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Embracing Multidisciplinarity: Exploring Challenges and Identities of Teachers in the Subject Integrated Sciences

Jasper Cirkel, 14.03.2024

The **multidisciplinary subject "integrated natural sciences"** has become a prevalent approach to **teaching science** in German comprehensive schools as a **combination of the traditional science subjects biology, chemistry and physics in the lower secondary level** (grades 5-10). However, the existing teacher education system in Germany (during University and preparatory service phase) is structured around individual subjects, requiring teachers to specialize in two subjects, with at least one being a science discipline. As a result, it is **common for teachers** to find themselves **teaching (partly) out-of-field of their expertise**.

The presentation shows results from a semi-structured **interview study involving n=15 teachers**. The transcribed online interview recordings are analyzed through qualitative content analysis. Results regarding the question **whether teachers self-identify as science teachers** versus e.g., biology-teachers are discussed.

Integrated Natural Science as a subject

- Integrated Natural Science ≈ Biology + Chemistry + Physics

- Broad definition for teaching: “INTERDISCIPLINARY: A knowledge view and curriculum approach that consciously applies **methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience**.” (Jacobs 1989:14)

- Example of a teaching unit (Cirkel et al., 2017):
  - context: bats and wind energy plants
  - content: biology of bats, physics of their echolocation, conflict of interest between clean energy and conservation of nature

Integrated Natural Science as a subject

- Multiple arguments for and against (e.g. Handtke & Bögeholz, 2023:4f)
  - Constructionism: connecting separated areas of knowledge
  - Learning outcome: „Enhanced Context Strategies“ show big effect size=1.48 (Schroeder et al., 2007)
  - Improved tolerance for ambiguity

Integrated Natural Science as a subject in Germany

- Long and varied history and debate in Germany (Gebhard et al., 2017:203)

- Focus of this study: integrated middle / high school type (~17% of total students)
  - Specific implementation varies by school (Labudde, 2014)

Faltiska, I. (2017) Eine überregionale Studie zur Umsetzung Fächerübergreifender Naturwissenschafts-Unterrichtskonzepte an Gymnasien und Gesamtschulen, unpublished masters's thesis Uni Göttingen

Integrated Natural Science: Teaching perspective

- **Traditional approach**:
  - separated subjects Biology, Chemistry, Physics starting in grade 5 taught by up to three teachers
- **Integrated approach**:
  - One integrated subject taught by one teacher
  - Grades 5-10

- Teacher Education in Germany (Price et al., 2019):
  - Two subjects in University studies (Master of Education) and 18 month state-organized teacher training/preparatory service
  - Teachers are specialists for two subjects

Out-of-field Teaching (OoFT) in the sciences

- Working definition for OoFT: teaching (partly) out-of-field occurs when the teacher was not educated for all three subjects of the natural sciences (Biology, Chemistry, Physics)
  - Typical science teacher has two OoFT subject areas
  - "OoF teaching ***within*** the sciences" (Perl-Nussbaum et al., 2023:3)
    - As opposed to the case e.g. in mathematics where OoF teaching is more of a binary distinction

- Integrated teaching leads to (partly) out-of-field teaching which in turn features multiple **challenges for teachers** (Hobbs & Porsch, 2021)

- Roughly 30% of science teachers experience OoFT in a typical year in Germany (Price et al., 2019)

Out-of-field Teaching and teacher identity

- Teacher identity can be described as the answer to the question ‘who am I as a teacher?’ e.g. (Côté, 2006)

- professionalism of teachers should not be reduced to their knowledge and ability
  - Teachers’ identity strongly influences how they teach and how they perceive their situation (Demirkasımoğlu, 2010)

- subject integrated natural sciences
  - one discipline specialist teacher (e.g. a biology teacher)
  - multidisciplinary, integrated science teacher

Research Interest

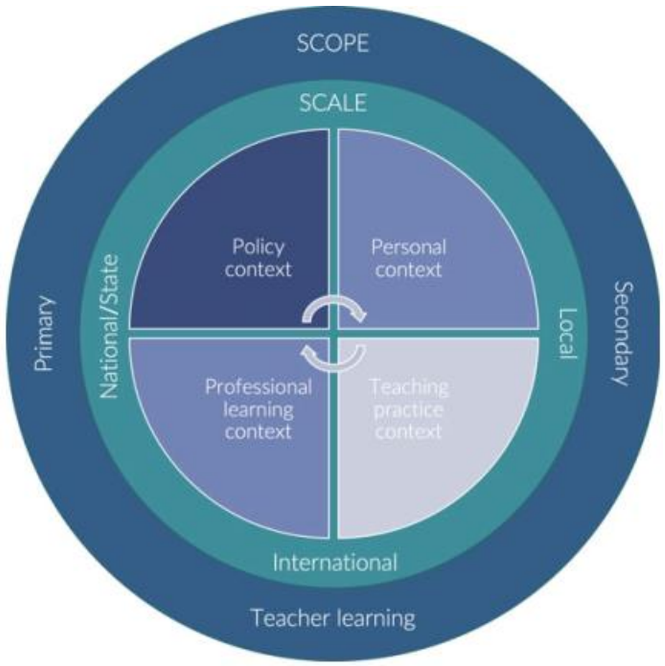
- Describing the phenomena of teachers teaching (partly) out-of-field of their expertise in the subject integrated science

- How do teachers describe their self image? Are identifying themselves as “science teachers” or “specialist”?

- Focus: generating hypothesis’s

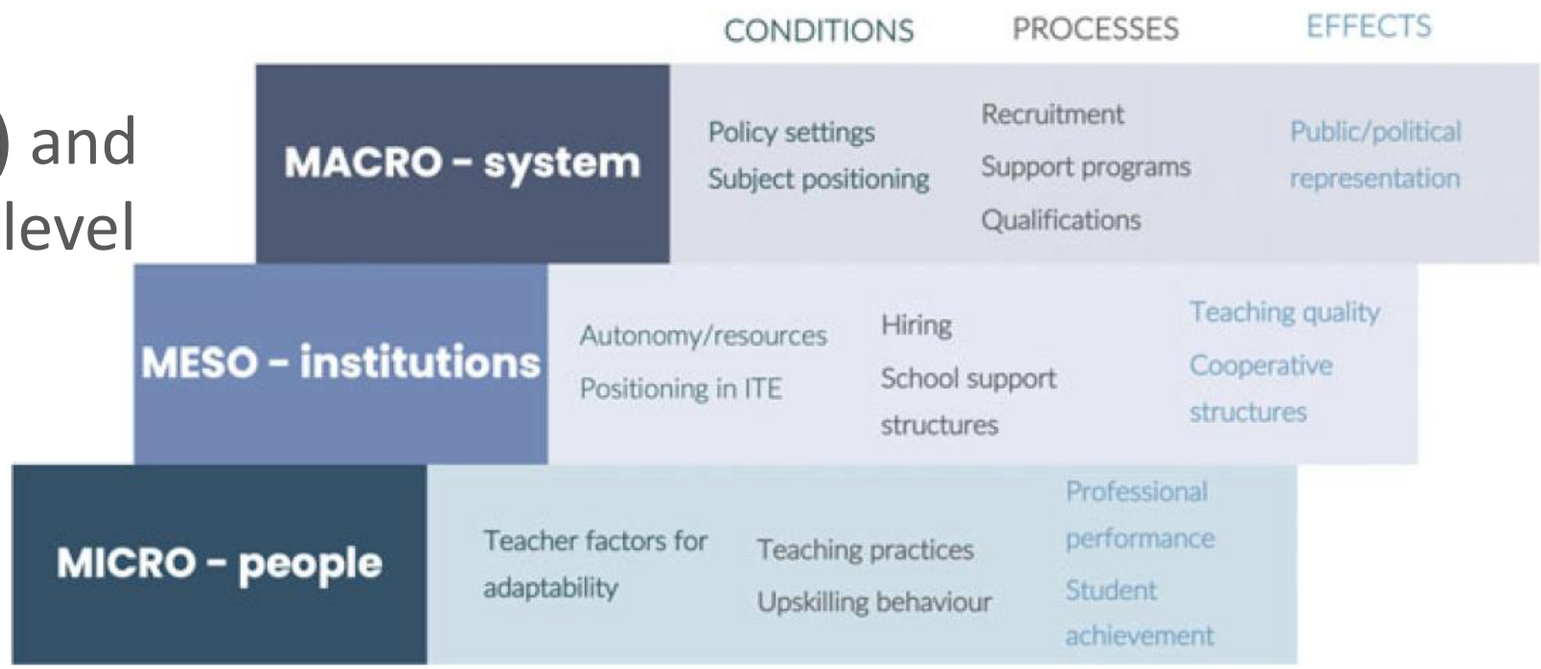
Research context & levels

- Focus of this study are **personal context** and **teaching practice contexts**



Hobbs & Porsch (2022:369f)

- Examining the phenomenon on the **micro-level (teachers)** and to some extent meso-level (school support)



Method

- Semi-structured guided-interviews (per Video-conference) and biographical data
- Qualitative Content analysis (deductive-inductive) (Mayring, 2014)

- Why no observations:
  - Instructional quality of teaching not stable: e.g. „Cognitive Activation: Between 1 and 9 lessons per teacher were necessary for a reliable measure.” (Praetorius et. al, 2014:9)
  - Congruity-theory: shown beliefs correspond with actions (Bryan, 2012:481f)
  - Teachers and administration likely more hesitant to in person observations

Definition of the Material

- N=15 interviews, duration Median: 32:42 min; MW: 33:20 min; SD: 8:49 min
- most (12) cases did complete a full teacher education consisting of university studies in education and teacher training
- Surface features age, gender, working experience seem reasonably balanced
  - Working experience: newly hired teachers, department heads, former school types
- Natural sciences subjects:

  Biology: 8x
  Chemistry: 3x
  Physics: 7x
- Chemistry might be slightly under represented

Interview guide

- **Main Questions**, (more detailed/focused) **follow-up questions**, “upkeep questions”

1. How **did you become a teacher for the subject science**?
2. Please describe **what makes teaching science special for you**? What do you **spontaneously associate with teaching science**?
3. I am particularly interested in your teaching practice in science; please describe **how you plan** and deliver **a sequence on a topic with a content focus in an out-of-field subject**?
4. Is there a **typical way you approach the planning**?
5. You could perhaps be said to be **partly out-of-field** to the subject of science; please describe **if and how this is relevant to you**.
6. How would you describe **your self-image**? Do you **see yourself as a “science teacher"**?
7. How would you **evaluate the subject science overall** or in general?

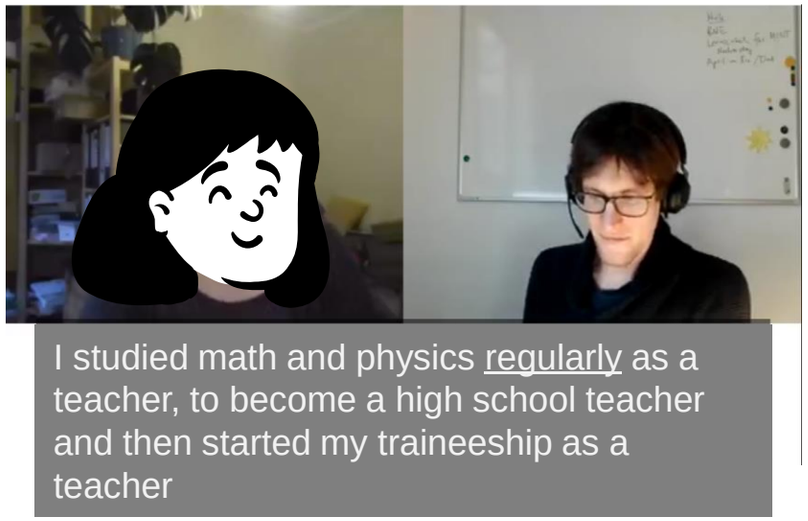
Formal characteristics of the material

- word-by-word transcription of audio recordings
  - Automated, local transcription using whisper/OpenAI (Radford et al., 2022)
  - „manual cleaning“ (simplified transcription system based on Dresing & Pehl (2011))
  - anonymization

Ideally: 2 audio channels

I (00:22): How did you become a teacher for the subject science?
Teacher (00:28): I studied math and physics regularly as a teacher, to become a high school teacher and then started my traineeship as a teacher. […]

End formats: .txt, .srt, .tsv, .vtt, .json



Results – challenges of OoFT within science

- Most cases stress that were not adequately prepared for the integrated approach to science

- Teachers turn to schoolbooks and their own faculty for help
  - Example: specialist for chemistry showing experiments to non-specialist

- Teachers who feel supported seem more happy with the challenging situation and show less feelings of dilemma

Results – challenges of OoFT within science

- where content knowledge CK is missing it is cited as the foremost challenge
  - once a certain level of CK is attained then limitations in pedagogical content knowledge (PCK) become apparent

- In accordance with former research e.g. (Childs & McNicholl, 2007; Hobbs, 2013)

Results - science teacher versus specialist

- The extent to which teachers **embrace the idea of an integrated approach** and **see themselves as science teachers**
  - Central dimension to classify teachers

I'm a science teacher.

So in my role right now, absolutely [I see myself as a science teacher]

I still think of myself more as a biology teacher.

So I don't sort of identify as a science teacher.

Results – Potential to develop versus stable

- Some teachers see it as a goal for themselves to **(actively) develop an identity as a science teacher**

Science-teacher-in-training, despite having a degree, is how I would describe myself.

So I would say right now I would still consider myself a subject teacher for chemistry, but there's definitely an openness there for the transitions.

Results – situational versus static

- Some teachers **actively change their own role** depending on the situation and the perceived expectations of e.g. students and parents

If I were to introduce myself for grades 5-10, I would say I'm a science teacher.

But if I go to a school where science is taught, I'm just the science teacher, not the physics teacher, and I would sell it that way accordingly.

Results - science teacher versus specialist

- Some see themselves more as scientist

"I'm still a physicist first and foremost."

- Some see themselves as generalist teachers primarily

I see myself as a teacher first.

Results – summary & Outlook

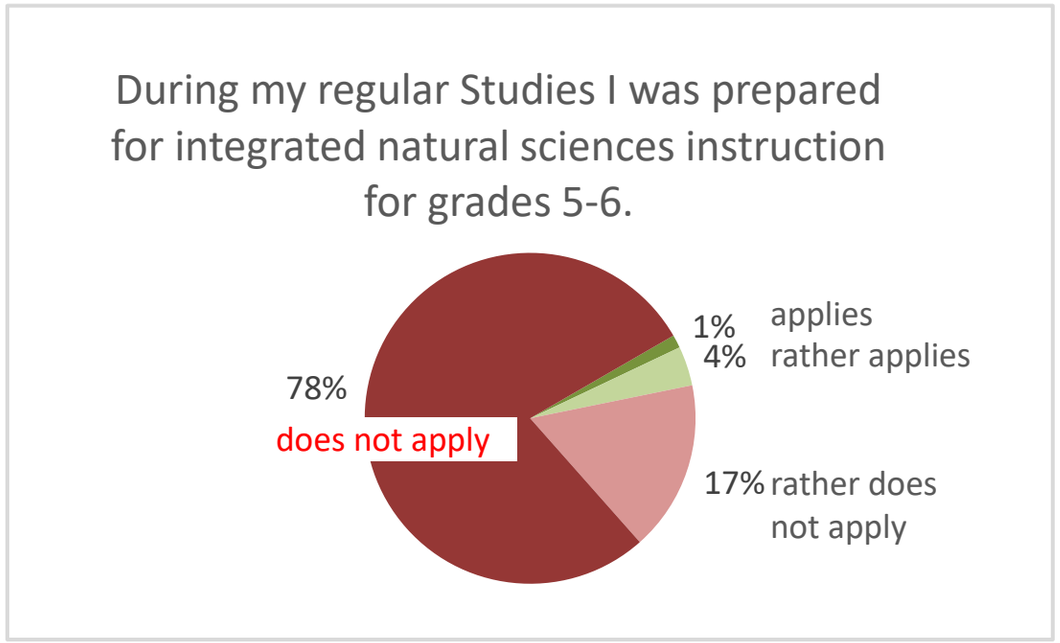
- Happy despite challenges versus feeling of dilemma

- In their role as teachers
  - Potential to develop in the future versus stable
  - Situational versus static

- Science teacher vs. specialist
  - Ideally teachers **embrace both** their respective specialty subjects and integrated science depending on situation as a reflective practitioner (Schön, 2017)

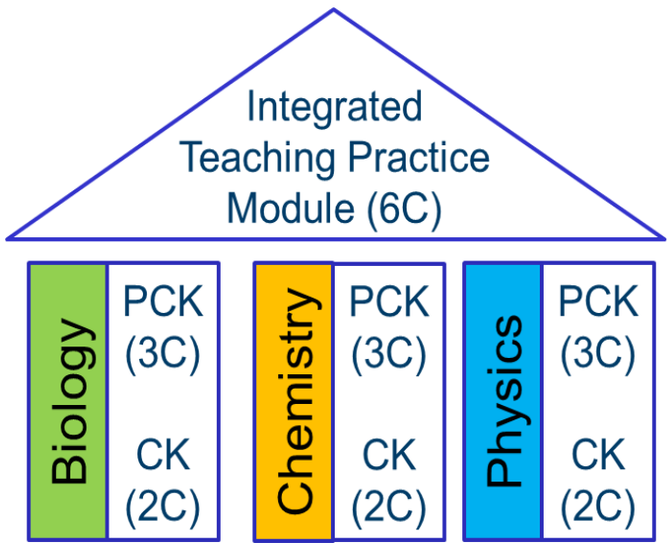
At the University of Göttingen:

Survey of university teacher education students 2017, Göttingen, N=177



- Additional certificate „Teaching Integrated Natural Sciences“ established in 2017 (Cirkel et al., 2017)

- Roughly 20% of students complete certificate (graduates with at least one natural science subject)



Structure of Courses, C= ECTS

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slides:

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