

Measuring and Understanding Interdisciplinarity In Computer Science Doctoral Programs

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In Europe, new doctoral structures are proliferating to prepare interdisciplinary early career researchers.

- Interdisciplinary curricula
- Involvement of faculty members from different fields
- Collaboration with other fields via projects

FACULTY OF **INFORMATICS**



7 Parallel doctoral programs in the **same** faculty

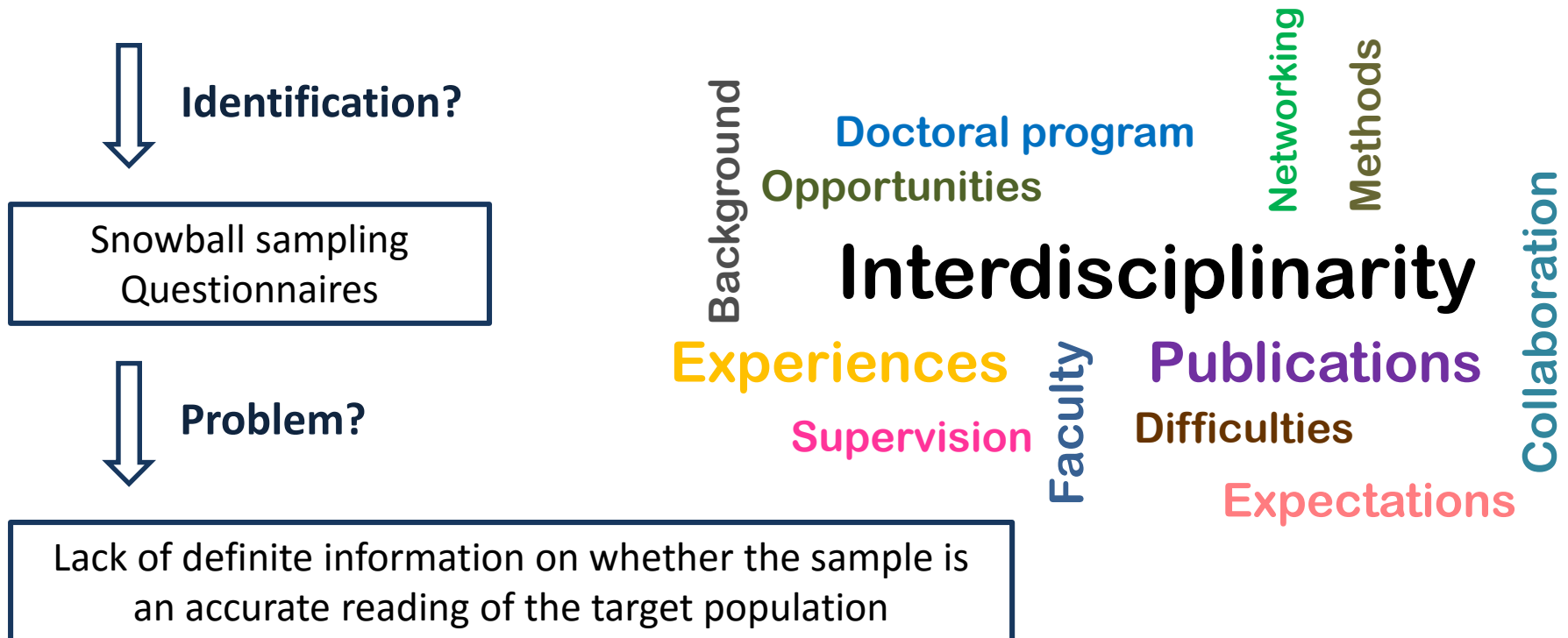
What are the facilitators and obstacles to **InterDisciplinary Research (IDR)** in different Computer Science programs?

We focus on 3 programs:

- Traditional European
- PhD School
 - Covers all research areas of faculty
- PhD College
 - Focuses on one field of expertise
 - Organized by 3 faculties: informatics, mathematics and physics

Step 1: Semi-structured interviews with interdisciplinary students

- Questions developed from the literature

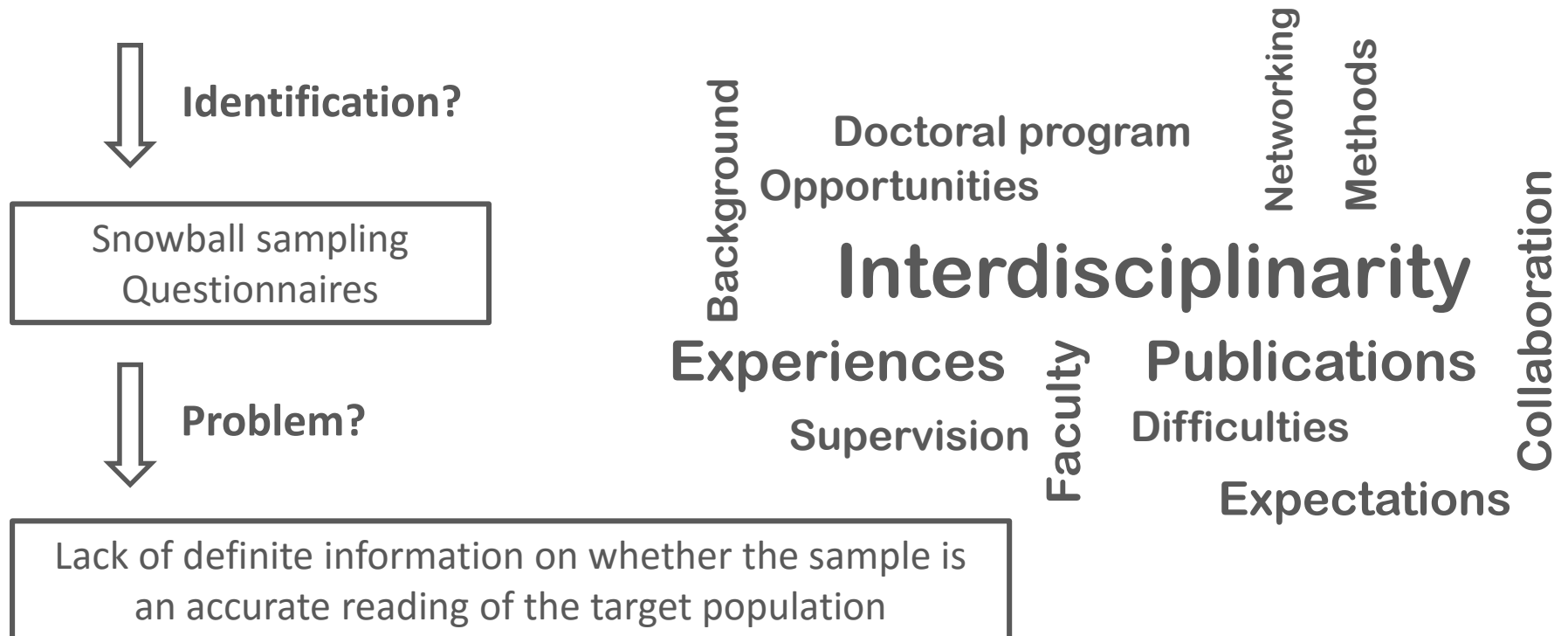


Step 0: Measurement of interdisciplinarity

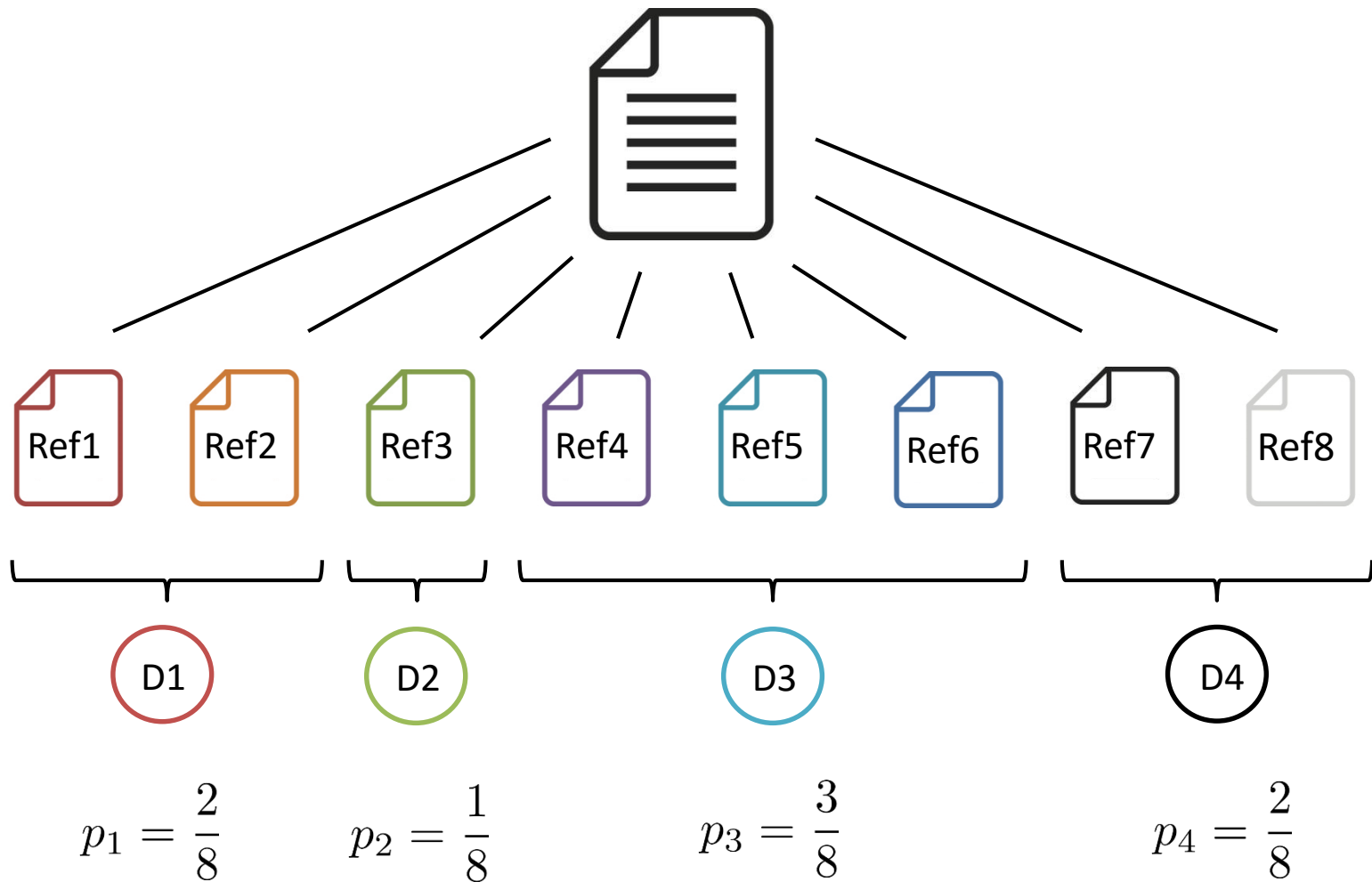
- Bibliographical analysis

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Bibliometric Measurement of IDR



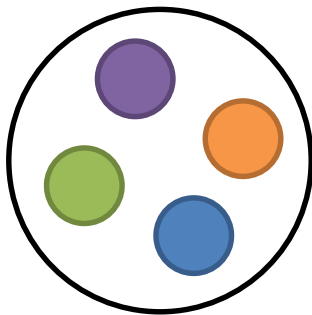
Rao-Stirling diversity index

$$I = 1 - \sum_{i,j} s_{ij} p_i p_j = 1 - \vec{p} S \vec{p}^T$$

S = Disciplines x Disciplines matrix

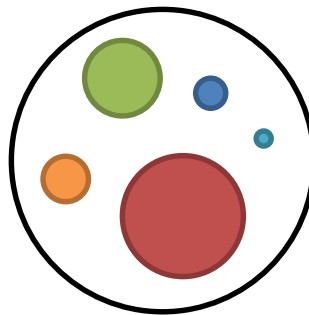
s_{ij} = cosine measure of similarity between disciplines i and j

p_i = proportion of references citing disciplines i in a given paper



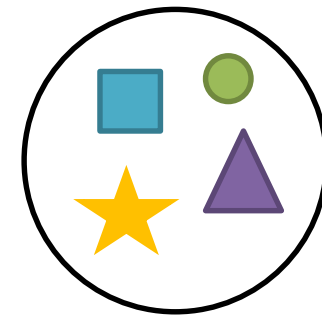
Variety:

Number of
disciplines



Balance:

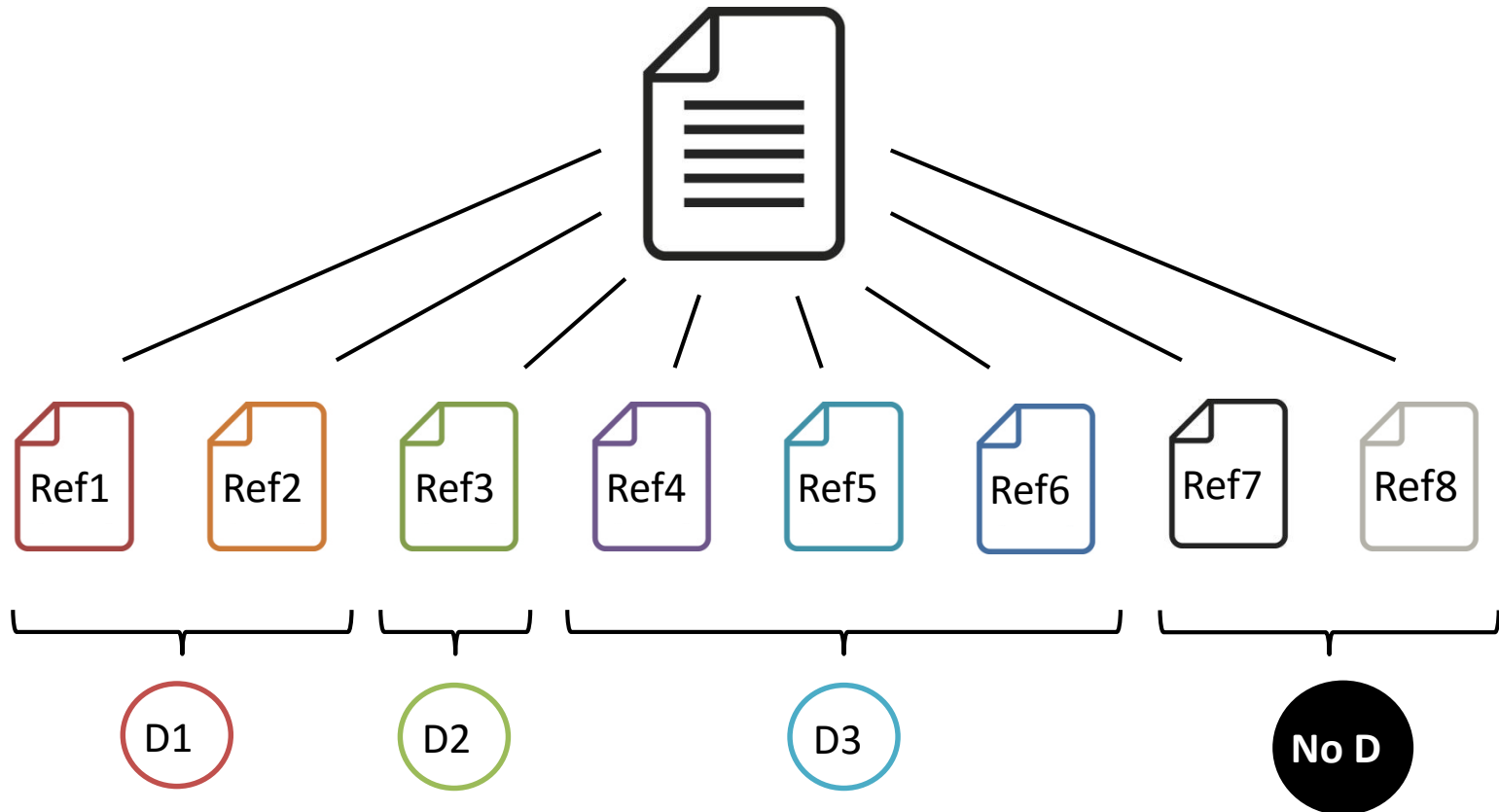
Evenness of the
distribution



Similarity:

Degree of
difference

Problem: Missing categorizations into disciplines





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Web of Science Category Terms

Acoustics
Agricultural Economics & Policy
Agricultural Engineering
Agriculture, Dairy & Animal Science
Agriculture, Multidisciplinary
Agronomy
Allergy
Anatomy & Morphology
Andrology
Anesthesiology
Anthropology
Archaeology
Architecture
Area Studies
Art
Asian Studies
Astronomy & Astrophysics
Automation & Control Systems
Behavioral Sciences
Biochemical Engineering

A total of 249 disciplines

- Web of Science only categorizes journals into disciplines
- Conference publications are not categorized into disciplines

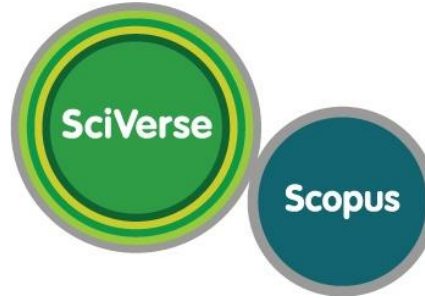


Problem?

Computer Science mainly publishes in conferences!



TECHNISCHE
UNIVERSITÄT
WIEN
Vienna University of Technology



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WEB OF KNOWLEDGESM

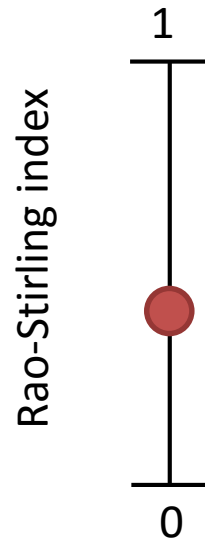
- # students: 223
- # students' publications: 1746
- # students' references: 16817
- **Categorized references: 43%**



Too many missing
categorizations for a
bibliometric analysis!

Solution: Extension of the Rao-Stirling index with an interval of uncertainty for interdisciplinarity measurements

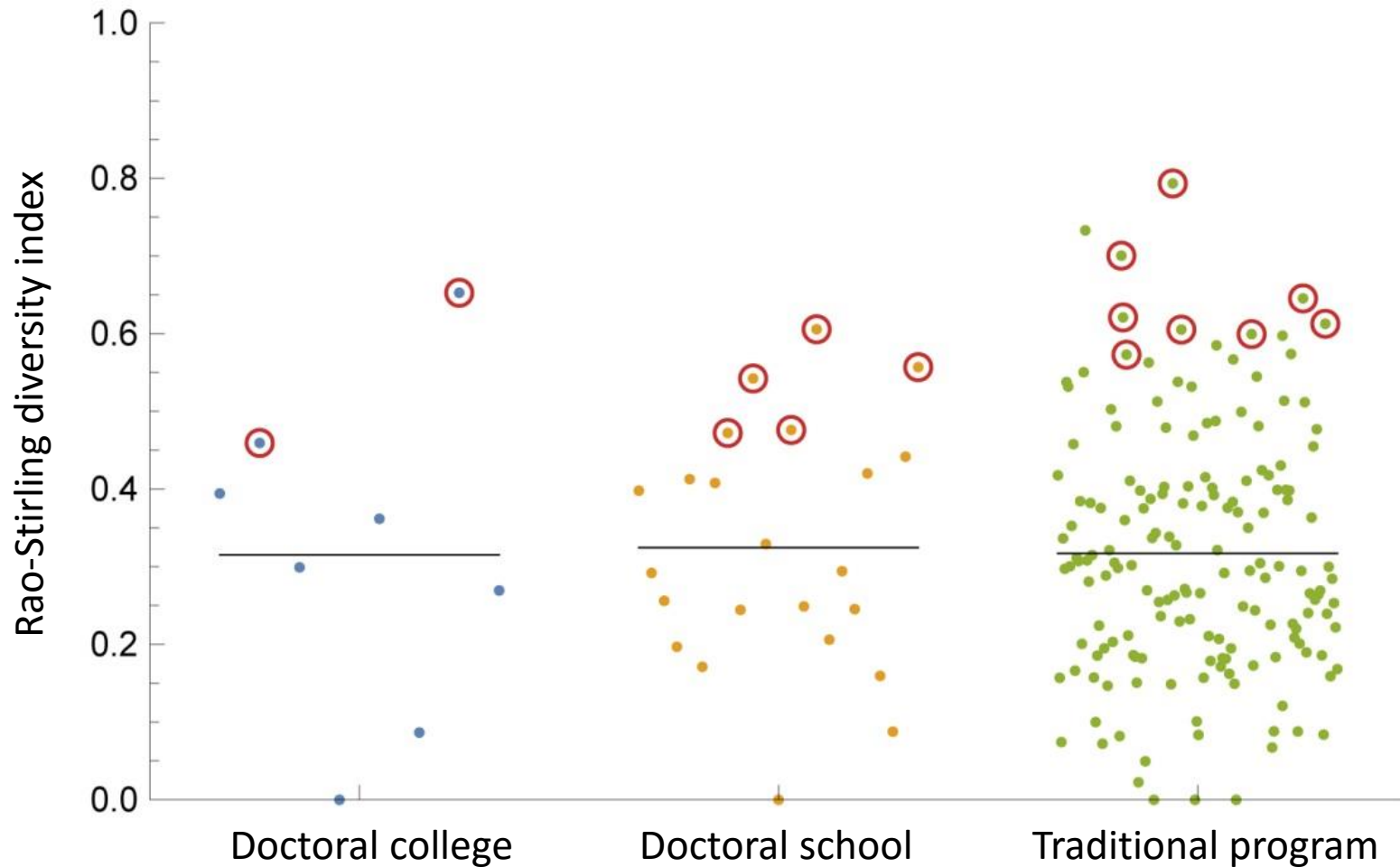
- Continuous and discrete optimization
- Graph-based pruning



- [1] Calatrava Moreno, M.C., Auzinger, T., and Werthner H. (2015). *On the uncertainty of interdisciplinary measurement due to incomplete bibliographic data*. Scientometrics.
- [2] Calatrava Moreno, M.C, Auzinger, T. (2016). *R package “robustrao”*. Available in CRAN

Students' interdisciplinarity

Integration of disciplines in the students' publications



Step 0: Measurement of interdisciplinarity

- Bibliographical analysis

Step 1: Semi-structured interviews with interdisciplinary students

- Questions developed from the literature
- 50-80 minutes
- 15 participants



Factors and processes allowing IDR:

One would expect influence from:

- ~~Participation of different faculties~~
- ~~Interdisciplinary research projects~~

- [3] Calatrava Moreno, M. C., and Danowitz, M. A. (2016). *Becoming an Interdisciplinary Scientist: an Analysis of Students' Experiences in Three Computer Science Doctoral Programmes*. Journal of Higher Education Policy and Management.
- [4] Calatrava Moreno, M. C., and Danowitz, M. A. (Conditionally accepted). *Interdisciplinarity in Computer Science: Emergent patterns from doctoral experiences*. ACM Transactions on Computing Education.

Findings > Factors and Processes

- Individual background characteristics
 - Values
 - Motivation
 - Previous skills and experiences
- Policy and financial factors
 - Funding
 - Autonomy
- Supervision and networking
 - Supervision and co-supervision
 - Collaboration

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Funding & autonomy



Two main forms of inter-/multidisciplinary research in computer science:

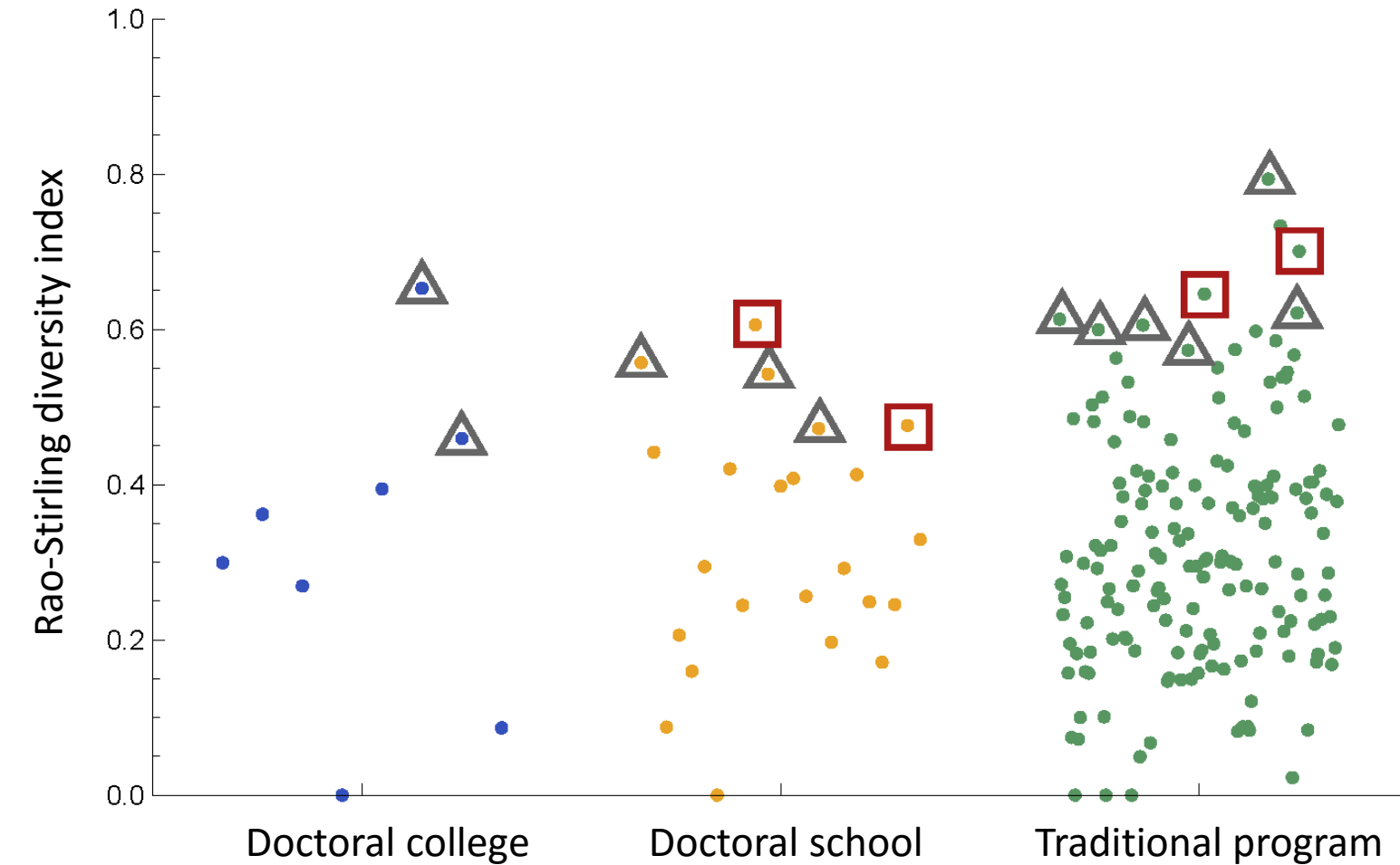
Intersection CS + Other discipline:

- E.g., Bioinformatics, artificial intelligence, medical informatics
- This combination of disciplines is likely to receive further funding and be continued in the future

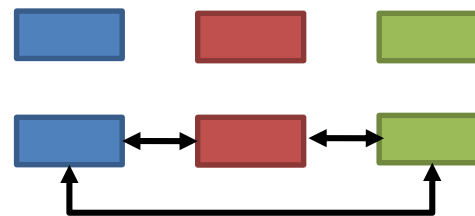
CS applied to other discipline:

- E.g., Information science applied to financial analysis, genetic analysis, etc.
- The next project might apply CS to a complete different discipline

Findings > Factors and Processes



△ Multidisciplinary students
□ Interdisciplinary students



Contrasting student quotes

“I think the scholarship gave me the possibility to discover my topic. I doubt I would have been able to do that if I would have had a specific customer for my research, like the research institute, or a project with a more defined problem.”

Interdisciplinary student in the doctoral school with **scholarship**

“I am given the description of their problem, data and the expected result. From that point on I do not receive any more input from them.”

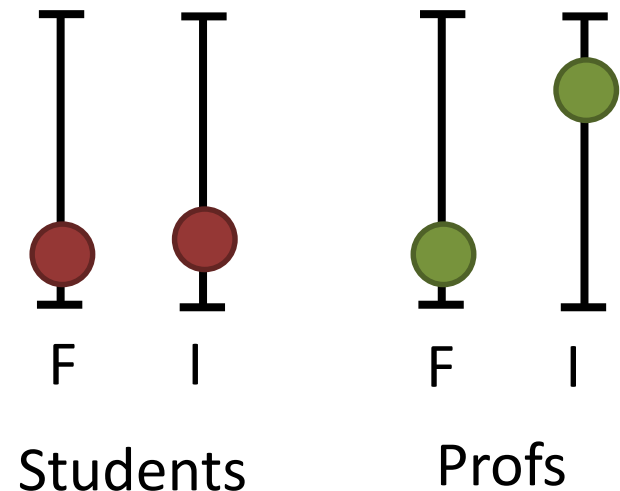
Multidisciplinary student in the doctoral college with **project assistantship**

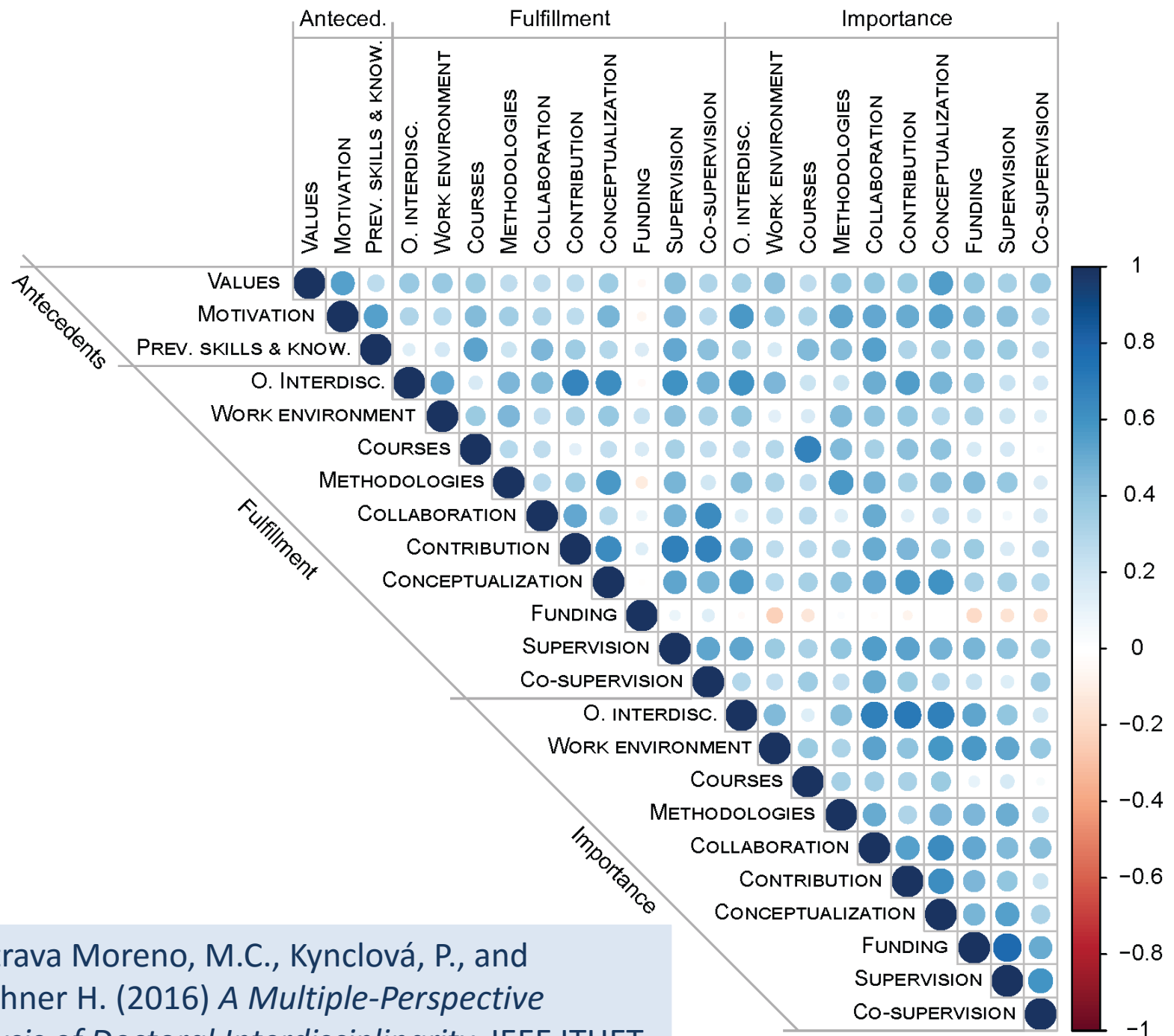
Step 0: Measurement of interdisciplinarity

Step 1: Semi-structured interviews with interdisciplinary students

Step 2: 360-degree survey of interdisciplinary factors and processes

- Respondents: Doctoral students, post-docs, (visiting) professors, department directors, funding agencies
- Factors and processes selected from literature and previous analysis
- Assessment of fulfillment and importance





[6] Calatrava Moreno, M.C., Kynclová, P., and Werthner H. (2016) *A Multiple-Perspective Analysis of Doctoral Interdisciplinarity*. IEEE ITHET.

Conclusions

- Funding for IDR might not result in truly IDR
- Funding for interdisciplinary students should provide them the necessary research autonomy to conduct a different kind of research
- The funding of the truly interdisciplinary students is more precarious
- IDR strategies are interrelated with other factors and processes that play important roles: giving rise to IDR in programs without interdisciplinary focus, and compromising the interdisciplinary goals of interdisciplinary programs
- Distinctive contribution: Analysis based on the combination of different approaches to analyze various aspects of interdisciplinarity

Thank you

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