

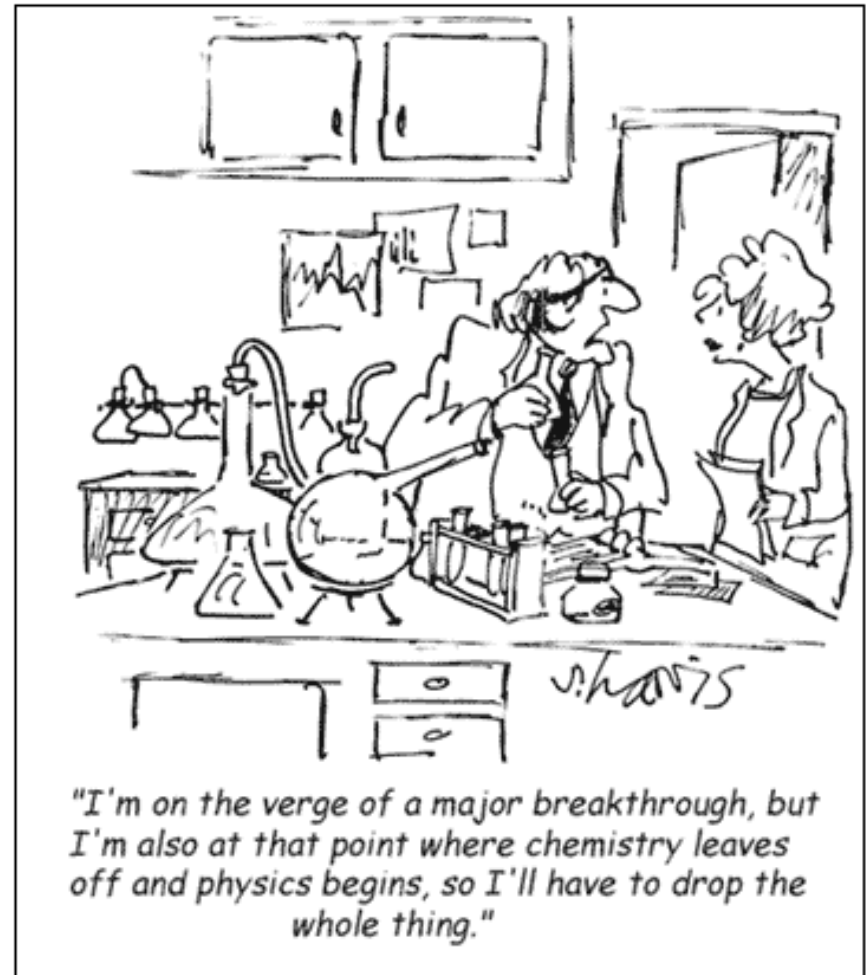
What is successful interdisciplinary research collaboration, why is it difficult, and how can it be easier?



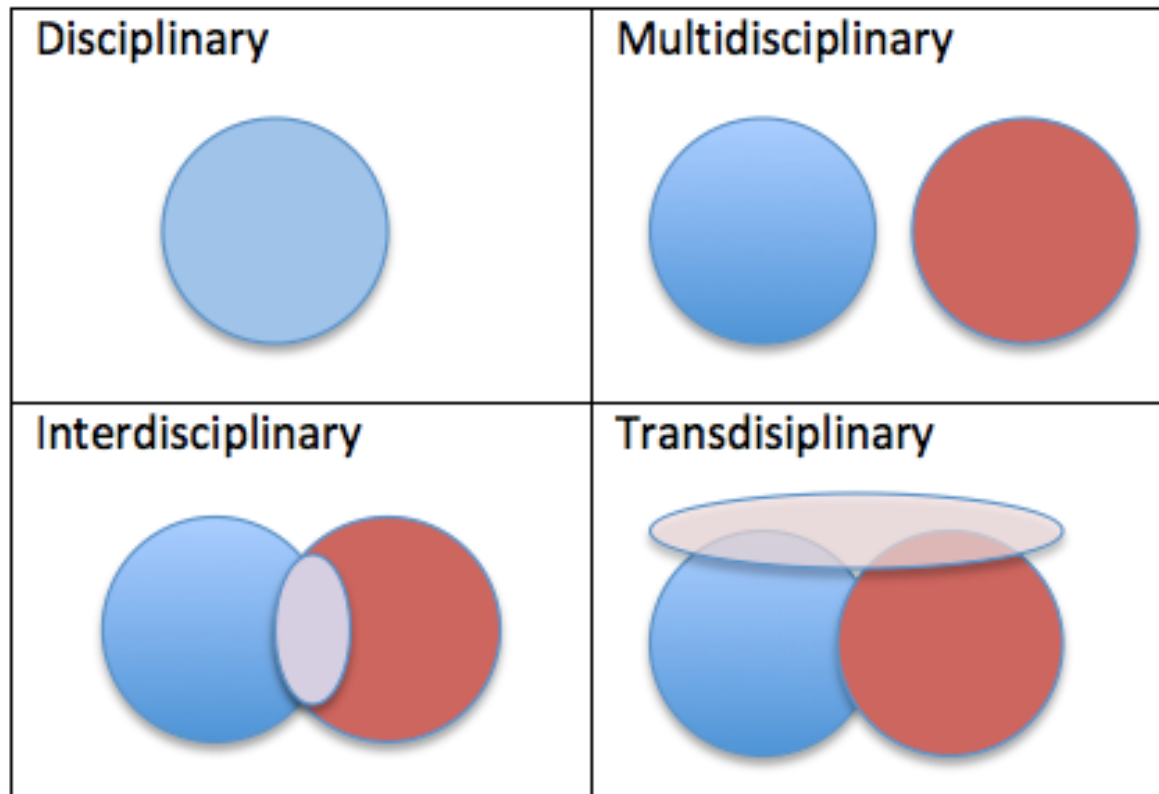
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Interdisciplinary research: why?

- Real world problems
- Unanswered questions
- Generating new research questions, and methods, to answer as yet, unidentified research challenges



Multidisciplinary, interdisciplinary, transdisciplinary



From: <https://www.totalcommunication.com.sg/>

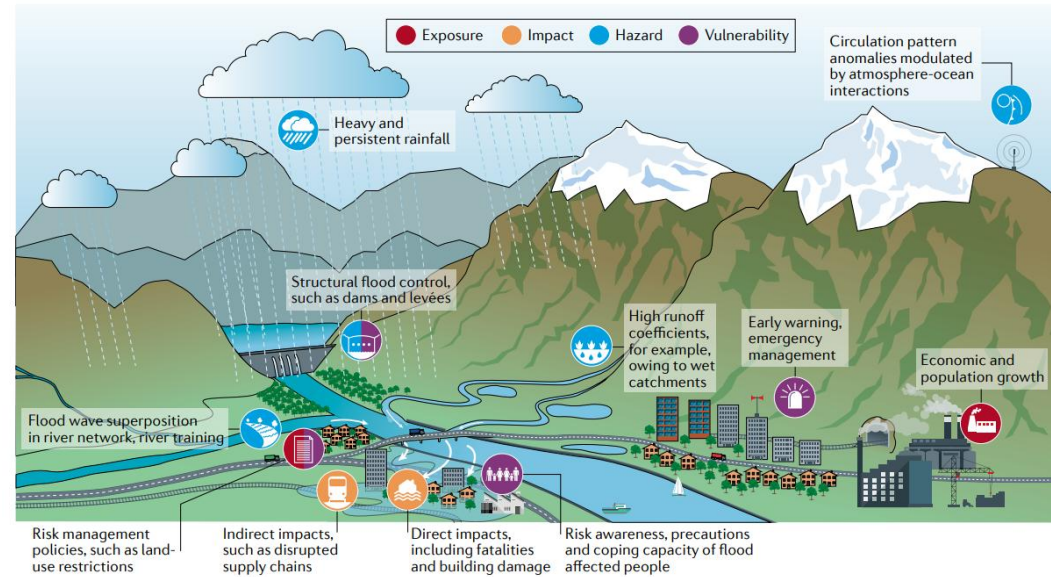
Cross-disciplinary as a catch-all term.....

Many interdisciplinary programmes and projects

Societal important: health, education, natural resources and management, pollution, hazards (e.g. floods)

Scientific importance:
Systems, that involve multiple, linked processes and scales

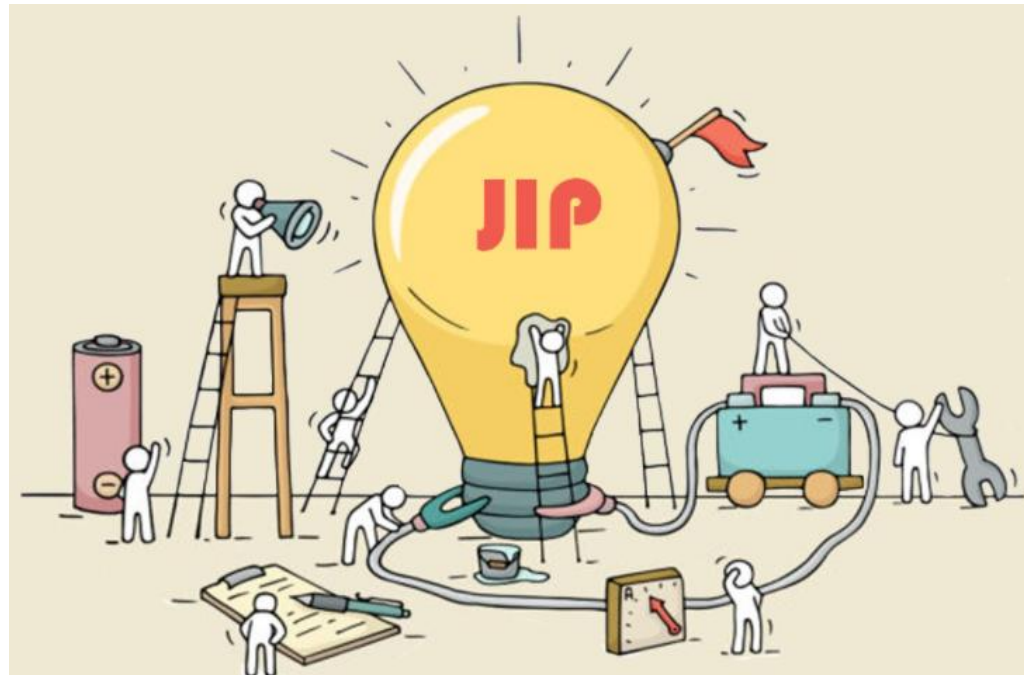
Educational importance:
Graduates are needed with skills to integrate across different fields and disciplines



Interdisciplinary programmes and projects

How to evaluate them to determine, i) their value and ii) how they can be improved?

- How can we measure successful interdisciplinary research collaboration?
- Why is it difficult?
- What are the supporting factors?



Case Study: Vienna Doctoral Programme on Water Resource Systems

Aims of the Programme

- Develop an interdisciplinary approach
- Produce cutting edge research
- Generate an international perspective

- Established in 2009
- Funded 2009-2017 by FWF
- Over 60 research students
- 10 faculty
- 1 coordinator
- 5 associated post-docs
- 41 graduates, 400 papers
- 10 research fields (aquatic microbiology, hydrology, hydro-geology, environmental economics, socio-hydrology, remote sensing, resource management, structural mechanics, and water quality)



The Programme's approaches



1st level of
integration –
joint groups

Shared offices,
study programme, block
courses, seminar series



2nd level of
integration –
joint science
questions

Joint supervision,
annual and six-month
symposia, research
cluster meetings



3rd level of
integration –
joint study sites

Hydrological Open Air
Laboratory, Danube
Porous Aquifer, Austria



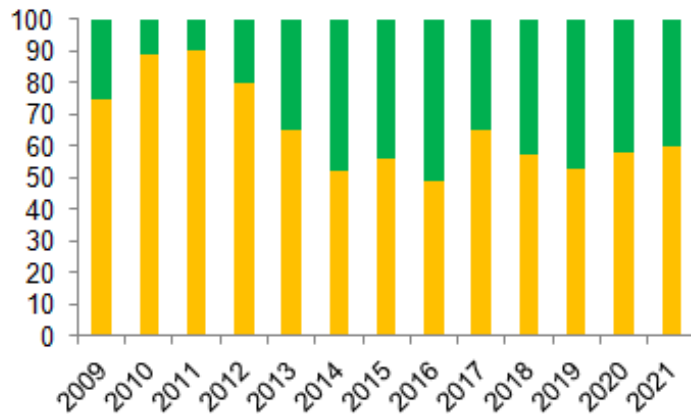
Questions and evaluation indicators

- Q1: Does cross-disciplinary research lead to more innovative scientific findings than mono-disciplinary research?
 - Publications and journal impact factors (IF).
- Q2: Do cross-disciplinary researchers develop professional skills that benefit their future careers?
 - Categorising graduates as cross-disciplinary or mono-disciplinary based on their publications and subsequent work.
- Q3: Does cross-disciplinary research produces findings of greater societal relevance than mono-disciplinary research?
 - Media interest or policy impacts relating to research results.

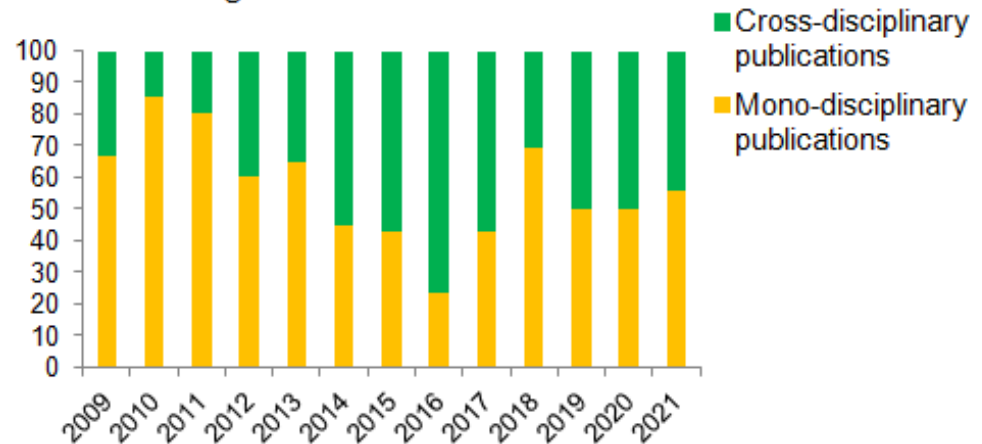
Findings - Innovation

- 261 ISI papers, average **38% cross-disciplinary** (authors from 2 or more discrete research fields).
- 171 ISI papers where first author is in programme.
 - 81 cross-disciplinary
 - 90 mono-disciplinary
 - Average **47% cross-disciplinary**

Percentage of mono-disciplinary and cross-disciplinary ISI publications



Percentage of mono-disciplinary and cross-disciplinary ISI publications where a member of the Doctoral Programme is first author



Findings – Innovation

- Impact factors 2020 for the 171 ISI papers where a member of the Programme is first author
 - IF of journals publishing the **cross-disciplinary** work average **4.792** (standard deviation 2.319)
 - IF of journals publishing the **mono-disciplinary** work average **4.008** (standard deviation 1.04)



Findings – Professional skills

41 graduates

- 15 mono-disciplinary PhD (based on publications)
 - 12 now work mono-disciplinary (research inst., uni. or agencies)
 - 1 cross-disciplinary (risk consultancy)
 - 2 unknown
- 26 cross-disciplinary PhD
 - 3 now work mono-disciplinary (micro-biology lab, hydrological computation)
 - 22 continue to work cross-disciplinary, including changing fields (i.e. Pharmaceuticals, policy, data analysis)
 - 1 unknown

Findings – Societal value

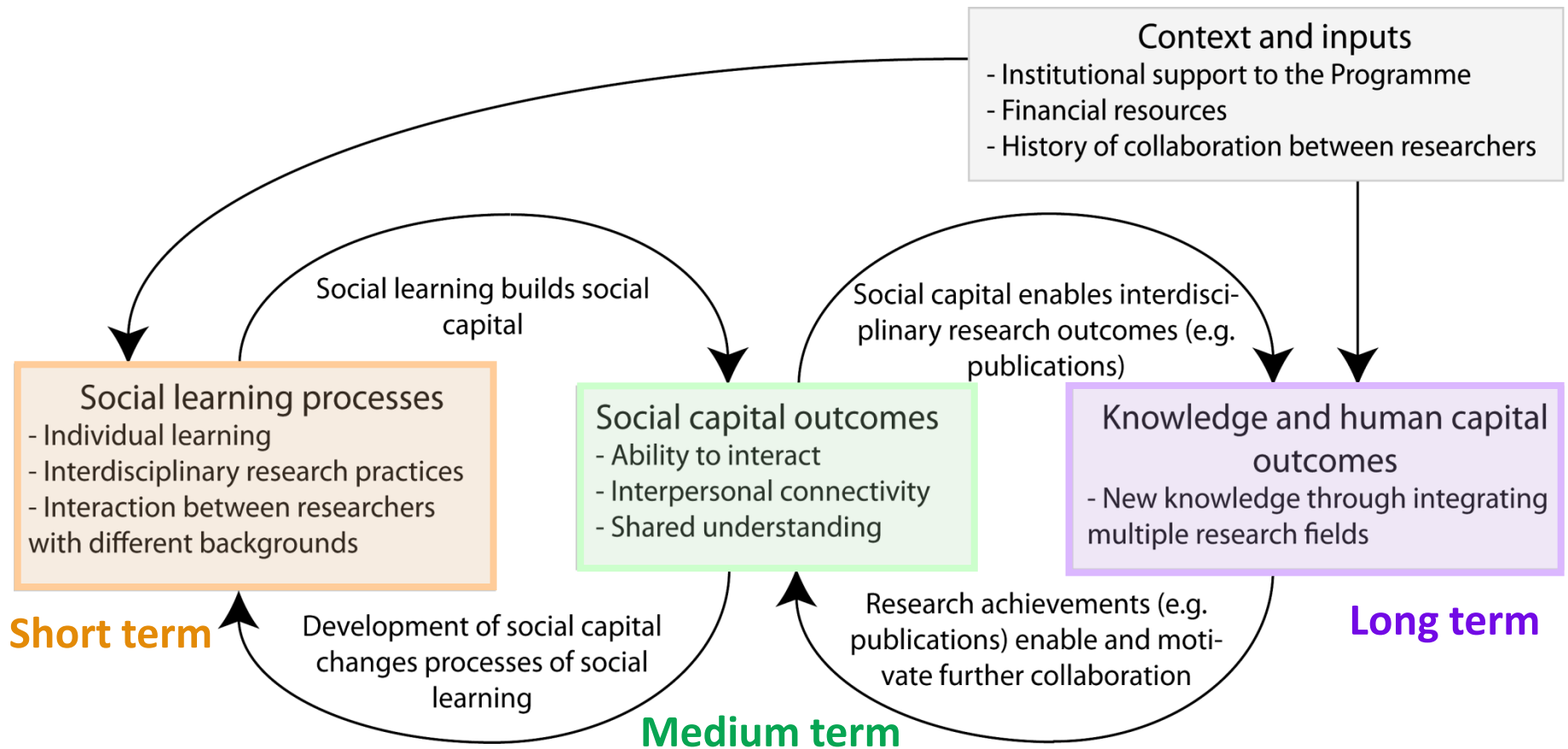
<i>Research theme leading to media interest or impact on policy and planning</i>	<i>No. of mono-disciplinary publications</i>	<i>No. of cross-disciplinary publications</i>	<i>Total ISI publications</i>
Drought	3		3
Flooding	12	7	19
Foam	5		5
Groundwater quality		9	9
Microbiology and drinking water quality	1	15	16
Phosphorous recovery		7	7
Human-water interactions		3	3
Soil moisture monitoring		4	4
Water and diet	2	1	3

Summary

- Being an active member of the Programme seems to generate 9% more cross-disciplinarity (based on ISI publications by members of the programme).
- The cross-disciplinary work may be more innovative, based on journal impact factors.
- Graduates who work cross-disciplinary for their PhDs continue to work in this way following graduation.
- Societal interest topics are addressed by both mono- and cross-disciplinary research – bringing in new research fields enables exploration of new aspects.

But why.....?

Conceptual framework for exploring development of cross-disciplinary research



Criteria for the evaluation

Social learning processes

Individual learning

Features of the Programme that support cross-disciplinary learning

Developing shared interdisciplinary research practices

Features of the Programme that generate interdisciplinary research practices

Facilitating interaction between researchers with different world views

Features of the Programme perceived by participants to support cross-disciplinary collaboration

Social capital outcomes

Ability to interact

Perceived ability of researchers to interact and communicate with those from other research fields

Interpersonal connectivity

Development of cross-disciplinary collaborative research through time based on authorship of publications

Shared understanding

Research questions in each student's thesis proposal that are addressed through bringing in theories or methods from more than one research field

Knowledge and human capital outcomes

New knowledge through integrating multiple disciplines

Types of cross-disciplinary work produced in the Programme and individual progression from multi- to interdisciplinary work based on analysis of cross-disciplinary publications

Data for the evaluation

Social learning processes

Semi-structured interviews with students and graduates

Lecturer reflection on learning in cross-disciplinary courses

Faculty questionnaires

Scoring of programme activities by students and graduates

Social capital outcomes

Semi-structured interviews with students and graduates

ISI journal publications where a member of the Programme is the first author

Faculty questionnaires

Thesis proposals

ISI cross-disciplinary journal publications

Knowledge and human capital outcomes

ISI journal publications produced through cross-disciplinary collaboration

Media response

Project implementation

Career destinations of students

Social learning processes (short term)

Individual learning

→ Easier to learn about a new field if familiar with it – lecturers use “**knowledge bridges**” to place their field knowledge in context of each students background

“I find biology the toughest because there is lots of jargon and I've no background in this. Structural mechanics was also a bit tough as there is a lot of maths, but I have a background in this so it was okay.

→ Learning **how to learn** about other research fields is self-taught and comes through experiences of working directly with people from different research fields.

“I've learnt the process. First I'm exposed to new stuff, I develop an understanding, then I talk to the people again, learn more and digest it, then go back to ask more questions.”

→ Learning **how, why and what to integrate** through courses on integrated water management

Practice in model building and solution, beginning with less complex problems and then advancing to more complex ones with more uncertainty and more conflict between stakeholders.

Social learning processes (short term)

Shared interdisciplinary research practices

→ Clear communication and clarification through questioning

Use clear and simple terms, no acronyms, ask when something is not clear, extended discussion time after presentations, co-speeches.

→ Recognize and work constructively with differences

“To do interdisciplinary work you need mutual respect and understanding between the people. You need to listen to the other side's thoughts and opinions. With us, mutual respect existed, and this is rare to find.”

→ Set defensible boundaries around the research enquiry

Thesis proposal and defense



Social learning processes (short term)

Interaction

Student scores for the benefit provided by each of the approaches for conducting interdisciplinary collaborative research

<i>Programme activity/ Interviewee code</i>	<i>Av. Score (out of 7)</i>	<i>Description</i>
Study sites	6.7	High benefit
Joint supervision	6.5	High benefit
Shared offices	5.7	Some benefit
Block courses	5.7	Some benefit
Social events	5.5	Some benefit
Advanced study programme	5.4	Some benefit
Basic study programme	5.3	Some benefit
Annual symposium	5.0	Neutral to low benefit
Cluster meetings	5.0	Mixed response, high to low benefit
Six month symposium	4.4	Neutral to low benefit
Seminar series	4.4	Mixed response, neutral to low benefit

Social learning processes (short term)

Interaction

→ Facilitating interaction needs to consider more than just face-to-face interaction between researchers

Intensive processes to bring people together to generate data, develop experiments, explore different parts of the same system, extensively discuss the research from conception to completion



Social capital outcomes (medium term)

Ability to interact

→ Students related their self-confidence in their interaction abilities to different aspects of the learning processes

→ Strong link between **individual learning** and ability to interact:

“I feel quite capable interacting with people from other disciplines. I'm not scared at all and feel confident, provided that the fields are not too far away from my own field. There are many reasons for why I developed this – the extra knowledge from the courses, the shared courses, my past experience – I've always done interdisciplinary research. I know what to do to talk to people from other disciplines – so a bit of everything.”

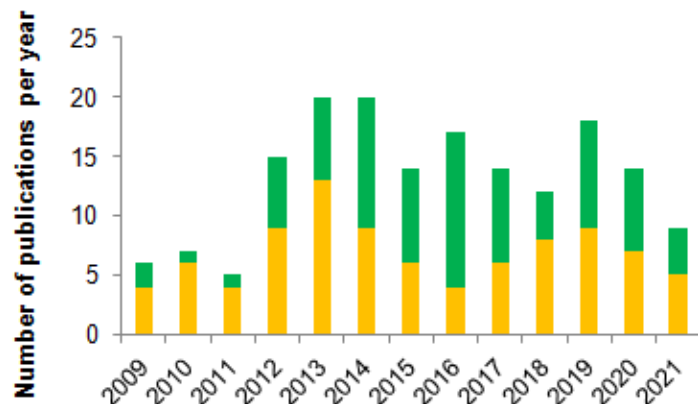
Social capital outcomes (medium term)

Interpersonal connectivity

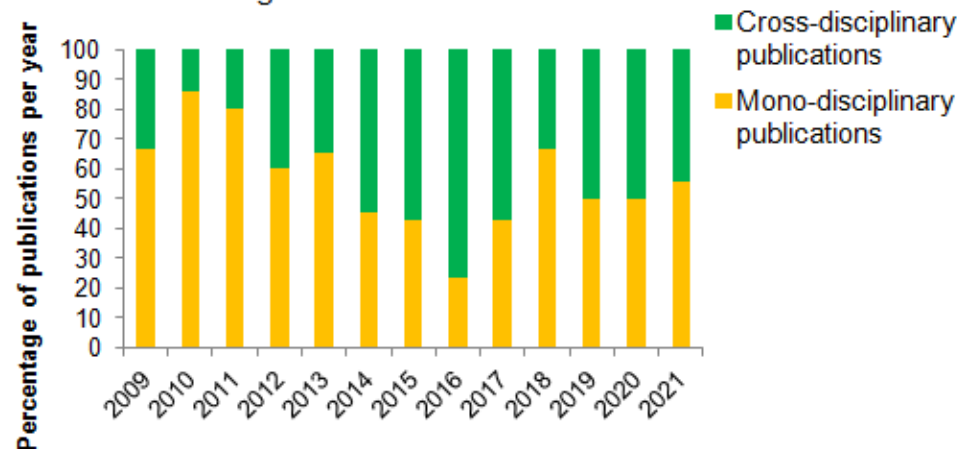
→ Since 2013, approx 50% of publications per year are produced through cross-disciplinary collaboration.

→ In 2016, approx 70% of publications were cross-disciplinary – the group was very well connected!

ISI publications where a member of the Doctoral Programme is first author



Percentage of mono-disciplinary and cross-disciplinary ISI publications where a member of the Doctoral Programme is first author



Social capital outcomes (medium term)

Shared understanding

→ Identifying cross-disciplinary joint research questions was challenging because **additional time** was needed to familiarise oneself with another research field:

“It is much more difficult and time consuming to come up with joint research questions [than individual questions]. As you learn more you can think of more ideas but not at the beginning.”

“The main support strategy, or barrier if it's not there, is that you need support from your supervisors. The topics need to be interdisciplinary right from the start. Interdisciplinary is not especially supported in the programme. For example, if you want to work on something interdisciplinary you would need to work at the weekend on something that is at a tangent to your actual work. So you're expected to work on something interdisciplinary on the side. There's a time problem. There's not enough time. For example, the mechanics people aren't going to work on something with me just as a hobby.”

Knowledge and human capital outcomes (long term)

Different types of outcomes

- New models that are built
- New data sets collected
- New understanding that is developed
- Papers that are published
- Students who graduate
- Proposals that are funded



Knowledge and human capital outcomes (long term)

Categorisation of sub-set of publications according to type of cross-disciplinarity (based on Huutoniemi et al.'s (2010) framework)

<i>Category</i>	<i>Description</i>
Encyclopaedic MD	Sub-projects brought together around a topic. Multiple authors contribute sections that are only linked together by the problem.
Contextual MD	Problem focussed with an integrative background pulling material from lots of disciplines, but no integration of other disciplines in the methods or analysis. Or methods borrowed from one field to solve a problem in another field.
Composite MD	Division of labour approach. Different specialisations responsible for different sections of the research and write up.
Empirical ID	New or existing empirical data from lots of different fields integrated to solve an inter-disciplinary problem.
Methodological ID	Methods specifically developed to fit the inter-disciplinary research question being addressed.
Theoretical ID	Brings together concepts, models or theories from more than one field to develop a new theory.

Knowledge and human capital outcomes (long term)

The majority of publications are interdisciplinary (rather than multi-disciplinary)

<i>Category</i>	<i>Number of publications</i>
Theoretical ID	1
Methodological ID	8
Empirical ID/Theoretical ID	1
Empirical ID/Methodological ID	3
Empirical ID	14
Composite MD/Empirical ID	3
Contextual MD	6
Encyclopaedic MD	1
Not MD or ID	3
Total	40

Knowledge and human capital outcomes (long term)

Type of cross-disciplinarity and student development

→ 26 out of 41 graduates were lead author of at least one cross-disciplinary publication during PhD.

→ 18 students (13 female, 5 male), more than 1 cross-disciplinary paper.

→ Their research tends to achieve higher levels of interdisciplinary integration through time.

Student	Sex	Paper 1	Paper 2	Paper 3
1	Female	Empirical ID	Empirical ID/ Methodological ID	Empirical ID/ Methodological ID
2	Female	Empirical ID	Empirical ID	Methodological ID
3	Female	Contextual MD	Contextual MD	Empirical ID
4	Female	Contextual MD	Empirical ID	Empirical ID
5	Female	Composite MD/ Empirical ID	Methodological ID	Contextual MD
6	Female	Empirical ID	Empirical/ theoretical ID	
7	Female	Methodological ID	Methodological ID	
8	Male	Empirical ID	Contextual MD	
9	Male	Methodological ID	Methodological ID	Empirical ID

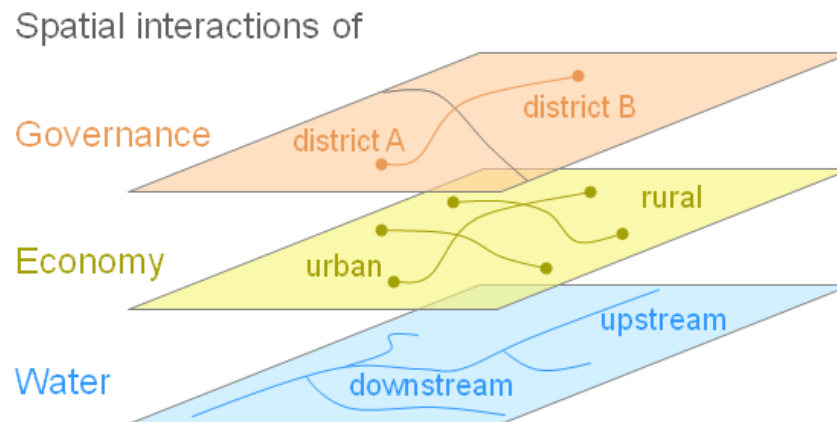
Why is interdisciplinary collaboration difficult?

- Understanding and communicating with colleagues from other research fields:
 - Takes longer and requires more effort than engaging with experts (and the literature) from your own field.



Why is interdisciplinary collaboration difficult?

- Problematisation: Developing a new, joint, interdisciplinary research question requires detailed understanding of the broad topic. This takes time. Then it needs funding.



How do floods change as human values and other factors change over the long term?

Why is interdisciplinary collaboration difficult?

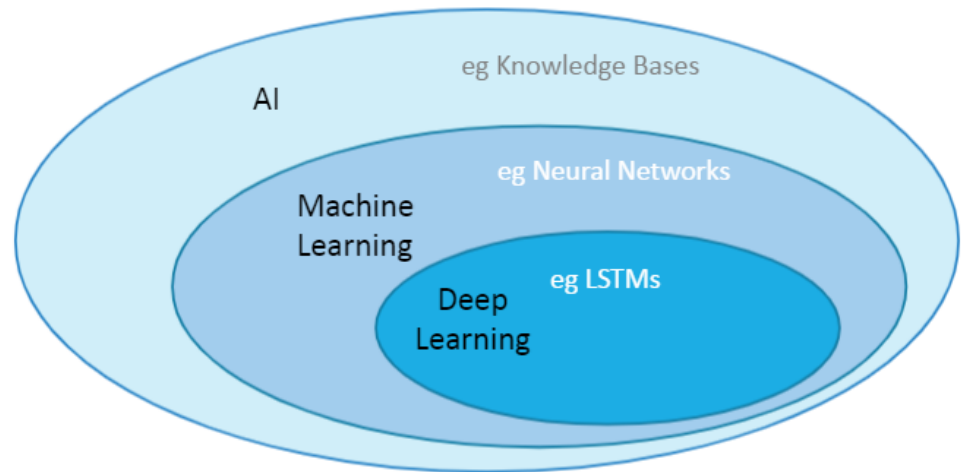
- Setting defensible boundaries:
 - Cross-disciplinary research needs to capture the perspectives required by the research objectives. But who decides which perspectives must be included (primary researcher, supervisors, other team members, examination panel, reviewers....)?
- “..participants in a multi-disciplinary research team use questioning and clarification to uncover each other's assumptions and to capture as fairly as possible the different priorities of each researcher. They negotiate which theoretical processes must be included and which could be omitted in order to reach agreement on the boundaries of the research.”

Why is interdisciplinary collaboration difficult?

- Recognising limitations:
 - Collaboration aims to take your research beyond the limits of your own field of specialisation. However, the collaborators' field(s) also have limits that you have to work within.



From: www.globaltimes.cn/page/202108/1232157.shtml, Remote sensing detects 8,450 potential hazards in areas including Three Gorges Reservoir, 2021



From: Poelz, A., PhD Thesis Proposal: Data-driven modeling for drinking water management, 2021

Strategies to support collaboration across disciplines

1) Support different aspects of learning

- Learning differences between research fields and their limitations
- Learning how to learn about other fields
- Learning how, why and what to integrate

2) Identify and support shared interdisciplinary research practices

- Clear **communication** and **clarification** through **questioning**
- Practices for harnessing **differences** that require mutual respect, trust and open-minded personalities
- Setting defensible **boundaries** around the research enquiry

3) Encourage critical debate – harnessing differences

- Social sciences tend to open up debate, recognising and embracing the many different "truths" that exist
- Natural sciences/engineering tend to be consensus disciplines

4) Intensive interaction is essential

- Intensive processes needed to get people to discuss, formulate research questions, generate data, develop models, run experiments – more than just face to face interaction.
- Joint supervision, and interaction between supervisors
- **Study sites** bring people together to work on a place of shared interest
- These create **environment** that propagates interdisciplinarity

Collaborative interdisciplinary work is a process, and it evolves

- Speed up the evolution process by focussing on building human and social capital:
 - Collective networks, group values and shared understandings enable collaboration.
 - Supporting learning, intense interaction, questioning and clarification, defining defensible research boundaries enables bridging the disciplines.
 - Creating a culture of interdisciplinarity will generate even more interdisciplinarity!

Thank you for listening



www.waterresources.at

Further reading

Carr, G., Barendrecht, M.H., Debevec, L., Kuil, L., Blöschl, G. (2020) People and water: understanding integrated systems needs integrated approaches. *Journal of Water Supply: Research and Technology-Aqua*, jws2020055.

Carr, G., Loucks, D.P. and Blöschl, G. (2018) Gaining insight into interdisciplinary research and education programmes: a framework for evaluation. *Research Policy*, 47(1), 35-48.

Carr, G., Loucks, D. P., Blanch, A. R., Blaschke, A. P., Brouwer, R., Bucher, C., Farnleitner, A. H., Fürnkranz-Prskawetz, A., Morgenroth, E., Parajka, J., Pfeifer, N., Rechberger, H., Wagner, W., Zessner, M. and Blöschl, G. (2017) Emerging outcomes from a cross-disciplinary research and education programme. *Water Policy*, 19, 463-478

Blöschl, G., Carr, G., Bucher, C., Farnleitner, A. H., Rechberger, H., Wagner, W. and Zessner, M. (2012) Promoting interdisciplinary education – the Vienna Doctoral Programme on Water Resource Systems. *Hydrology and Earth Systems Science*, Special Issue on: Hydrology Education in a Changing World 16, 457-472.