the big factor associated with effort, other factors contribute. (Design, review, programming language, individual developers)


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# Next Steps

Analyze other search algorithms and characterize the strength and direction of effects.

Replicate IPA results with separate dataset (TSP)

Combine multiple sets of data in a more complete model


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