# Search Interfaces for Mathematicians

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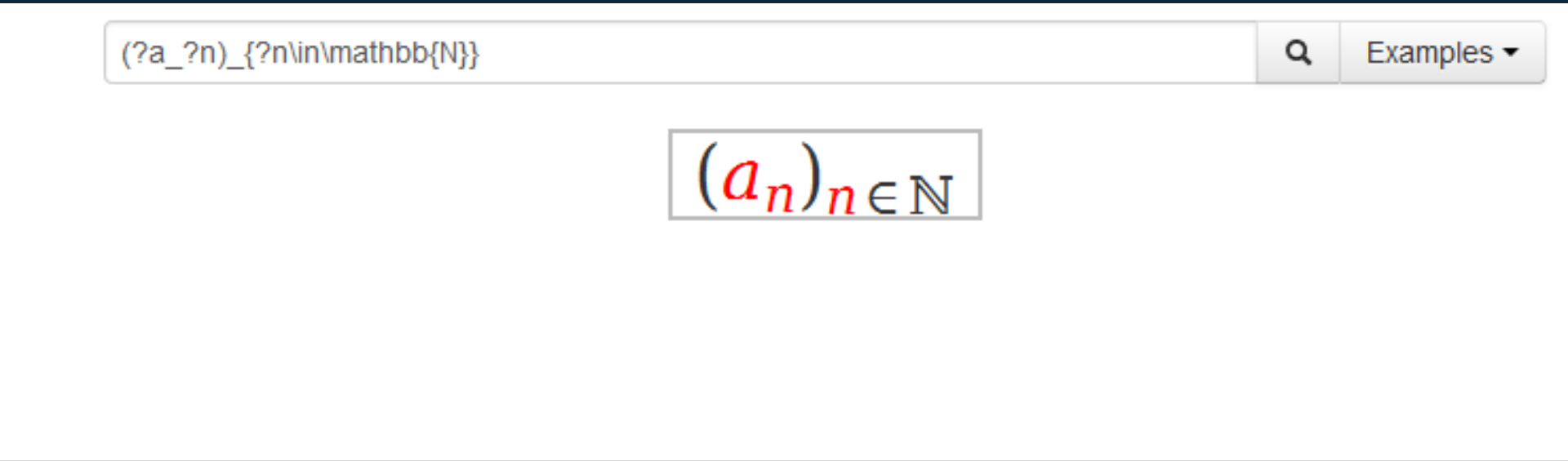
# MathSearch Project




FormulaSearch = MathWebSearch

How to make best use of it for Mathematicians?

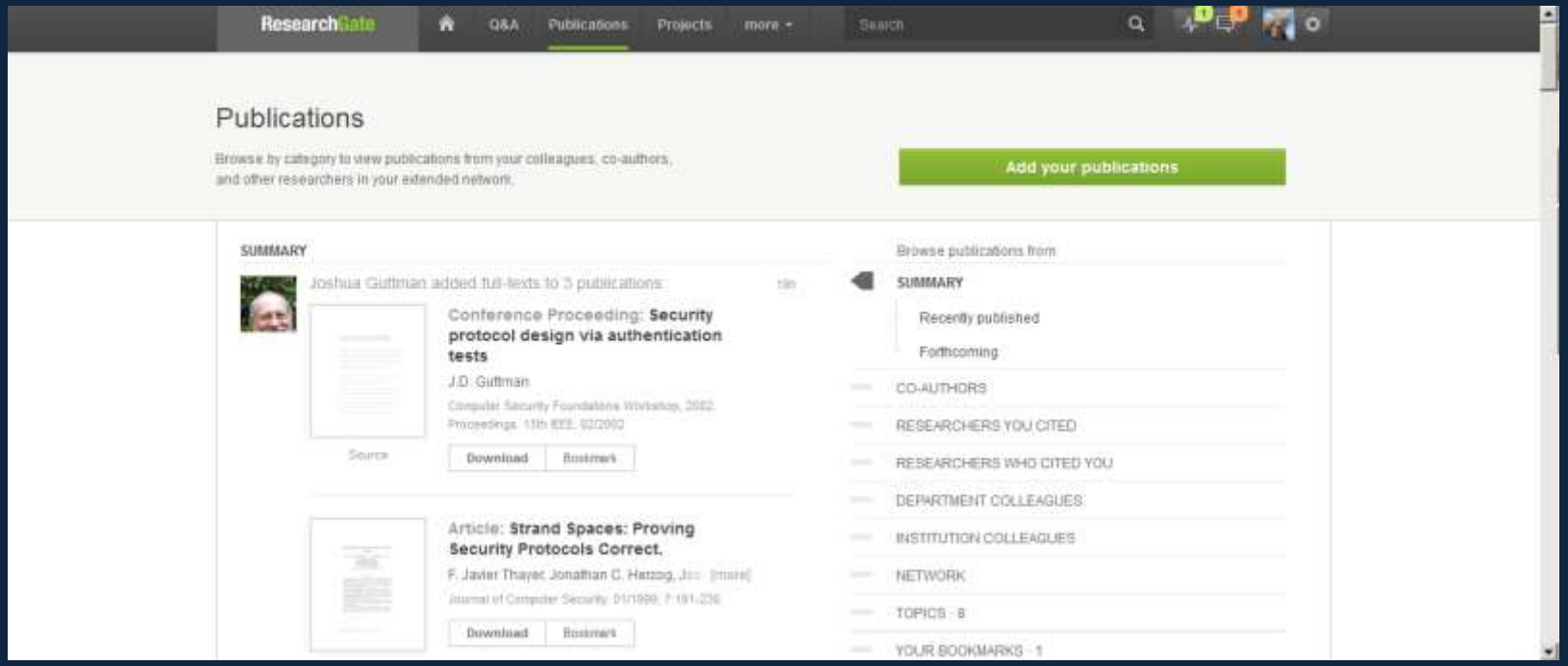
# Design for Mathematicians?


An older version of zbMath ...

# Design for Mathematicians?

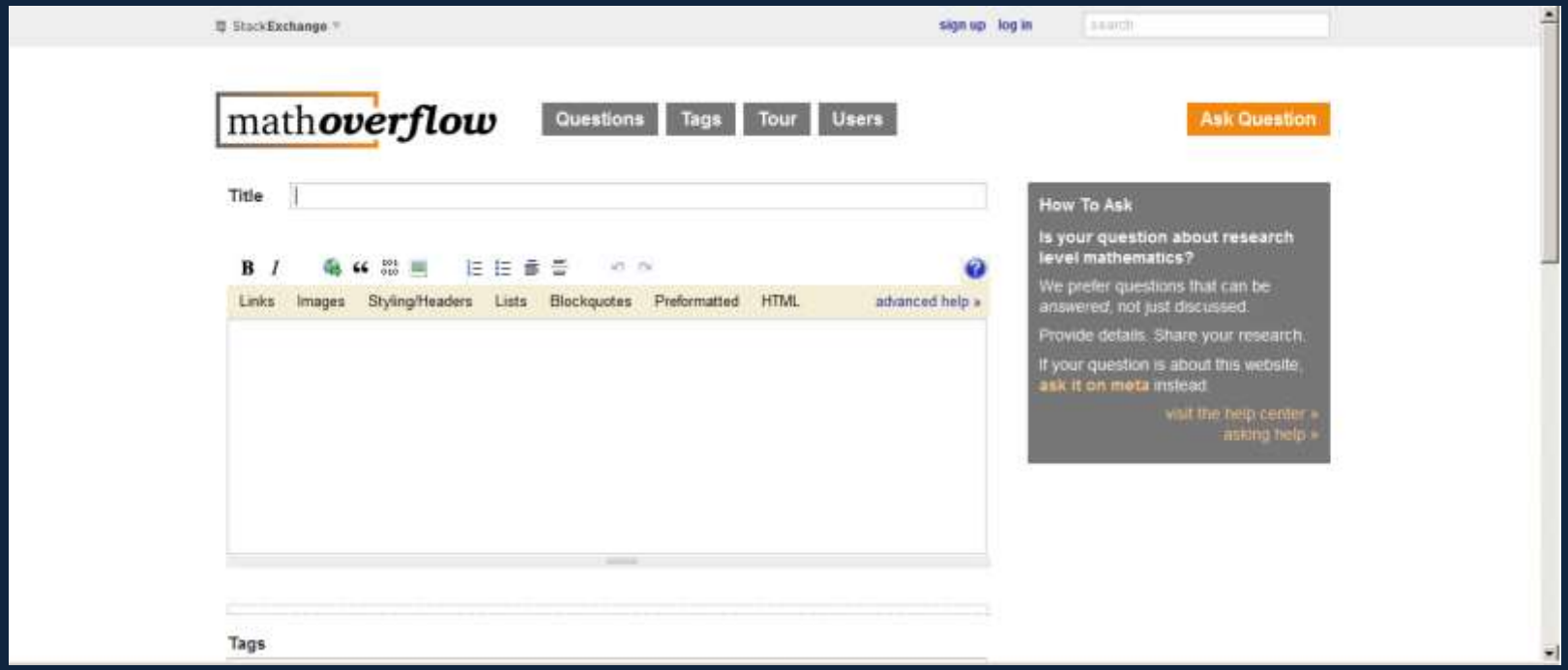

vifamath

# Design for Mathematicians?




ResearchGate

# Design for Mathematicians?

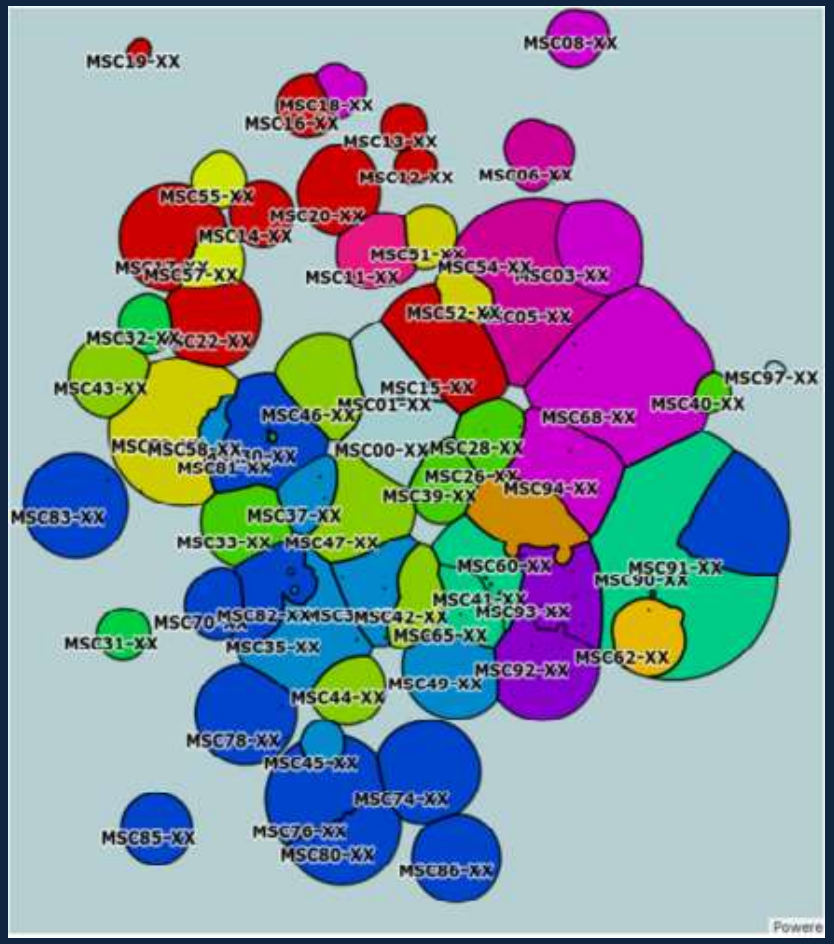



mathoverflow

# Design for Mathematicians?


MathSciNet

# Design for Mathematicians?




MSC Map

# No-Go Questions

- **Which tools** are used by mathematicians for search?
- **What** do mathematicians search for?
- **How often** do mathematicians search?
- Which search engines are **preferred** by mathematicians?

# The Question at Hand

## What is „mathematical search“ all about?

(If we understand what mathematical search is all about, then we should know better how to design math search interfaces.)

# Methodology

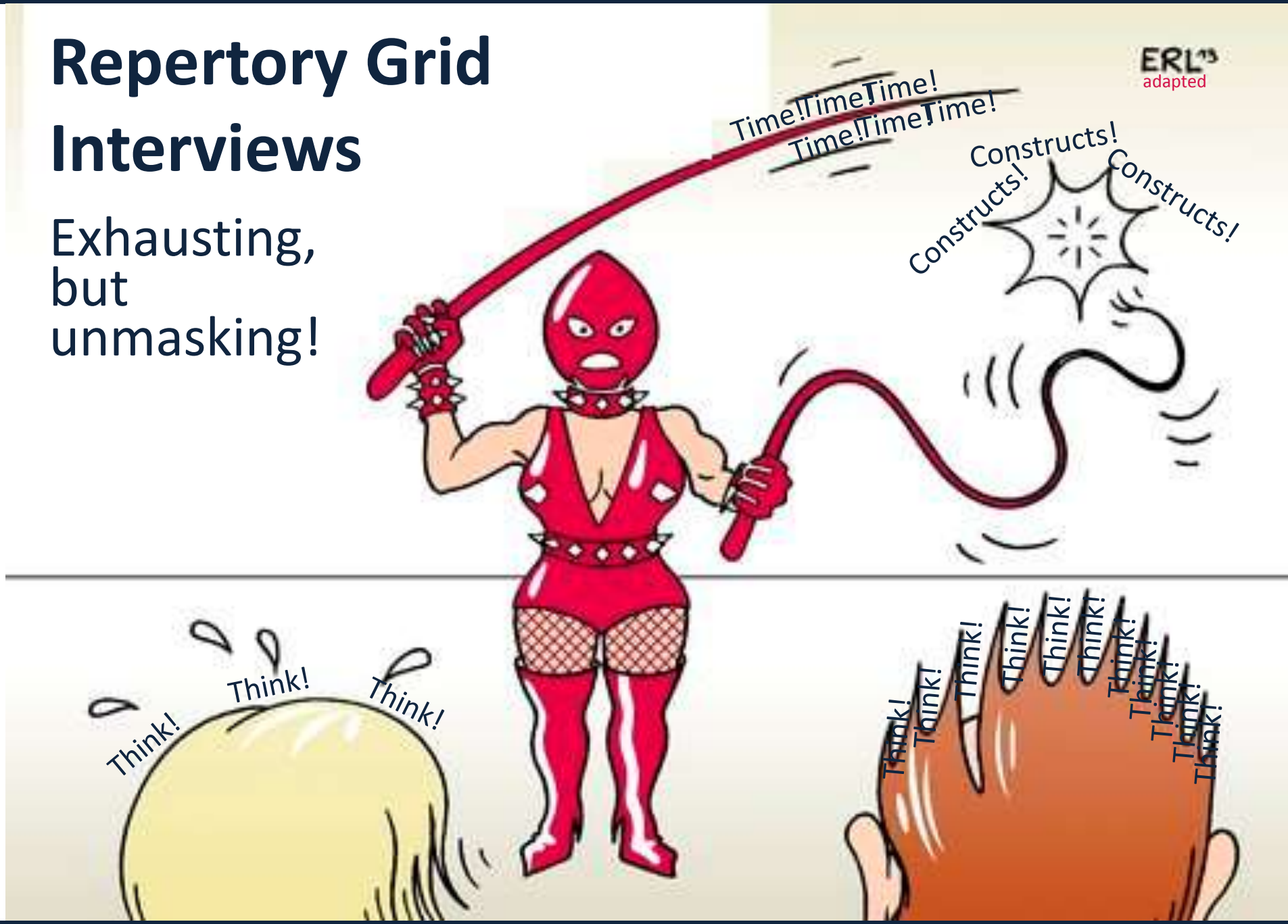
- Quantitative Methods? No!

- Qualitative Methods:
  - Questionnaires?
  - Interviews?
  - Ethnographic field studies?

- Semi-Empirical Method:
  - Repertory Grid Interviews!

# Repertory Grid Interviews

Exhausting, but unmasking!



# Repertory Grid Interviews = RGIs

**„RGI Elements“**

| |
|---|
| zbMathNew |
| zbMathOld |
| MathSciNet |
| Google-Scholar |
| Google |
| myOffice |
| TIB |
| vifamath |

| |
|---|
| myLibrary |
| arXiv |
| ResearchGate |
| mathoverflow |
| myColleagues |
| MSC-Map |
| arXiv-Catchup |
| FormulaSearch |
| Bibliography |

# Repertory Grid Interviews = RGIs

## Procedure

i. The interviewee randomly chooses three RGI elements.

ii. He declares which two of the three elements seem more similar.

iii. He determines the aspect under which these two are more similar and the aspect under which the third one is different.


iv. He evaluates all RGI elements with respect to this construct.

# A Repertory Grid Example

# The RGI Study

**# RGIs:** 22

**Total:** 107 Constructs

| Research Mathematicians | Info-Services-Mathematicians | Non-Mathematicians |
|---|---|---|
| 11 | 5 | 6 |

| 50 Constructs | 28 Constructs | 29 Constructs |
|---|---|---|
| **Average:** | **Average:** | **Average:** |
| 4,54 | 5,6 | 4,83 |

# Repertory Grid Interviews = RGIs

## Empirical Method

## = General Procrustes Analysis

1. Find a consensus grid

   (containing “abstract” constructs Con_1 – Con_n):

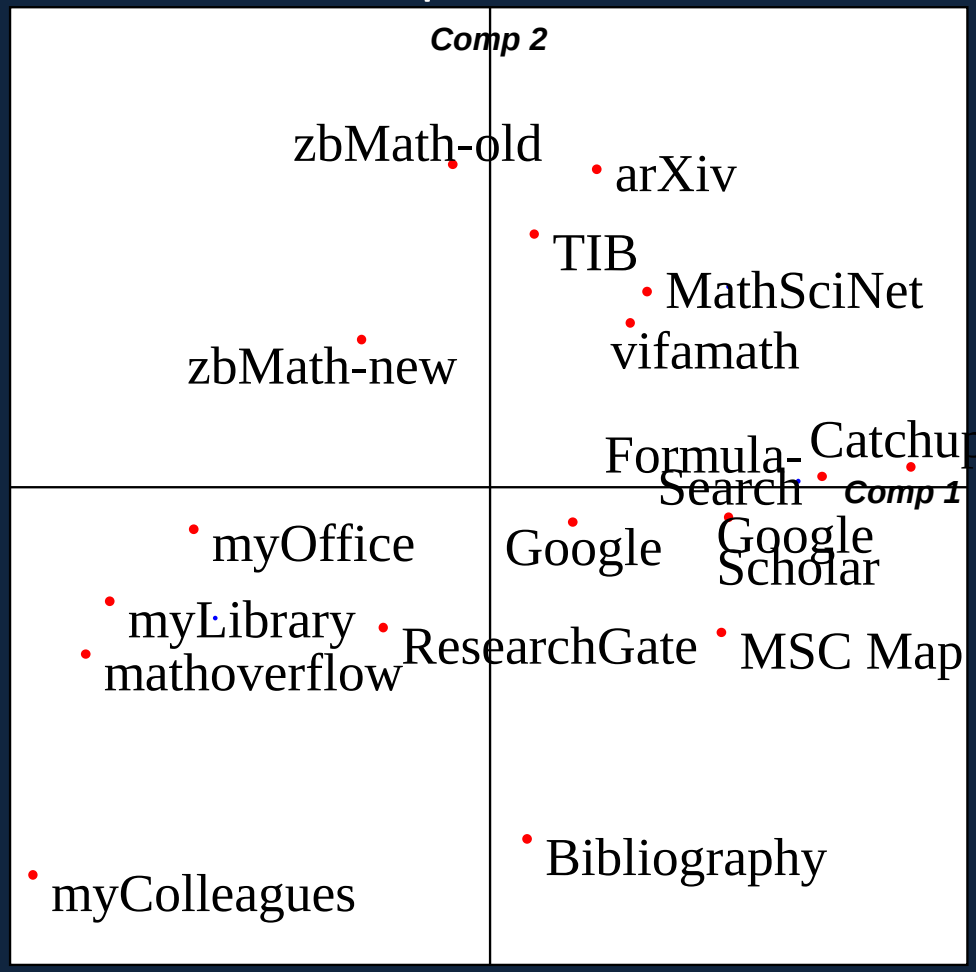
   – comparison of grids wrt the fixed set of RGI elements

2. Conduct a Principal Components Analysis on the consensus grid

   – find the dimensions that differentiate the most between the RGI elements

# Interpretation Tool: Biplot of RGI Elements

2nd Principal Component




1st Principal Component

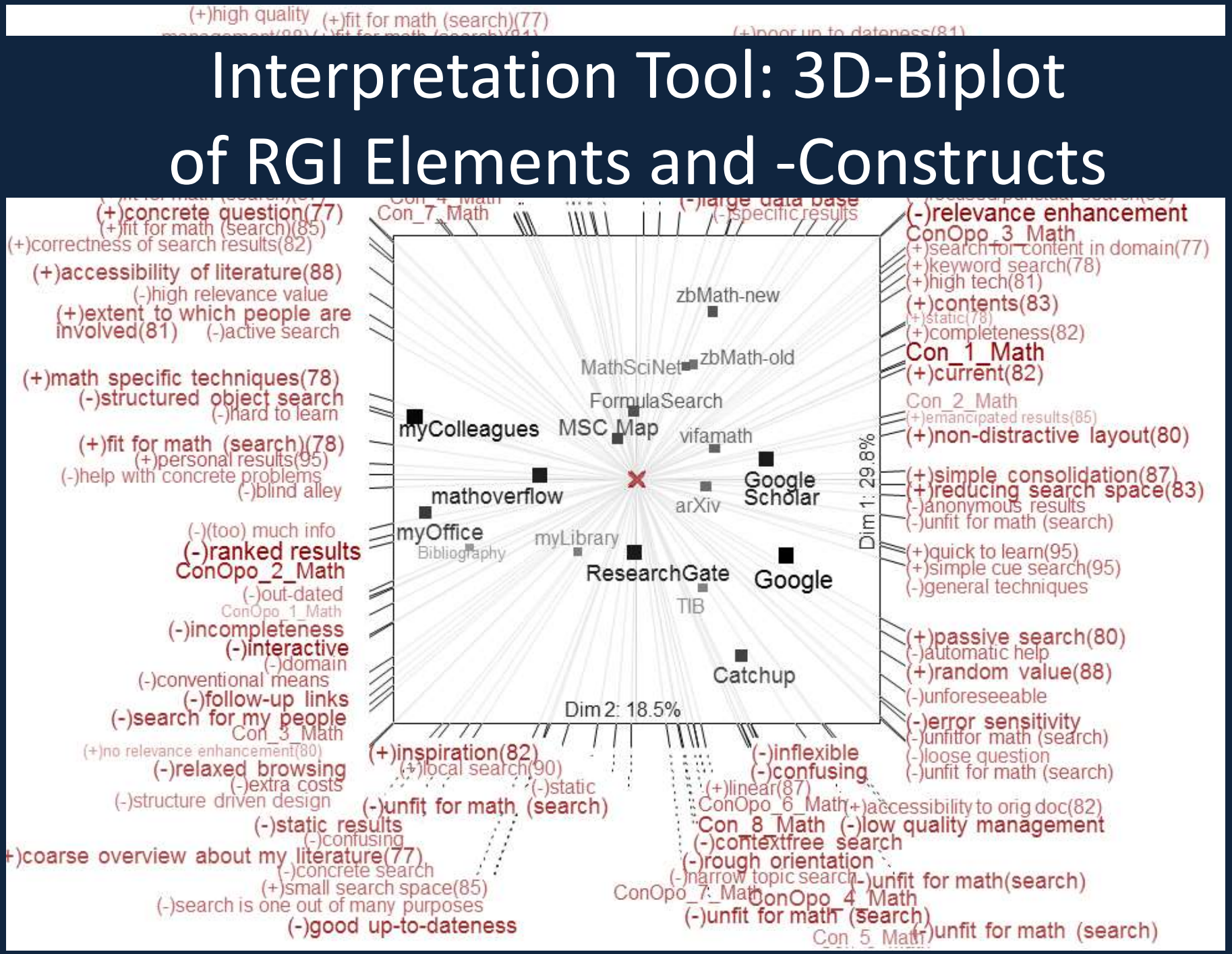
# Repertory Grid Interviews = RGIs

## Empirical Method

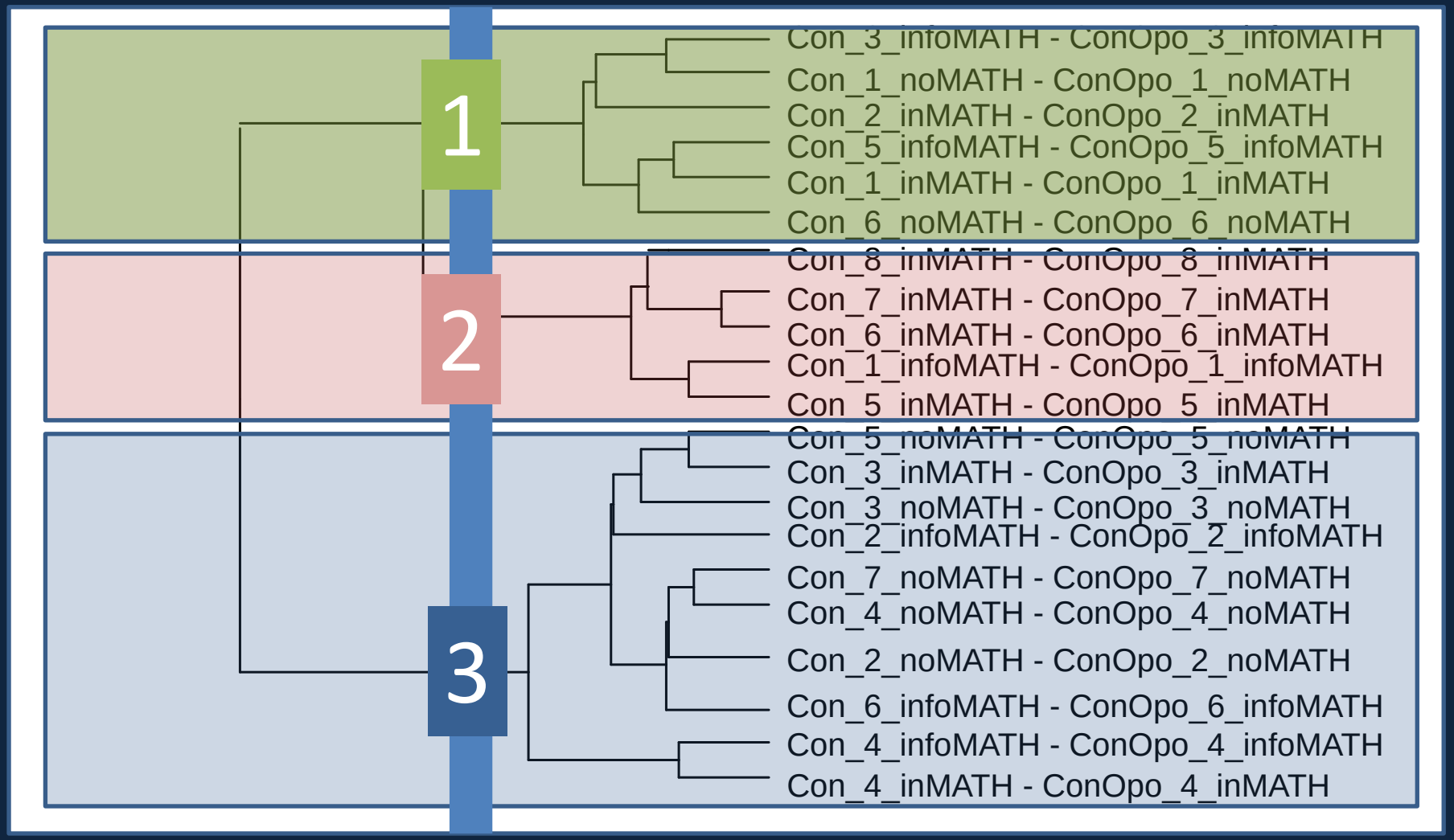
## = General Procrustes Analysis

1. Find consensus grid ...
2. Find Principal Components ...
3. Do a Multiple Groups Components Analysis
   - Recompute relative location of real and abstract constructs and visualize them in the biplot

# Interpretation Tool: 3D-Biplot of RGI Elements and -Constructs



# Interpretation Tool: Cluster Analyis in Form of Dendrogram



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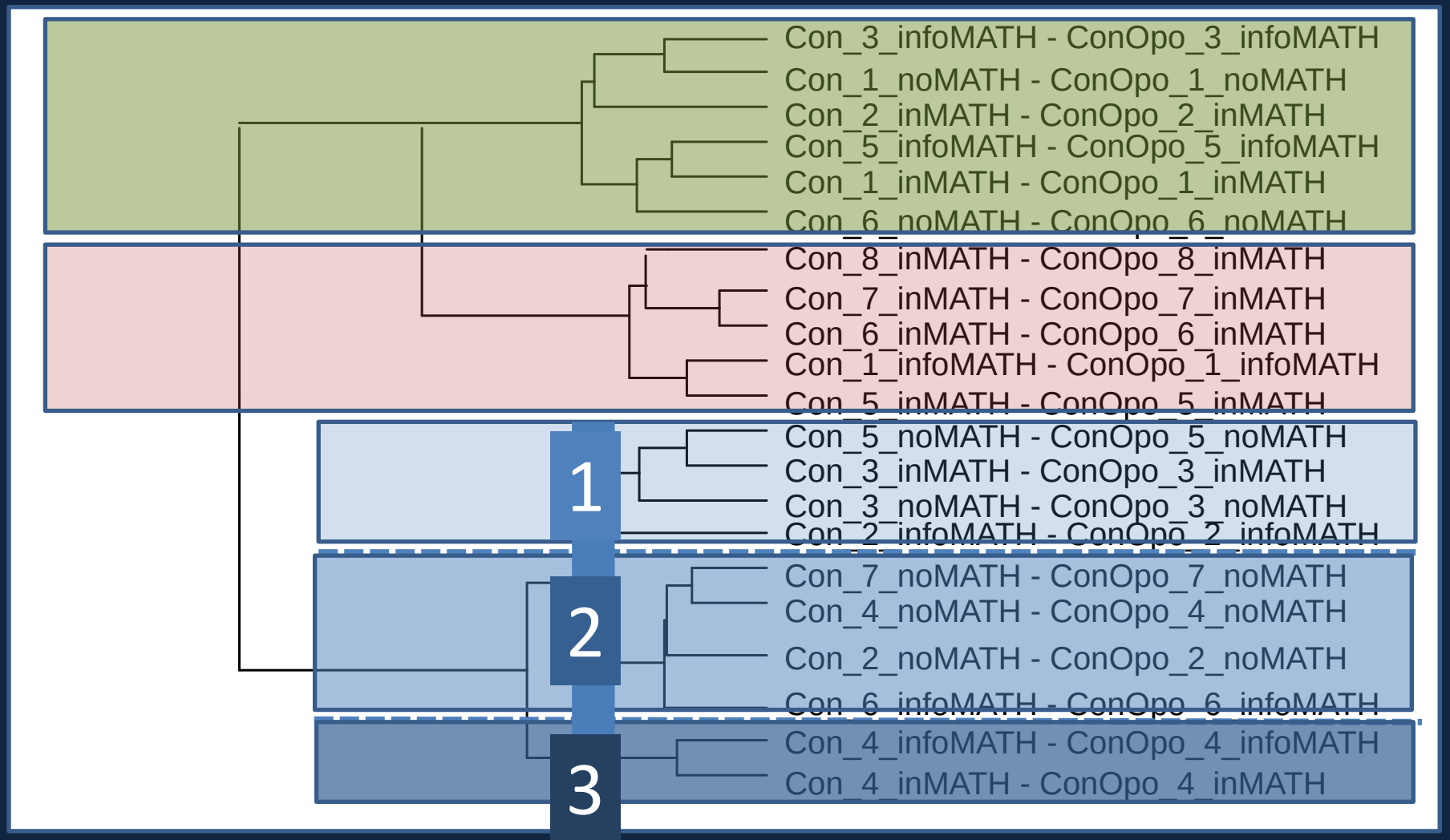
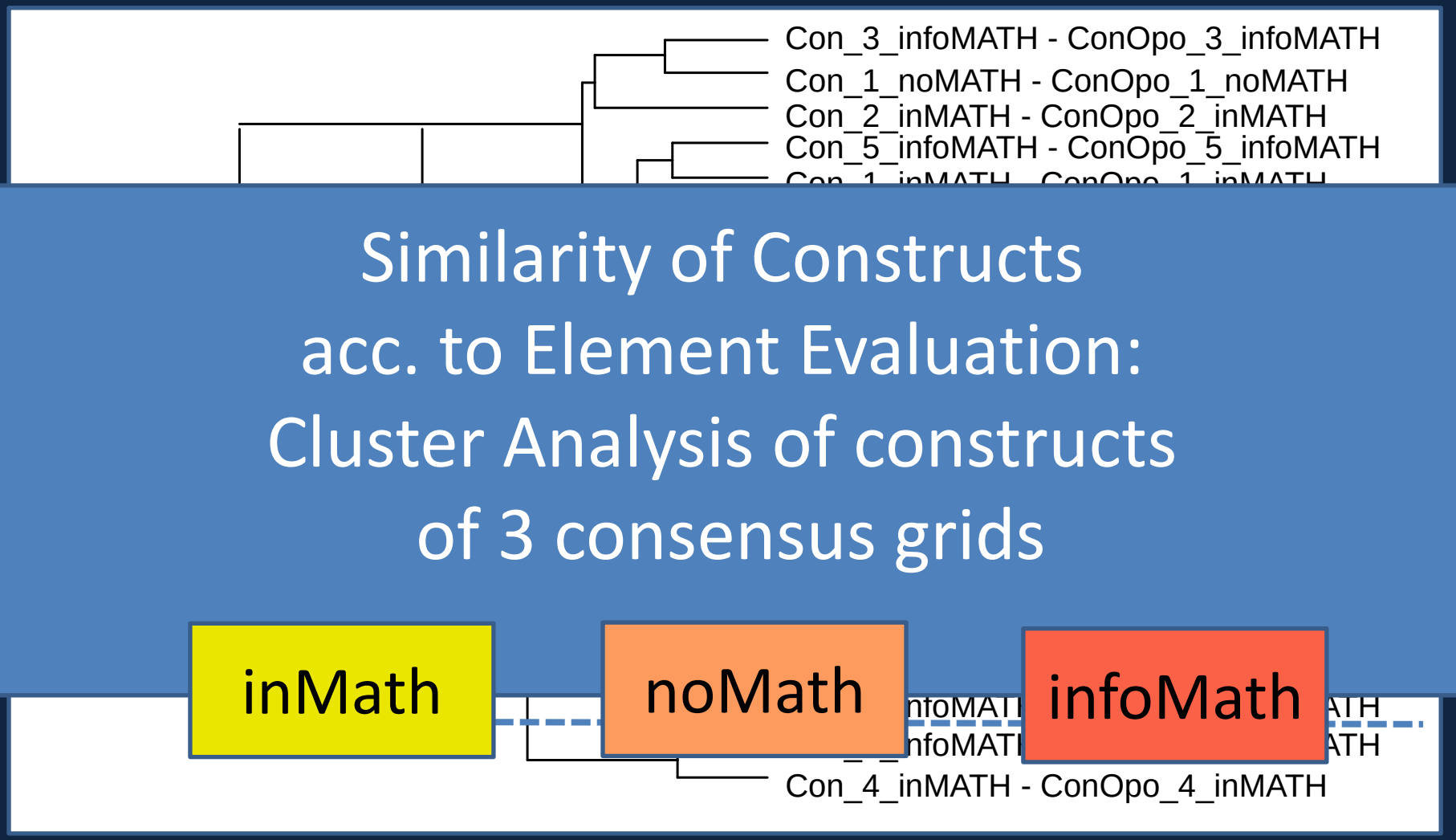


# Cluster of what acc. to what?



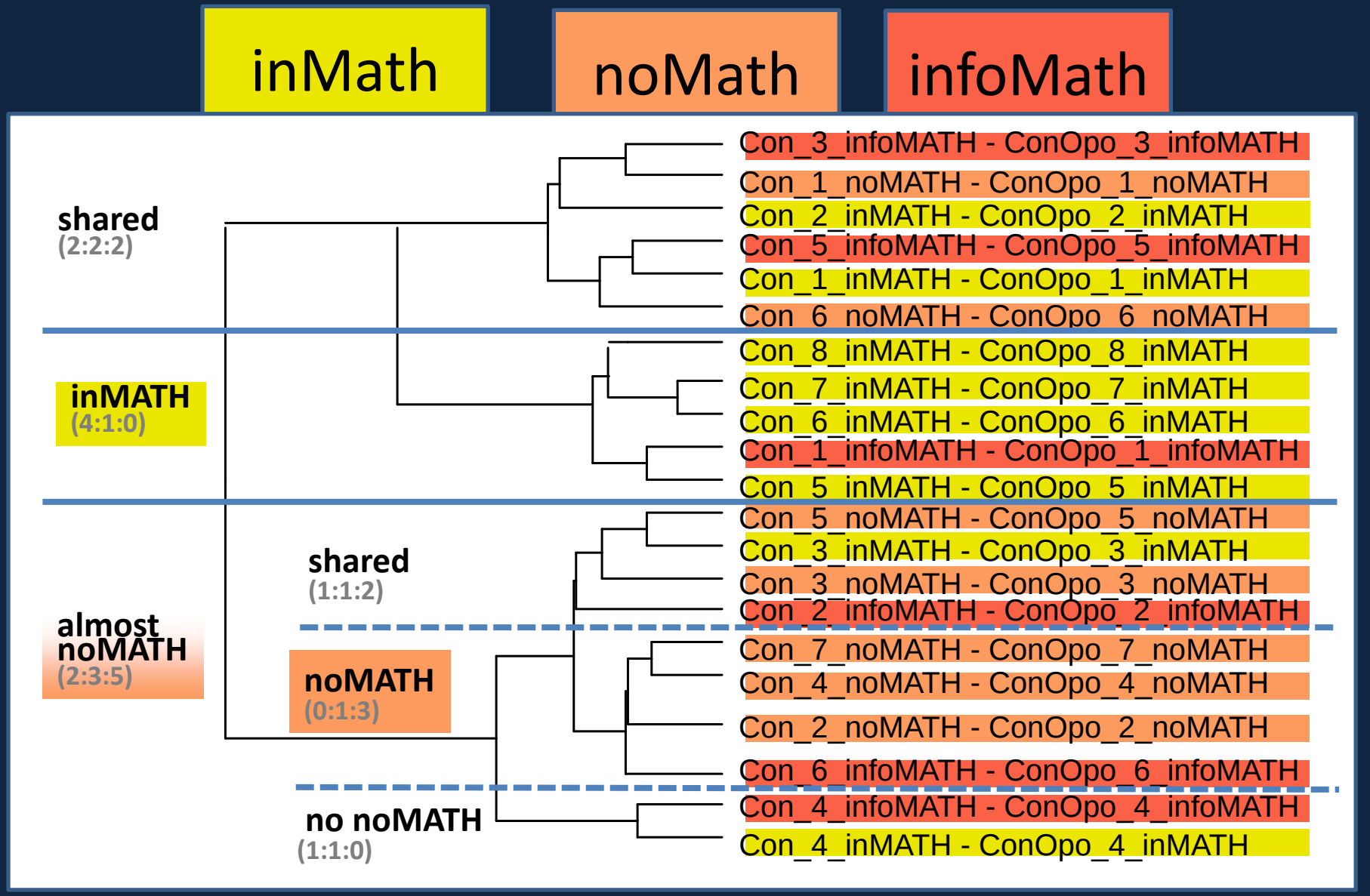

Similarity of Constructs
acc. to Element Evaluation:
Cluster Analysis of constructs
of 3 consensus grids

inMath

noMath

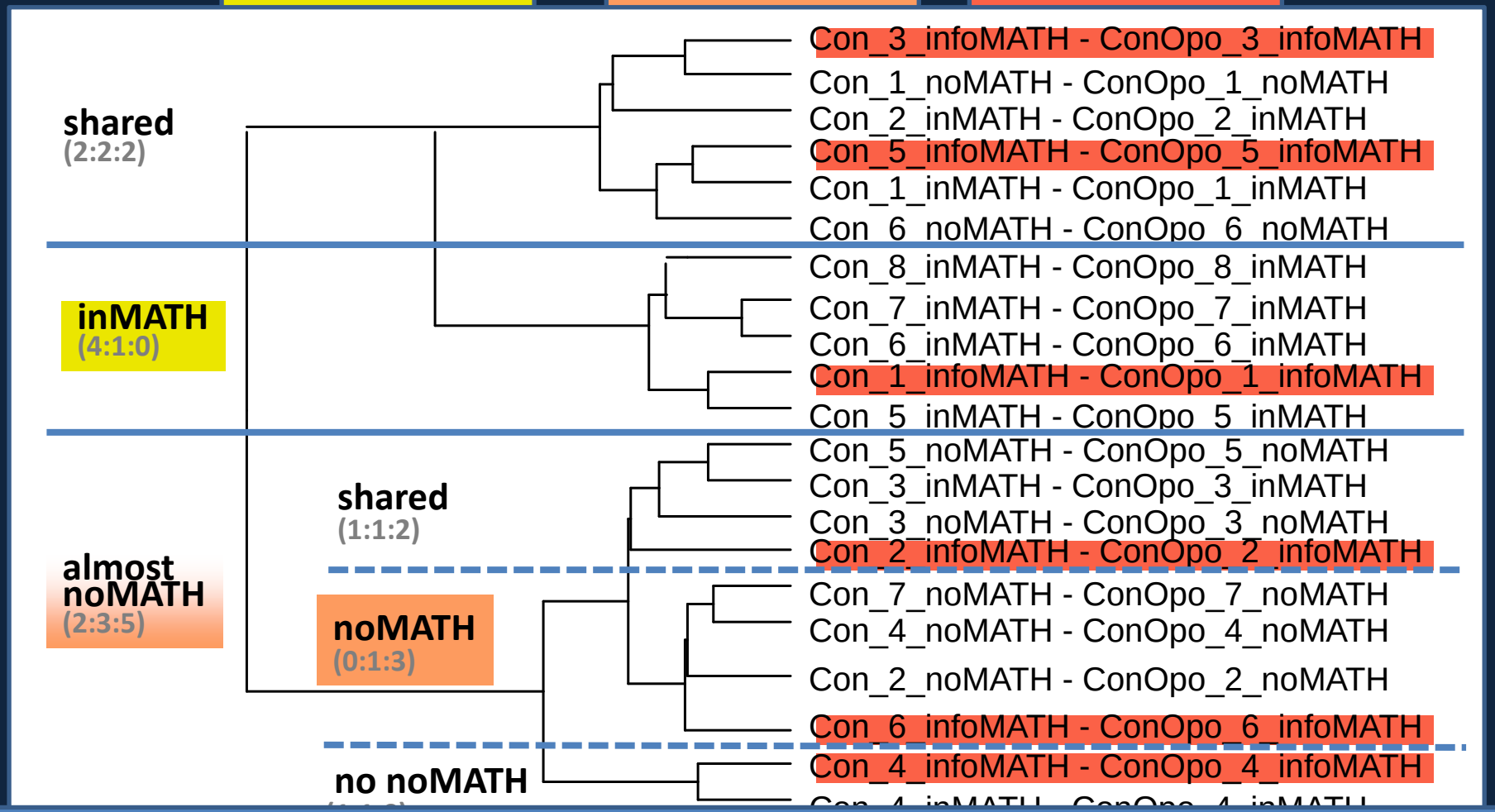
infoMath

# Consensus Grids for 3 Groups



# Result 1

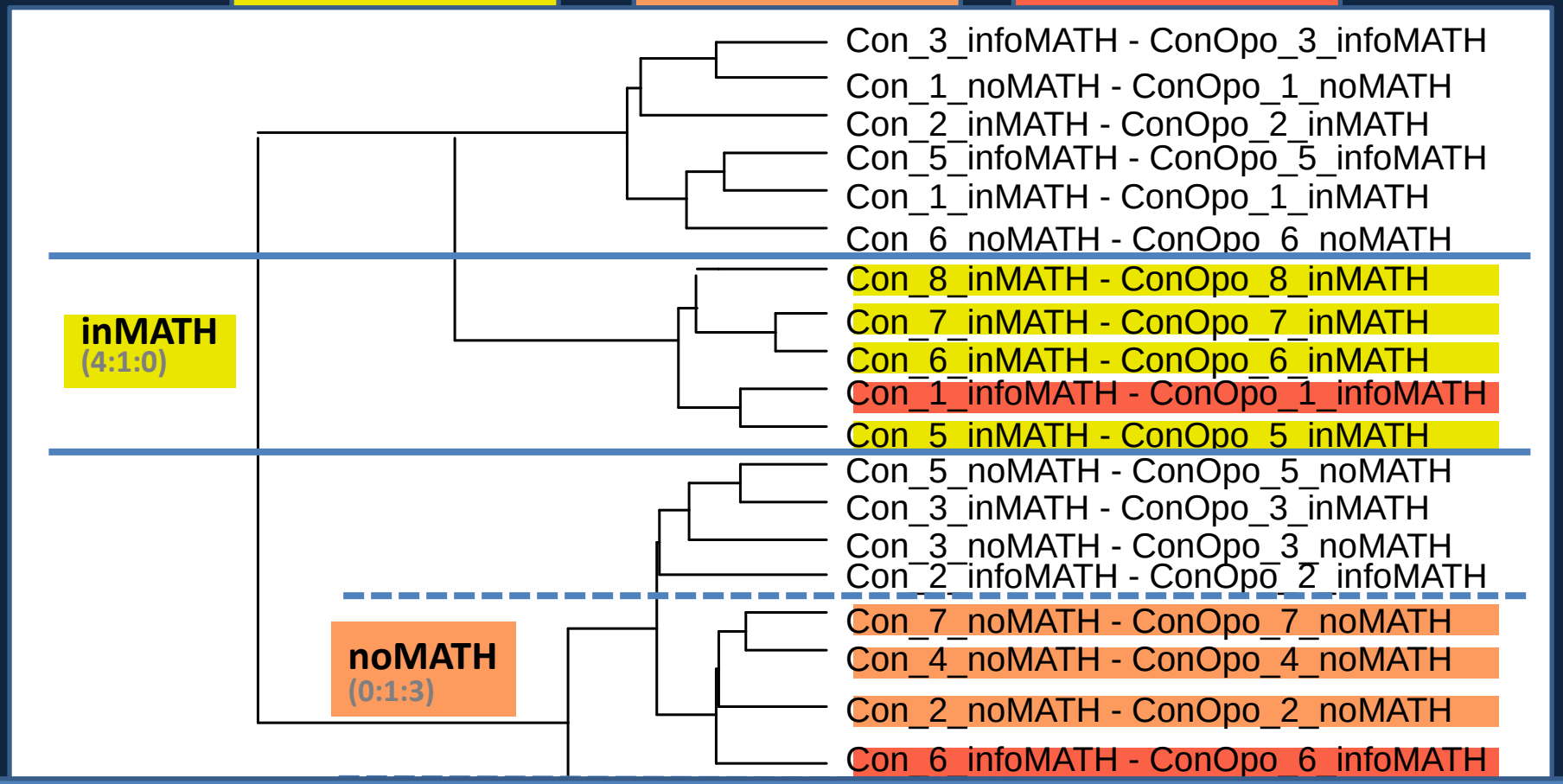
inMath | noMath | infoMath




„Info-Service-Mathematicians are inbetween“

# Result 2

inMath | noMath | infoMath



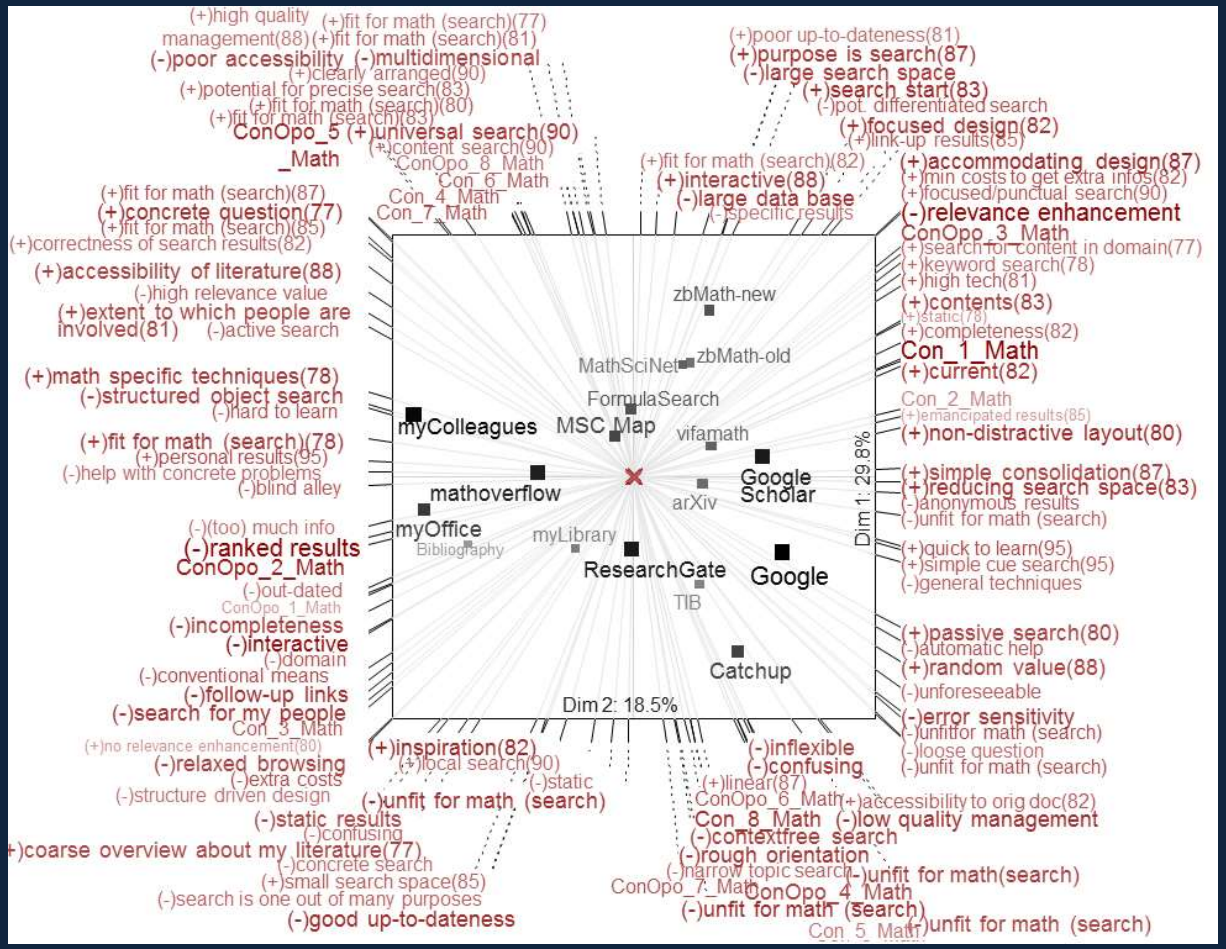

Validation of „Mathematicians are special“

# Relevance Ranking

| | PC_1 | PC_2 | PC_3 | Length |
|---|---|---|---|---|
| Con_6_inMATH | -0.61 | 0.52 | 0.52 | 0.96 |
| Con_7_inMATH | -0.72 | 0.09 | 0.63 | 0.96 |
| Con_5_inMATH | -0.59 | -0.61 | -0.37 | 0.93 |
| Con_1_inMATH | 0.03 | 0.70 | -0.59 | 0.92 |
| Con_4_inMATH | -0.81 | -0.20 | -0.35 | 0.90 |
| Con_3_inMATH | 0.05 | 0.72 | -0.03 | 0.72 |
| Con_2_inMATH | -0.36 | 0.50 | -0.34 | 0.70 |
| Con_8_inMATH | 0.34 | -0.05 | 0.49 | 0.60 |

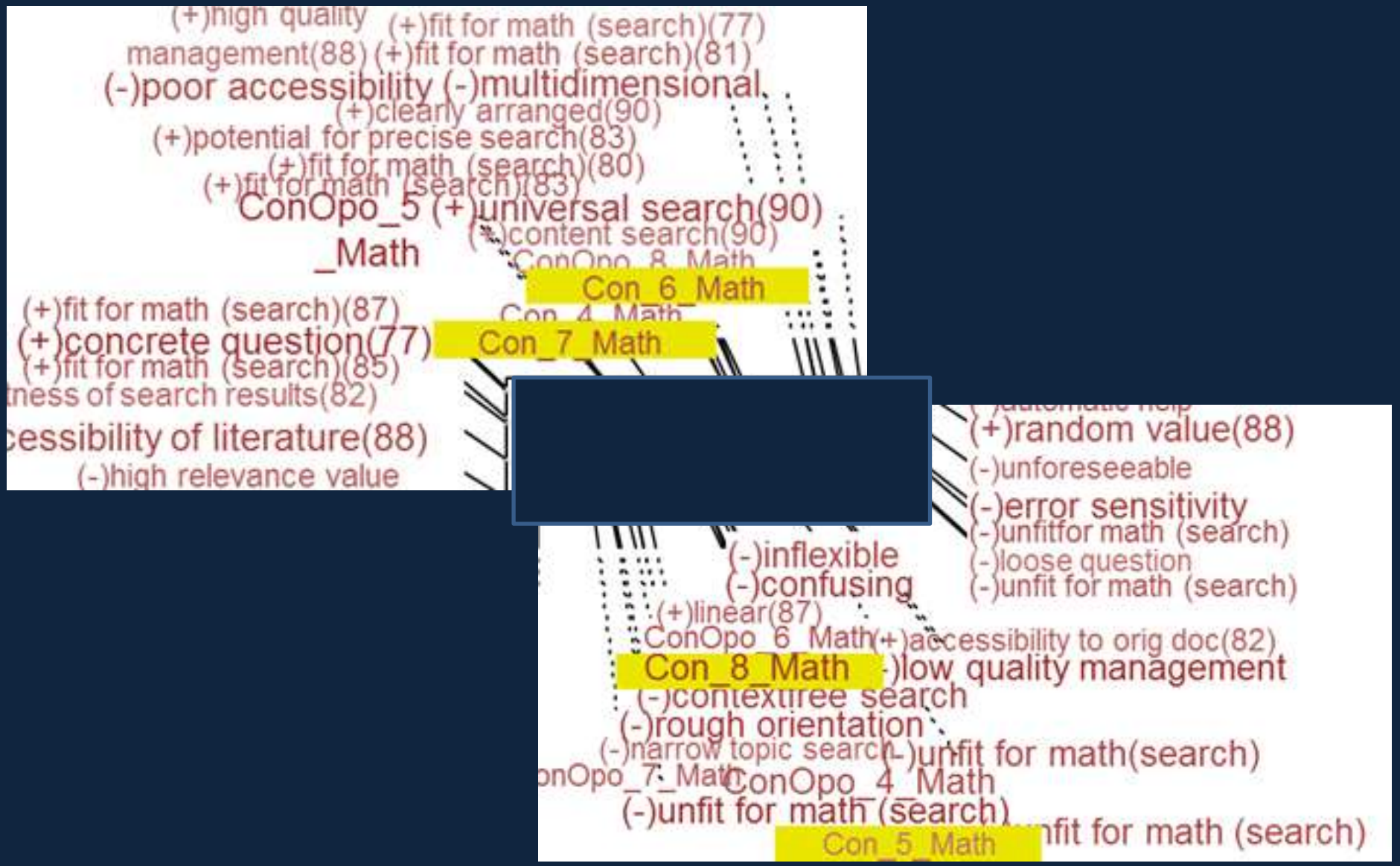
inMath-Specific Constructs

# Relevance Ranking: Interpretation




3D-Biplot

# Relevance Ranking: Interpretation



# Result 3

| Meaning | |
|---|---|
| relev. of results: driven by user | Con_6_inMATH |
| relev. of results: driven by data | Con_7_inMATH |
| precision of input | Con_5_inMATH |
| adequacy: search philosophy | Con_1_inMATH |
| math specificity | Con_4_inMATH |
| adequacy: trustfulness | Con_3_inMATH |
| supportiveness: result | Con_2_inMATH |
| preconditions for search | Con_8_inMATH |

Meaningful, math-specific evaluation schemes

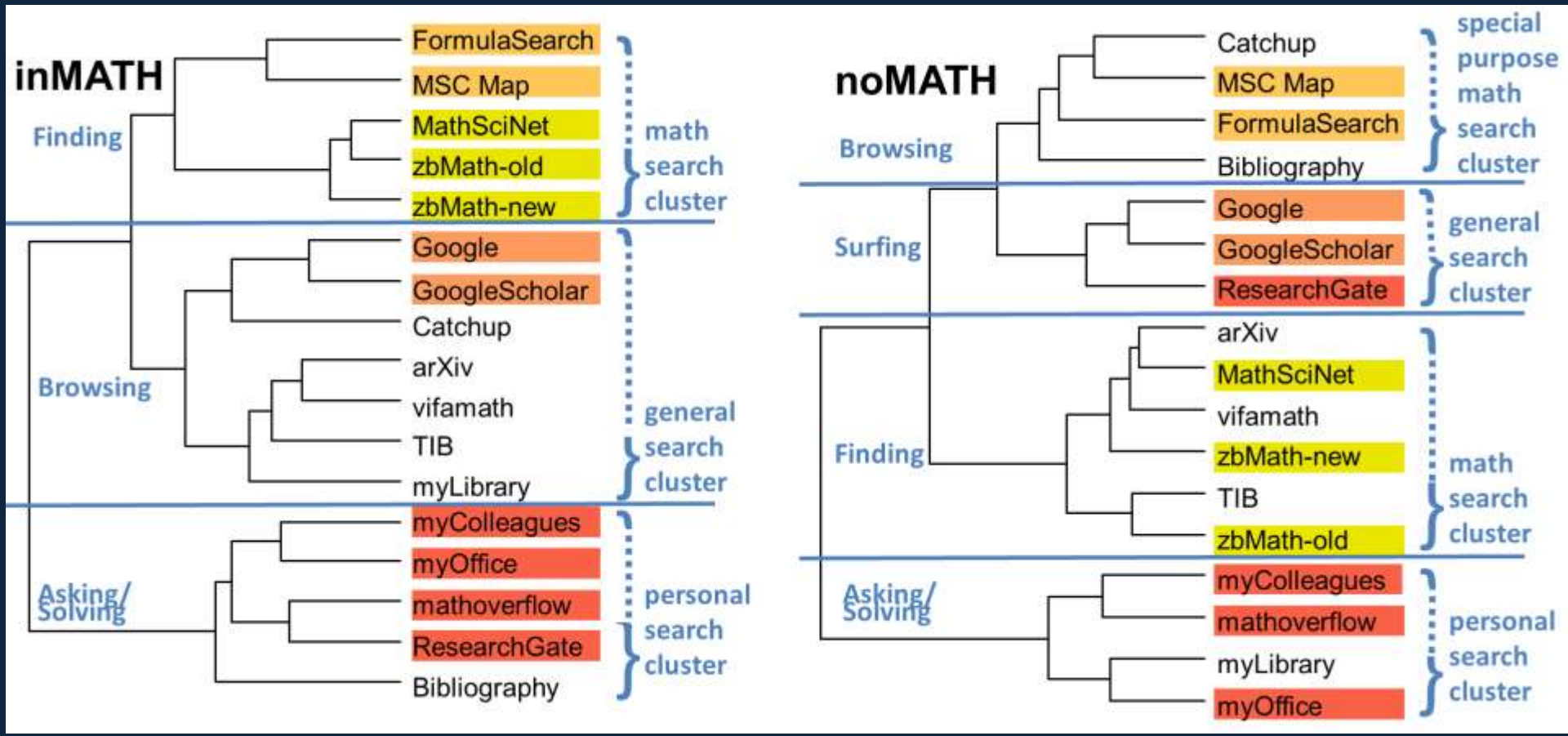
# More Cluster Analysis ...

Cluster analysis of all **elements** for

inMath vs. noMath

Which math search interfaces are more similar than others?

# Mathematicians vs. Non-Mathematicians




Element Clusters

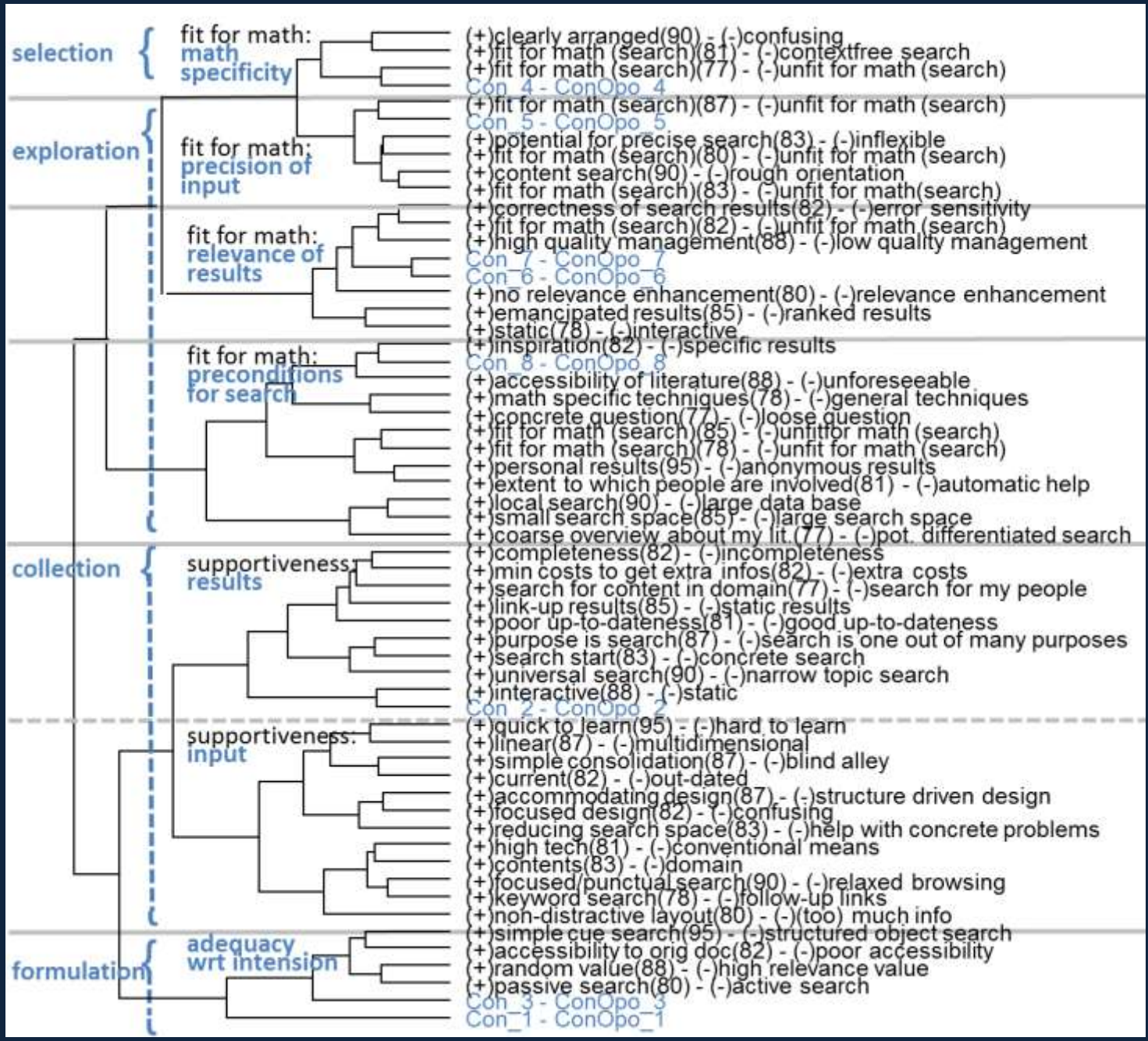
# More Cluster Analysis ...

Cluster analysis of all **constructs** for

inMath vs. noMath

Which evaluation schemes are more similar than others?

# inMATH Construct Clusters



# → Main Result: 10 Patterns

**P 1** "*Mathematicians do not assess mSIs based on familiarity.*"
**P 2** "*Mathematicians trust human and community resources.*"
**P 3** "*Finding is the primary mathematical search task.*"
**P 4** "*Mathematicians appreciate social interaction as a mathematical tool. In particular, it is a mathematical practice to collaborate and exchange feedback.*"
**P 5** "*Mathematicians aim at adopting a search tool as a medium.*"
**P 6** "*Mathematicians appreciate function over form.*"
**P 7** "*Mathematicians care more for the outcome than the input.*"
**P 8** "*Mathematicians want to be empowered in the search process.*"
**P 9** "*Mathematicians base their information search process on transparency of the search result.*"
**P 10** "*Mathematicians expect to find meaningful information in the search result.*"

# Pattern (1/10)

**„Familiarity“:**

Mathematicians do not assess math search interfaces based on familiarity.

D. Bruff: „Stevenson Center 1210“

# Pattern (2/10)

**„Community“:**

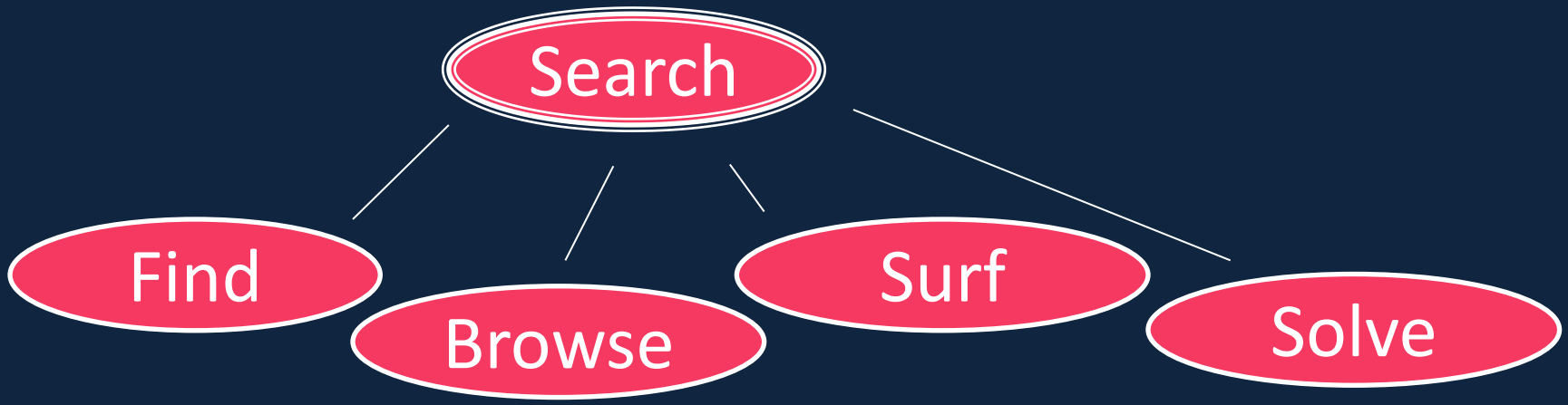
Mathematicians trust
human and community resources.

More so than other communities and more so the older the mathematician.

# Pattern (3/10)

**„Finding“:**

Finding is the primary mathematical search task.



# Pattern (4/10)

**„Social Interaction Tool“:**

Mathematicians appreciate
social interaction as a mathematical tool.
In particular, it is a mathematical practice to collaborate and exchange feedback.

≠ „Mathematicians are social“!

yes: mathoverflow

no, but maybe: ResearchGate

# Pattern (5/10)

**„Medium“:**

Mathematicians aim at adopting
a search tool as a medium.

Medium
= „Extension of Man“

# Pattern (6/10)

**„Function“:**

Mathematicians appreciate function over form.

# Pattern (7/10)

**„Outcome“:**

Mathematicians care more for the outcome than the input.

$$|f_j(x) - f_j(y)| \leq |\mathbf{f}(x) - \mathbf{f}(y)| = \left\{ \sum_{i=1}^{k} |f_i(x) - f_i(y)|^2 \right\}^{\frac{1}{2}},$$

# Pattern (8/10)

**„Empowerment“:**

Mathematicians want to be empowered in the search process.

spiegel.de

# Pattern (9/10)

**„Transparency“:**

Mathematicians base their information search process on transparency of the search result.


themarketingbit.com


marlismatthias.blogspot.com

# Pattern (10/10)

**„Expectations“:**

Mathematicians expect to find meaningful information in the search result.

≠ meaningful search result!

# Summary

**P 1** "*Mathematicians do not assess mSIs based on familiarity.*"

**P 2** "*Mathematicians trust human and community resources.*"

**P 3** "*Finding is the primary mathematical search task.*"

**P 4** "*Mathematicians appreciate social interaction as a mathematical tool. In particular, it is a mathematical practice to collaborate and exchange feedback.*"

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# Conclusion

Mathematicians are special,

you are probably not any longer a mathematician,

make use of the patterns

when considering the pros and cons of a design!



Old zbMath website and wonderful Google

# Conclusion

Mathematicians are special,

you are probably not any longer a mathematician,

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New zbMath website: very similar to Google!

# Conclusion

Mathematicians are special,

you are probably not any longer a mathematician,

make use of the patterns



the pros and cons of a design!

Very noticeable difference!

# Conclusion

Thank you!

Mathematicians are special,

you are probably not any longer a mathematician,

make use of the patterns



the pros and cons of a design!

No noticeable difference for mathematicians

– “*not really*“!