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KNOWLEDGE COORDINATION AND THE USE OF CONTEXT DURING THE TRANSFER PROCESS IN PHYSICS

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weiterdenken.

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1.
Aims and Objectives, Research Questions

1. Aims and Objectives, Research Questions

Why study transfer in physics education?

Students **struggle to apply their knowledge** in a different context situation with the same underlying structure like the problems in class (e.g. in our physics exam).

(our own observation)

"The literature on […] transfer suggests that **students may often fail to recognize the relevance** of these ideas when they are confronted with analogous **situations in the real world** […]"

(Day & Goldstone, 2012, p.156)

1. Aims and Objectives, Research Questions

Aims and objectives

- Development of a **framework** for the analysis of the **process** during the **transfer** of physics concepts in the topic of energy.

- Derivation of **methods** to **foster** students' development of strategies and flexible knowledge in physics lessons for the subsequent **transfer** of their concepts.

  *(→ Derivation of **hypotheses** for a subsequent quantitative study)*

1. Aims and Objectives, Research Questions

Research Questions

- What **strategies and procedures** are applied by students **during** a **transfer** situation containing an energy task in physics and how is the process of transfer **structured**?

- What could be interventions or **methods** in **physics instruction** to foster the transfer process in the topic of energy?

2.
Theoretical Background

2. Theoretical Background

There is **no** such thing as a comprehensive, elaborate, consistent, and empirically founded **transfer theory**.

Precise theories or models to explain transfer effects **don't exist**.

Schmid (2006)

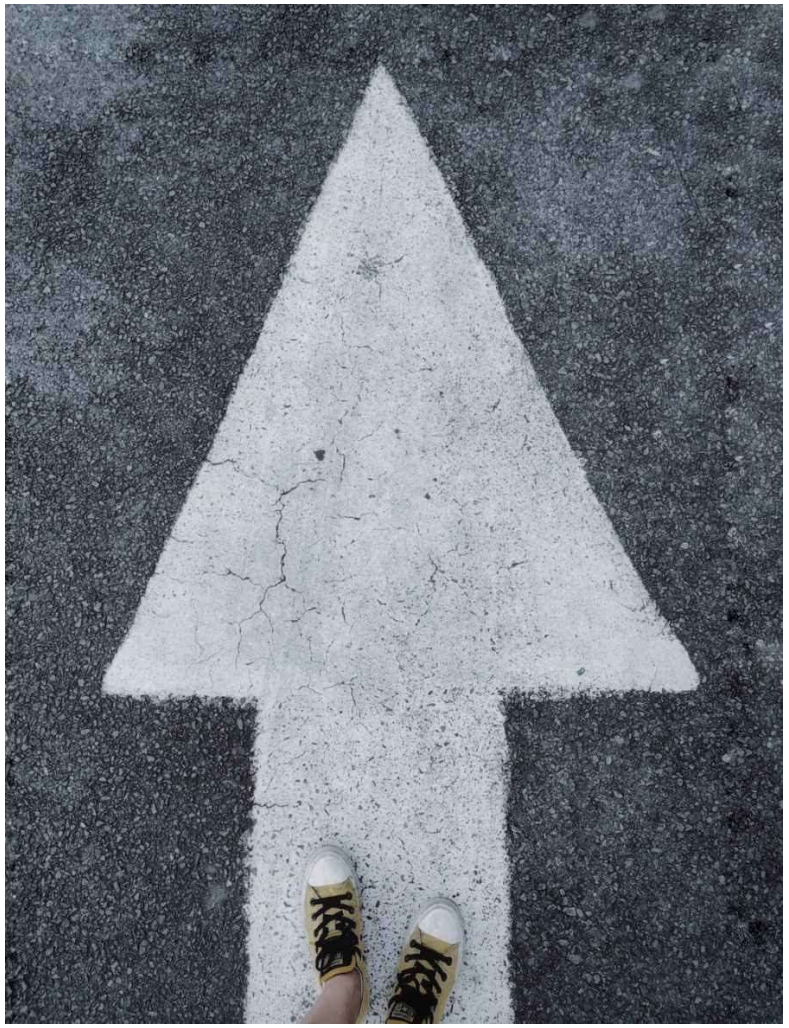
2. Theoretical Background

Traditional transfer approach:

Transfer is the **application of knowledge** learned in one situation to a new situation.

(e.g. Bransford et al., 2000)

→ Observer's (expert's) perspective



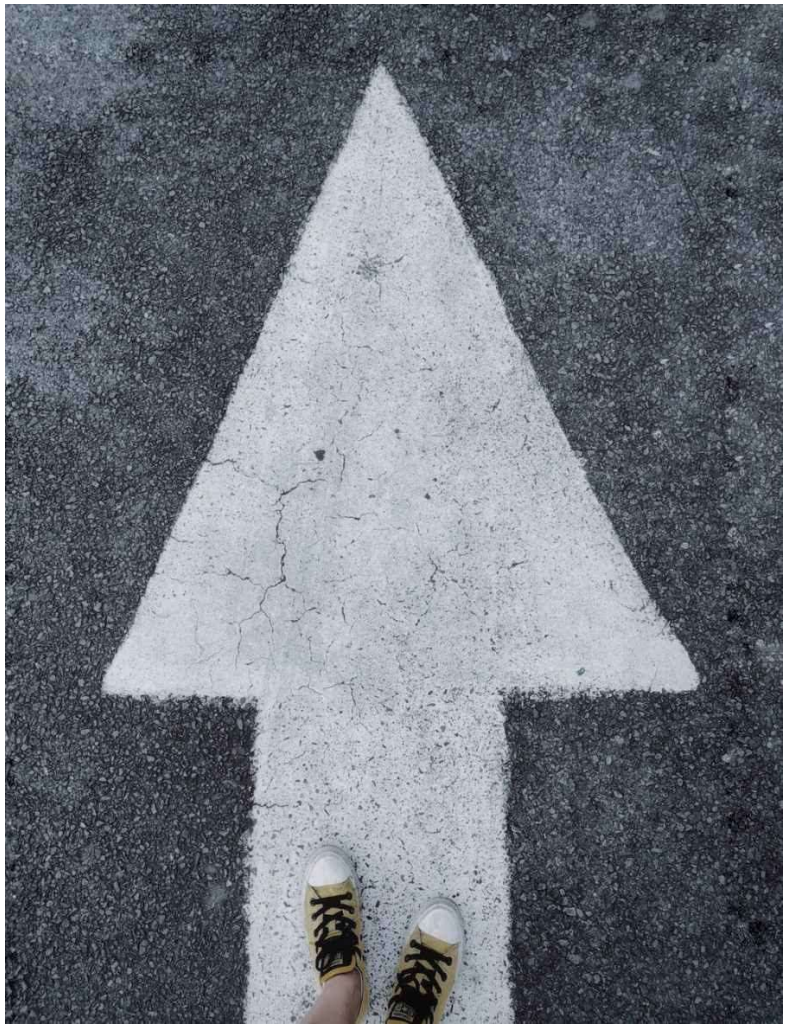
2. Theoretical Background

Actor-oriented transfer approach:

Transfer is the **personal construction of similarity** across activities (i.e. seeing situations as the same).

Lobato (2003, 2006, 2012)

→ Actor's (learner's) perspective



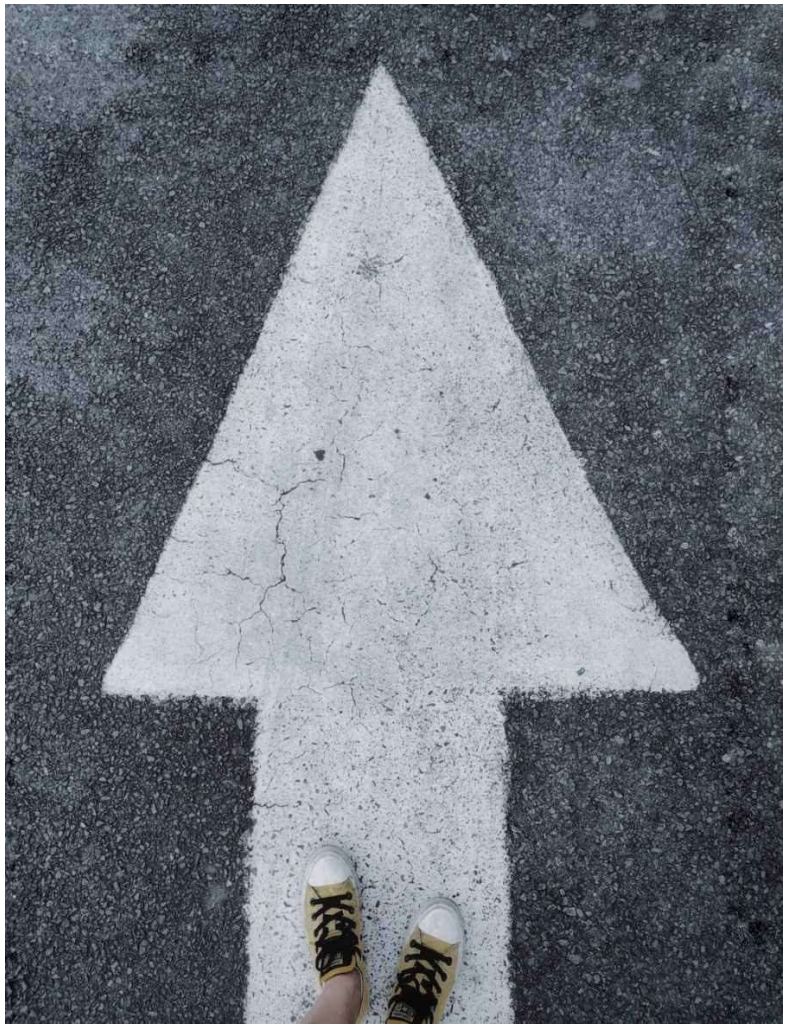
2. Theoretical Background

Transfer in Pieces & Coordination Class Theory:

Concepts are constructed anew in every **situation** and consist of individual **knowledge pieces** and **readout strategies** to deal with the information provided from the context situation.

→ **Coordination Class**

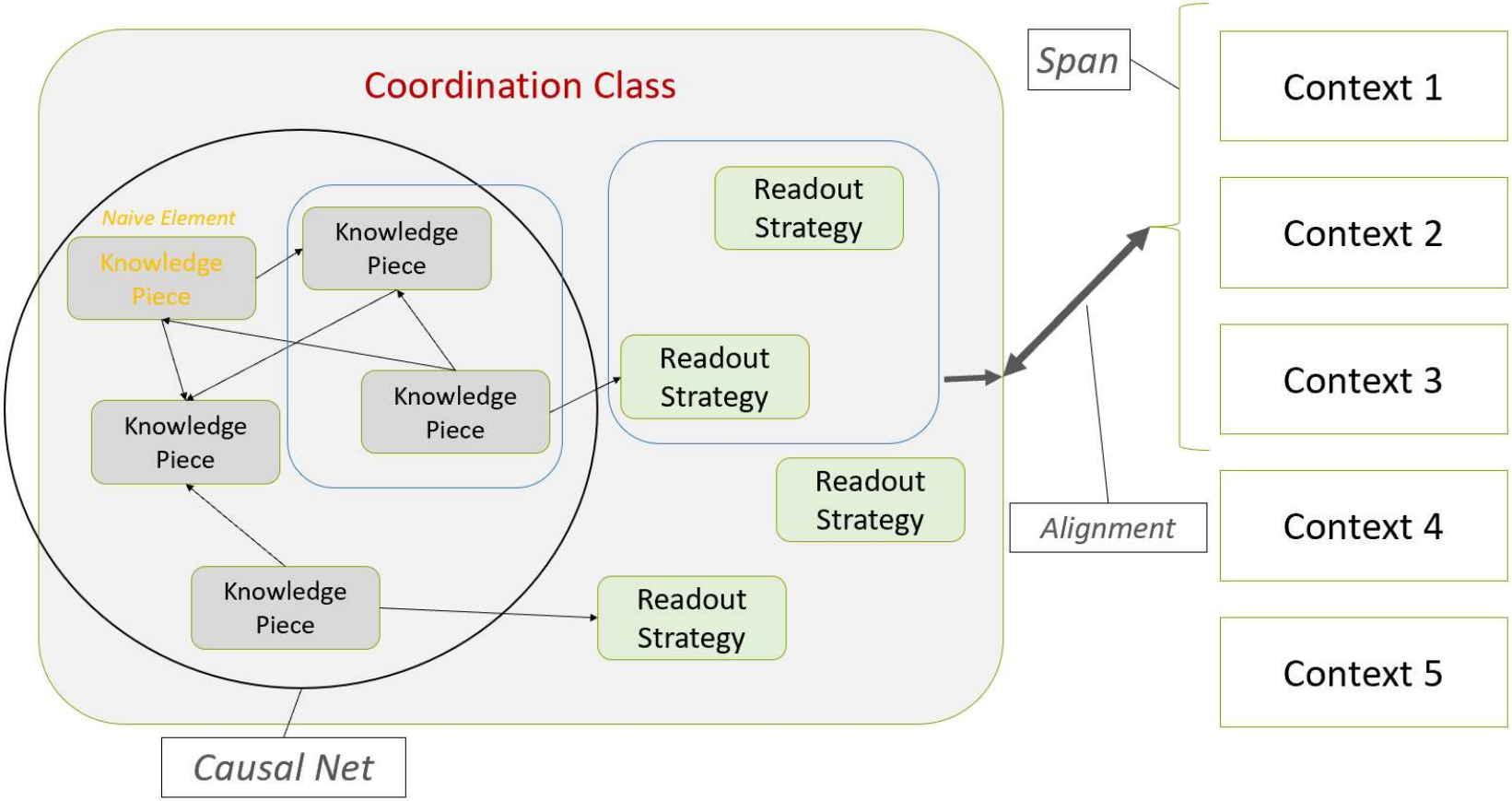
Wagner (2010), diSessa & Wagner (2005)



2. Theoretical Background

What happens during transfer?

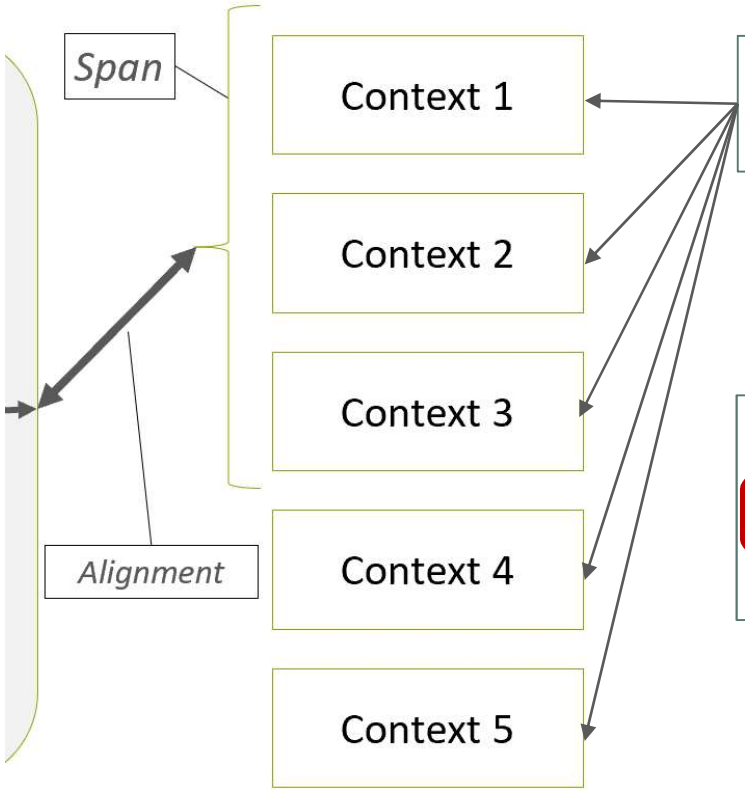
(**Coordination Class Theory** of diSessa & Wagner, 2005)



2. Theoretical Background

And on the context side?

(**Context model** according to Löffler et al., 2018; Löffler, 2016)



Context situations: Different **surface structure**, but (relatively) similar **deep structure**

Context features:

Table 1. Framework for context – Four sets of information.

	Scientific Model element	Non-scientific Model elements
Part of the Solution	MS	nMS
Not part of the Solution	MnS	nMnS

MS: scientific **M**odel element & part of **S**olution; **MnS**: scientific **M**odel element & **n**ot part of **S**olution; **nMS**: **n**on-scientific **M**odel element & part of **S**olution; **nMnS**: **n**on-scientific **M**odel element & **n**ot part of **S**olution.

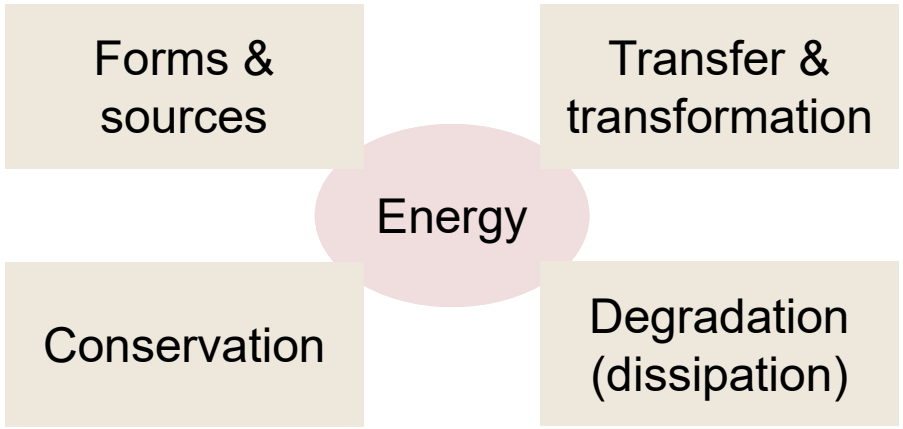
Löffler et al. (2018, p.1938)

2. Theoretical Background

The energy concept of students

(Neumann et al., 2013; Nordine et al., 2011)

Understanding energy (energy concept development):



Four levels of knowledge complexity:

1. **Fragmented knowledge** base (singular pieces of knowledge, unconnected facts)
2. **Simple connections** between the knowledge pieces (mappings)
3. More **qualified connections** (relations)
4. **Complex intertwined connections** between the individual knowledge pieces (concepts)

(Neumann et al., 2013, p.167)

3.
Method

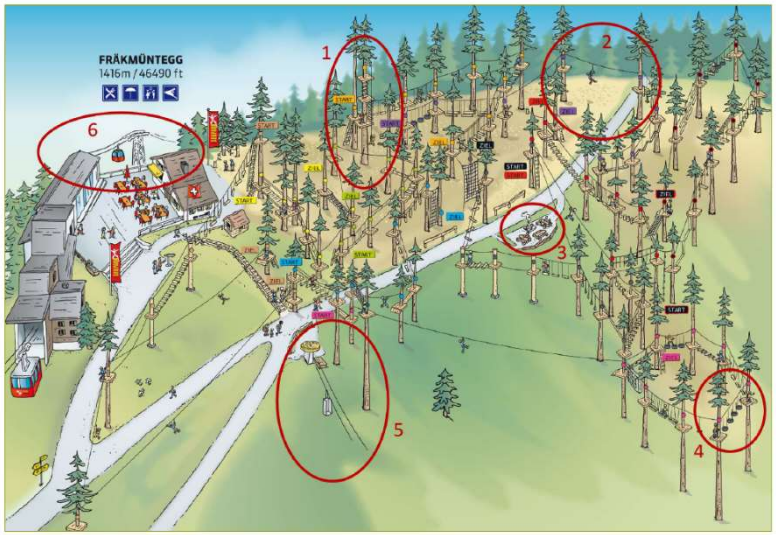
3. Method: Think Aloud Interviews

Procedure

Audiotaped, structured «Think Aloud»-interviews («introspection», e.g. Konrad (2010))

- **Transfer task**:
  - Context situation: **Climbing park**
  - **Questions** about energy forms, transformation, degradation, conservation
  - Additional questions, **prompts**

- **Time**: max. 45 min.
- **20 students** (12 interviews), 1 interviewer
- Students from **different ages and schools** (high school, secondary school, university of teacher education)



Freizeitpark Pilatus

Auf dem Bild siehst du den **Seilpark und die Umgebung** auf der Fräkmüntegg beim Pilatus. Es geht bei dieser Aufgabe um das Thema **Energie**. Beim Klettern im Seilpark und auch in der Umgebung des Seilparks kommt an verschiedenen Orten Energie vor.

Deine Aufgaben

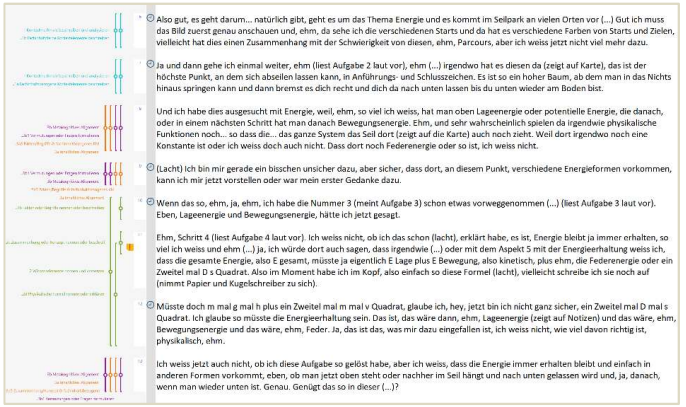
1. Schaue das Bild genau an. Lass Dir Zeit dafür.
2. Suche Dir eine Situation auf dem Bild aus. Was hat diese Situation mit Energie zu tun?
3. Welche Formen von Energie kommen in dieser Situation vor?
4. Wird in dieser Situation Energie umgewandelt? Wenn ja, wie genau?
5. Beschreibe die Energieerhaltung in der Situation, die du ausgewählt hast.

3. Method: Qualitative Content Analysis

Analysis and Validation

(Kuckartz, 2018; Flick, 2019)

- **Content structured qualitative content analysis**: Deductive and inductive approach after Kuckartz (2018)
- **Complete transcription** of all 12 interviews
- **Software for transcription and analysis**: MAXQDA
- Coding of all 12 interviews, **3 iterations**
- **Expert validation**: Consensual coding with 3 coders

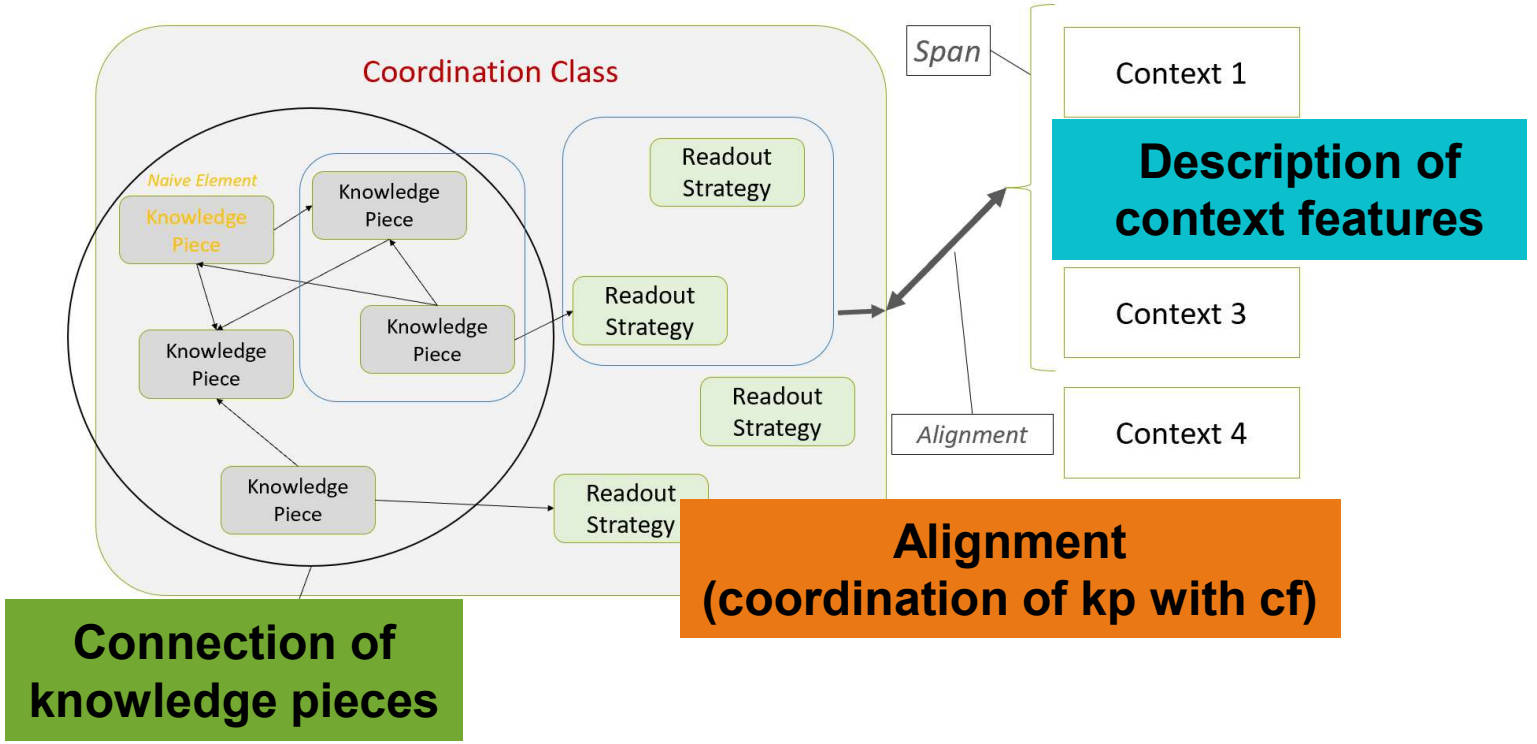


4.
Results

4. Results

A framework to capture the transfer process

3 main categories (deductively derived from the Coordination Class Theory)



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4. Results

***RQ**: What strategies and procedures are applied by students during a transfer situation containing an energy task in physics?*

The category system – A framework to capture the transfer process including a fourth main category and subcategories

(inductively derived from interview data)

1: Description of context features	2: Connection of knowledge pieces	3a: Content related alignment	3b: Metacognitive alignment
1a: Description of content related context features	2a: Description of not content related (naïve) knowledge pieces	3a1: Coordination of a ncr KP with a cr CF	3b1: Formulating assumptions or questions
1b: Description of not content related context features	2b: Description of a fact or notion	3a2: Coordination of a ncr KP with a ncr CF	3b2: Taking the perspective of a subject
1c: Description of a mix of content related and not content related context features	2c: Description of a relation or concept	3a3: Coordination of a fact/notion with a cr CF	3b3: Making references to one's own experiences
	2d: Description of a physical formula or abstraction of a relation	3a4: Coordination of a fact/notion with a ncr CF	3b4: Drawing conclusions
		3a5: Coordination of a relation/concept with a cr CF	3b5: Using a concept from prior knowledge (or using a p-prim)

Based on the **context model** of Löffler et al. (2018)

Based on the **complexity levels** and **energy concept development** (Neumann et al., 2013)

Connection between main categories 1 & 2, based on the **transfer in pieces** (Wagner, 2010)

Based on the concept of «**readout strategies**» (diSessa & Wagner, 2005), can overlap with other categories

Key to the table:
***CF**: context feature*
***KP**: knowledge piece*
***ncr**: not content related*
***cr**: content related*

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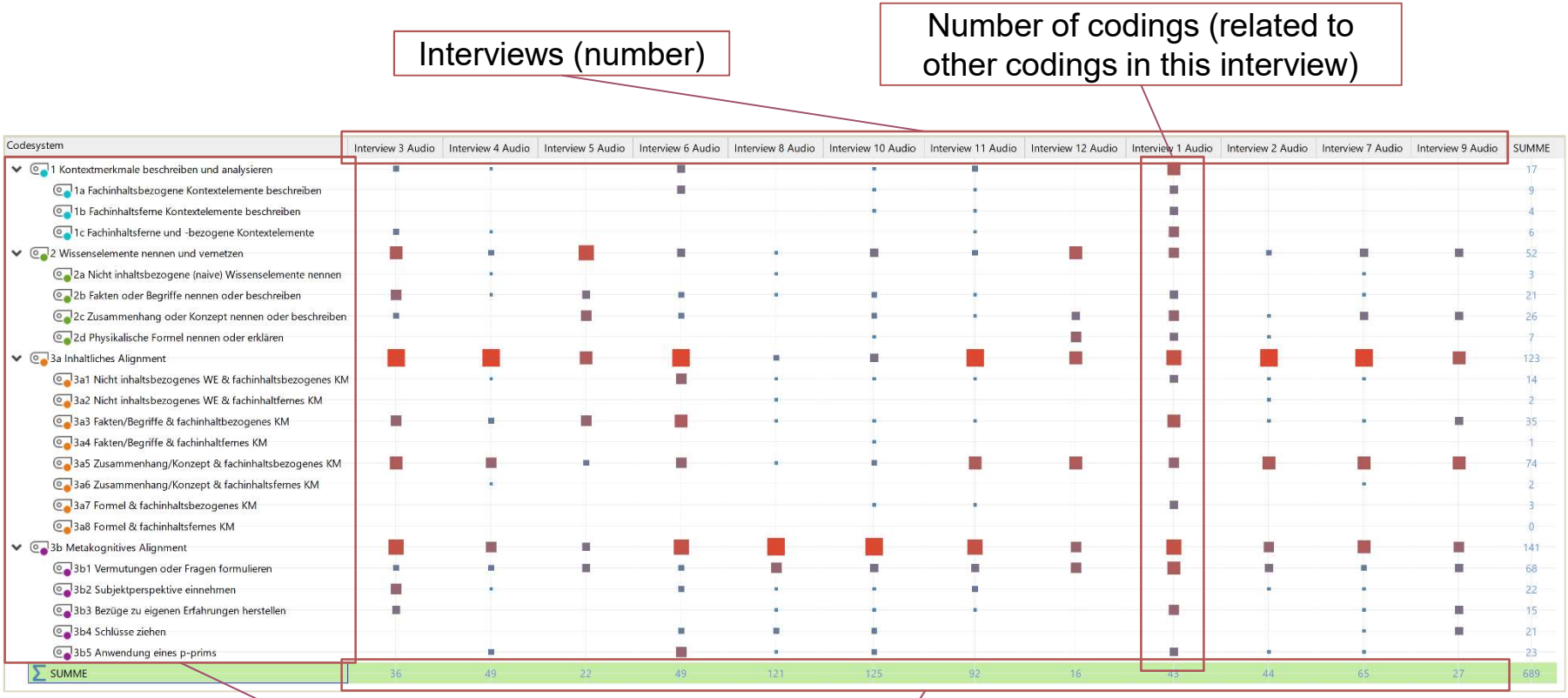
4. Results

***RQ**: How is the process of transfer structured?*

Code matrix (from MAXQDA)



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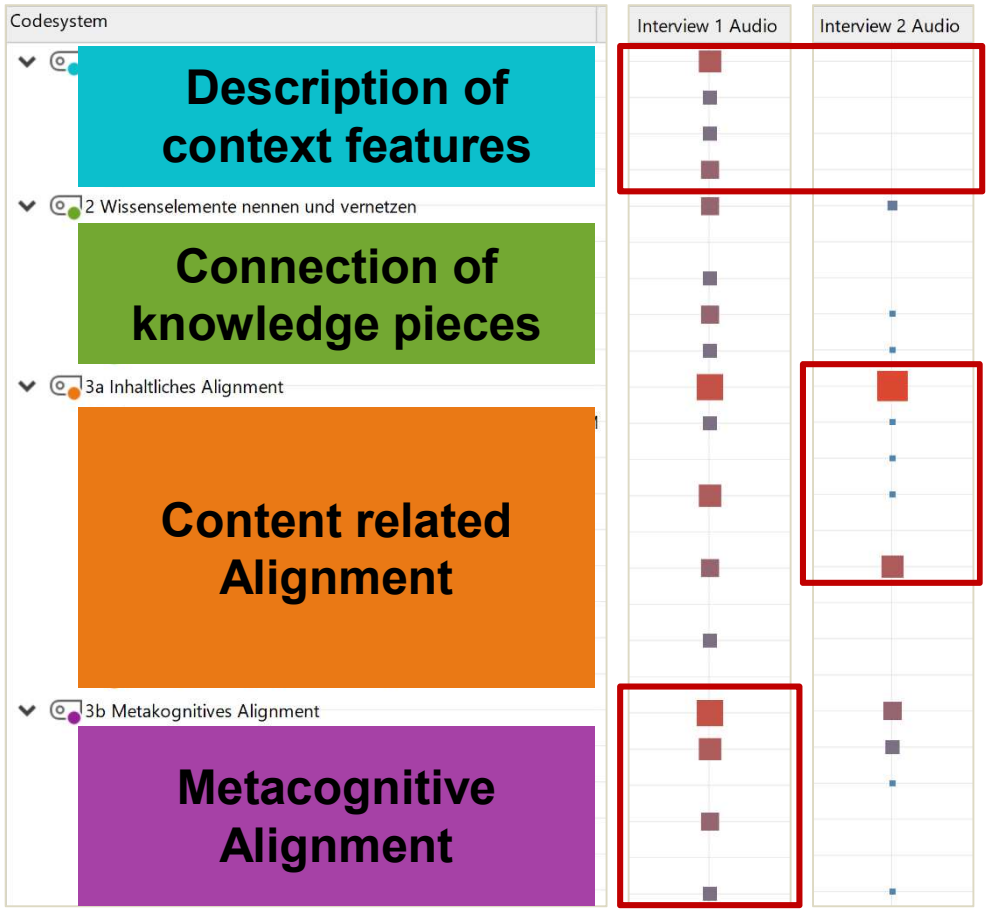
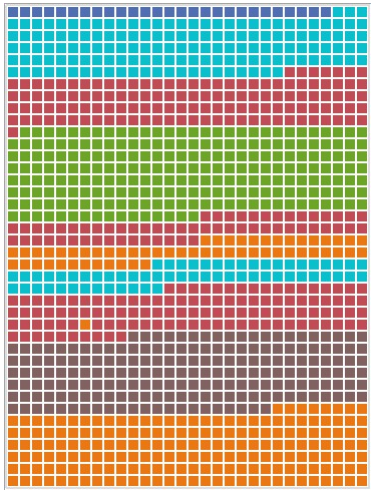
4. Results

***RQ**: How is the process of transfer structured?*

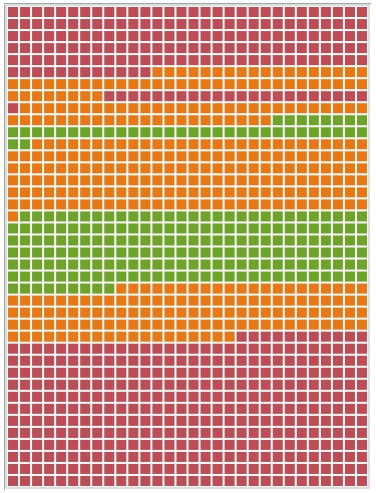
Examples of different transfer processes



Document portraits (MAXQDA, with mixed colors for overlapping categories):



Interview 1



Interview 2

4. Results

Quote from the «Think Aloud»-interview 2:

"I imagine that when I climb from the ground onto the tree and there, so to say, with the stairs to the first platform (points to the map), my energy changes with every step and I don't notice it until I jump down. And that's a bit strange for me to imagine. So if you just, it makes sense, if you jump down, then you have to cushion more in your legs, so that it hurts less. […]"

(Interview 2, Section 26)

Codings:

Main category: **Metacognitive Alignment** (3b)

Subcategory: **Taking the perspective of a subject** (3b2)

4. Results

Quote from the «Think Aloud»-interview 2:

"I imagine that when I climb from the ground onto the tree and there, so to say, with the stairs to the first platform (points to the map), my energy changes with every step and I don't notice it until I jump down. And that's a bit strange for me to imagine. So if you just, it makes sense, if you jump down, then you have to cushion more in your legs, so that it hurts less. […]"

(Interview 2, Section 26)

Codings:

Main category: **Content related alignment** (3a)

Subcategory: **Coordination of a relation/concept with content related context features**

5.
Main Findings & Conclusion

5. Main Findings and Conclusion

Main findings

- We developed a **framework** for describing the transfer process. The framework is **based on existing models** but **expands** and connects these in a new way.
- With the framework, the **«actor's perspective»** on transfer (e.g. thought processes or applied strategies) is respected.
- The **analyzation of context features**, the **connection of knowledge pieces** as well as a **content related, and a metacognitive alignment** are part of the transfer process.
- The individual transfer processes **vary a lot** and are different regarding the **sequence and the amount of codings of the categories** mentioned above and is therefore **not very structured**.

5. Main Findings and Conclusion

Main findings

- We found evidence that **concepts are not transferred as a whole**. The linking of the individual knowledge pieces seems to depend on the observed **context** and the use of **metacognitive strategies**.

- Knowledge can be transferred on **different levels of complexity** (e.g. facts, relations, formulas) and **with or without reference to specific context features**.

- We identified some **metacognitive strategies** (or procedures) like «taking the perspective of a subject». The framework **allows the integration of further "transfer strategies"** that have not yet been described.

5. Main Findings and Conclusion

Conclusion

There is no general transfer theory that describes every aspect of applying knowledge.

But we can structure and analyze specific transfer processes in physics topics (like «energy») with a framework that includes knowledge elements of individuals as well as features of the context situations.

6.
Outlook

6. Outlook

Planned second part of the study:

- Subsequent quantitative study to test different **effects of previous instruction and motivational aspects** on transfer

- We derived **hypothesis** from the qualitative study and literature for testing in the planned quantitative study, for example:

  - A better concept of energy (i.e. measured with the ECI) increases the transfer of more complex knowledge.
  - An in-depth examination and comparison of several context situations with the same structure let students develop strategies and use them for metacognitive alignment (e.g. “making references to one’s own experience”).
  - Etc.

→ **RQ**: What to do in class to foster subsequent transfer?

Thank you for your attention!

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