Fostering signed mathematical discourse that promotes learning

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Motivation

- Deaf learners of mathematics often treated as “hearing students that cannot hear” (Marschark et al. 2011, S. 4)

- So far no engagement with the distinct way of experiencing the world and of thinking

- Consideration of resources instead of deficits in mathematics instruction (Healy & Fernandes, 2014; Healy, 2015; Kurz & Pagliaro, 2020)

„Pointing out that deaf people can be every bit as competent as hearing people should not be taken as equivalent to the claim that deaf individuals necessarily think, learn, or behave exactly like hearing peers.“ (Marschark 2003, S. 464)

(Marschark 2003)

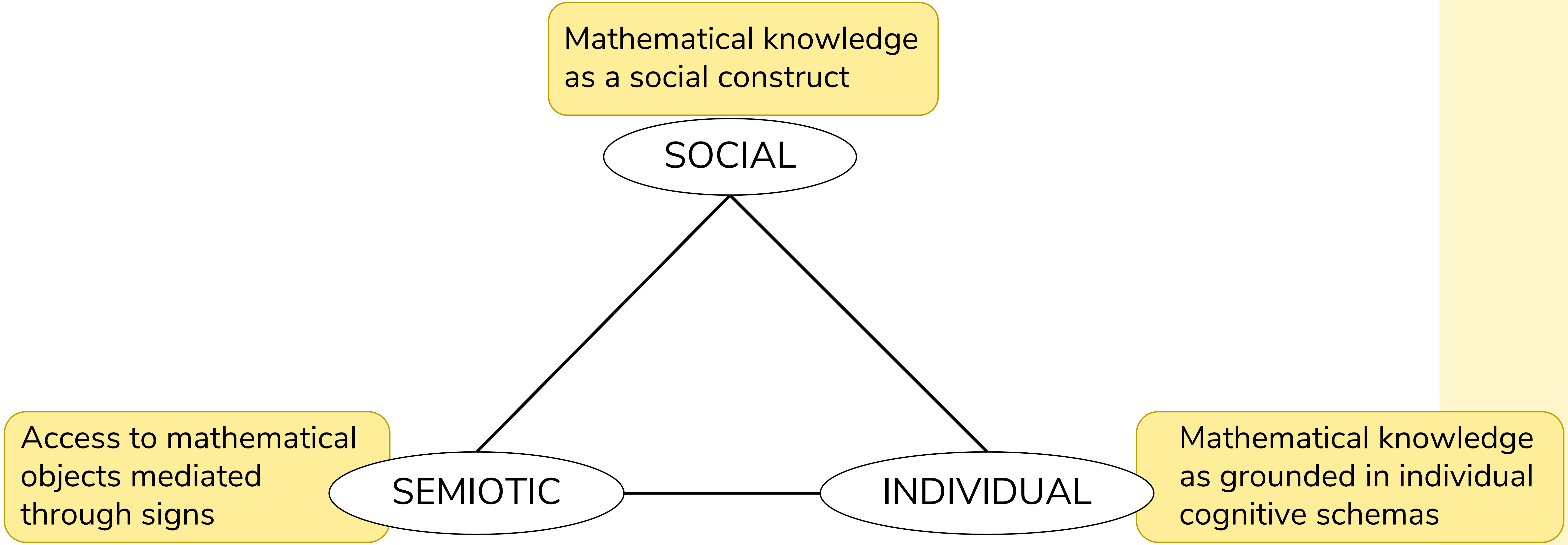
(Healy & Fernandes, 2014; Healy, 2015; Kurz & Pagliaro, 2020)

„Learning“ – not quite what the sign might suggest

Learning mathematics:
- Is a process
- Needs active involvement and engagement with the subject
- Happens in interaction with others and the environment
- Builds on individual conceptualizations and cognitive schemata

A math education perspective: components of processes of learning mathematics

(Krause, 2018; *in preparation*)



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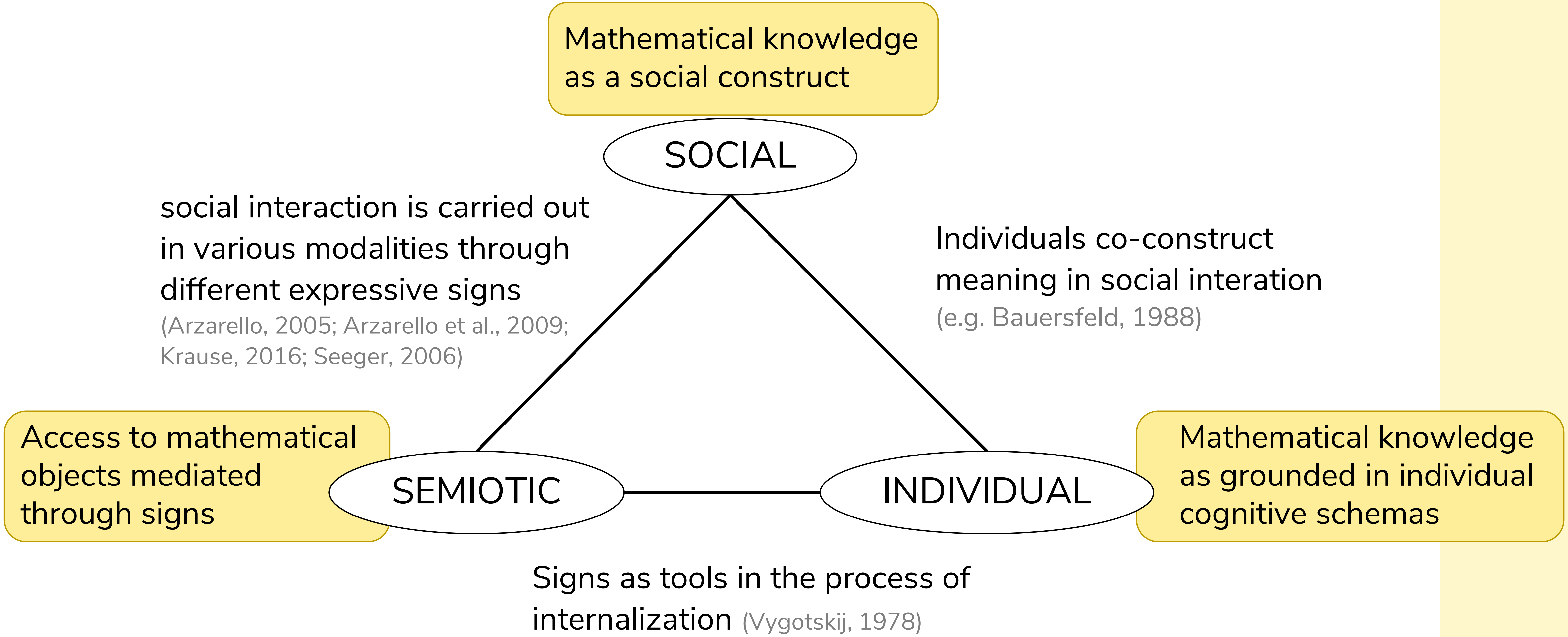
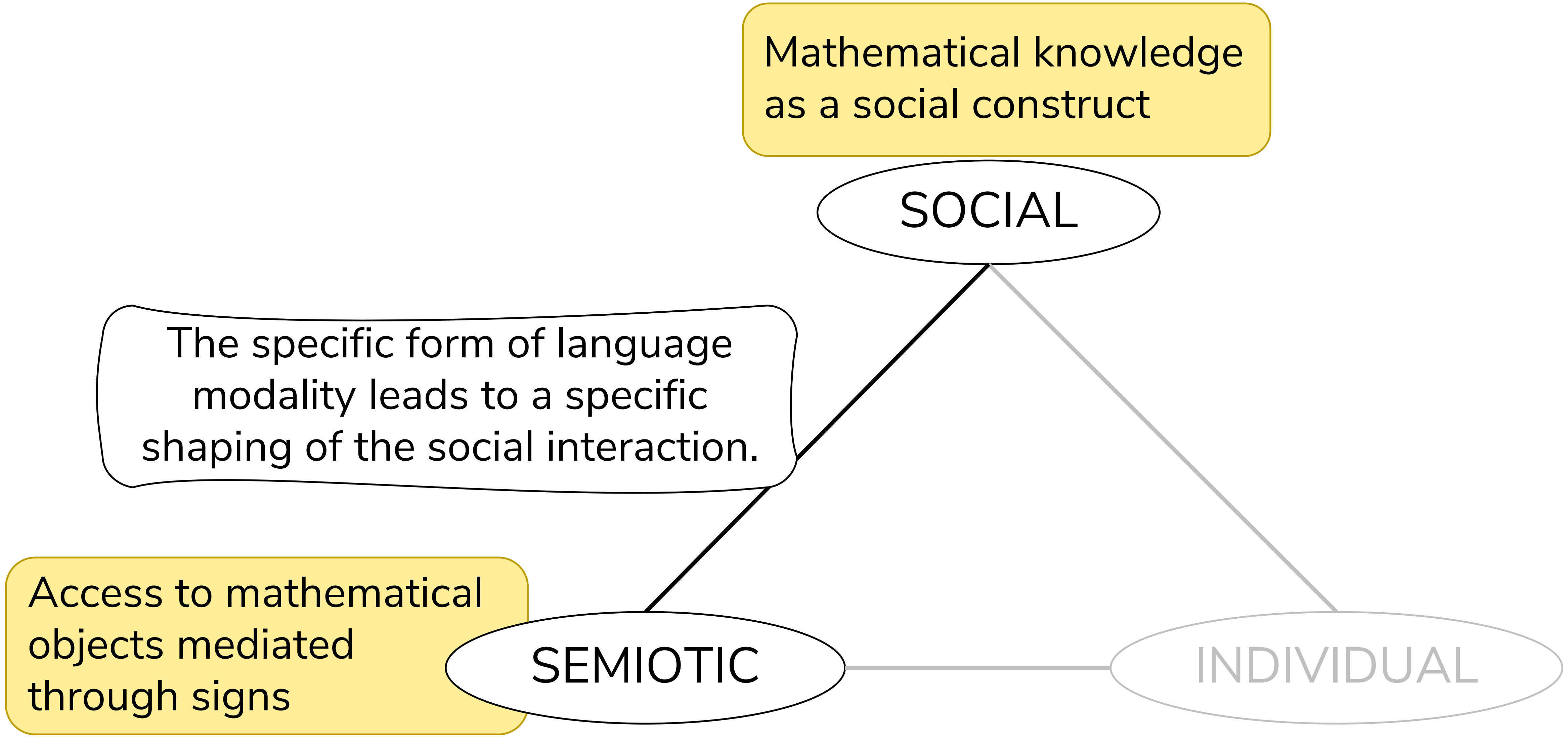


What about Deaf learners?

(Krause, 2018; *in preparation*)



What about Deaf learners?

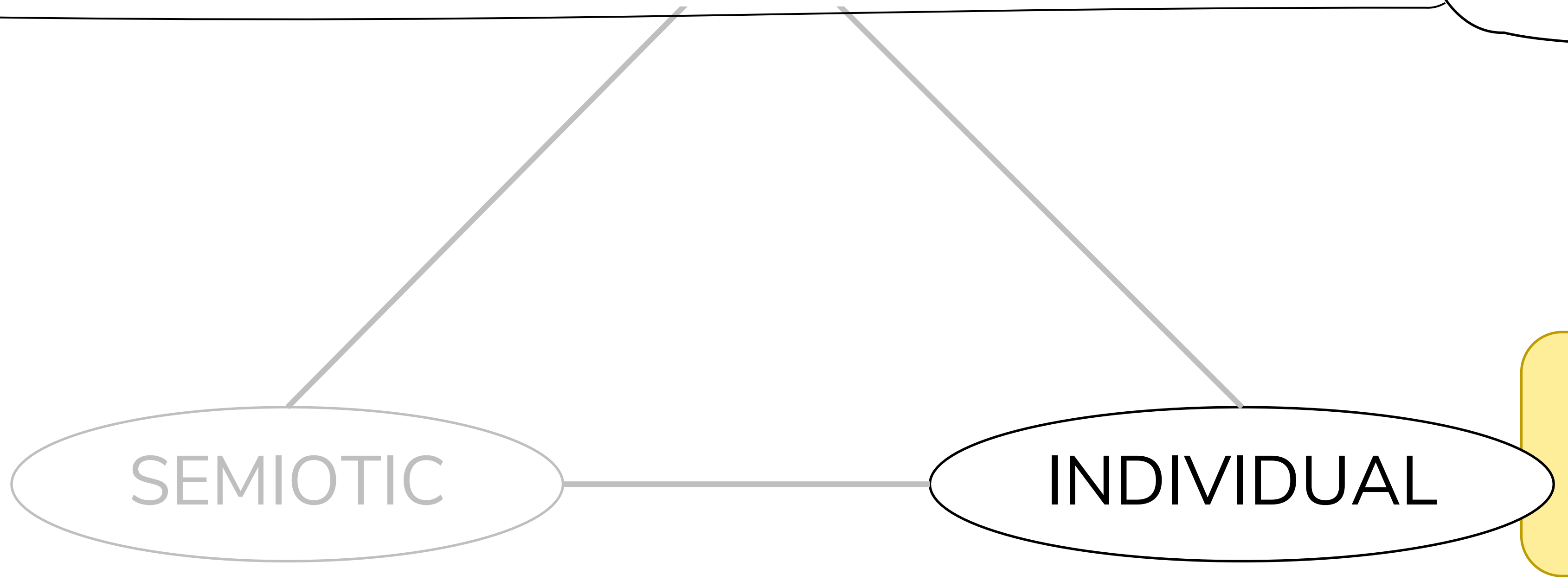
(Krause, 2018; *in preparation*)

Embodiment thesis (Wilson & Foglia, 2016):

“Many features of cognition are embodied in that they are deeply dependent upon characteristics of the physical body of an agent, such that the agent's beyond-the-brain body plays a significant causal role, or a physically constitutive role, in that agent's cognitive processing.”

Mathematical thinking as grounded in our experiences and interaction with the world

(Wilson & Foglia, 2016)
(Varela et al., 1991)
(Nemirovsky, 2003)
(Barsalou, 2008)



Mathematical knowledge as grounded in individual cognitive schemas

What about Deaf learners?

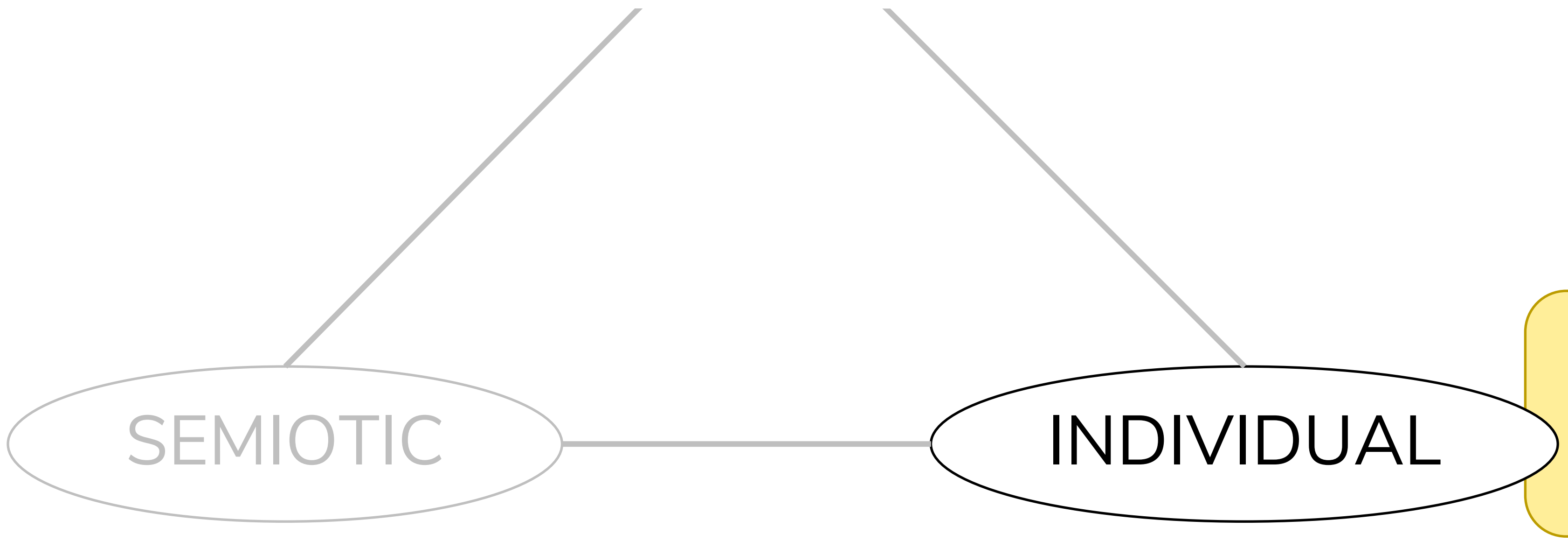
(Krause, 2018;
in preparation)

Embodiment thesis (Wilson & Foglia, 2016):

→ **Body as ‘constraint‘:**

- “Some forms of cognition will be easier, and will come more naturally, because of an agent's bodily characteristics; likewise, some kinds of cognition will be difficult or even impossible because of the body that a cognitive agent has.
- Cognitive variation is sometimes explained by an appeal to bodily variation.“

(Wilson & Foglia, 2016)



Mathematical knowledge as grounded in individual cognitive schemas

What about Deaf learners?

(Krause, 2018; *in preparation*)

bodily organs as instrumental tools in the sense of Vygotsky: influencing structure and process of thinking

substitution of one by the other “is expected to cause a profound restructuration of the intellect” (Healy, 2015)

Access to mathematical objects mediated through signs

SEMIOTIC — INDIVIDUAL

Mathematical knowledge as grounded in individual cognitive schemas

(Healy, 2015)
(Vygotsky, 1978)

So we might ask…

How can we use sign languages as a resource for learning mathematics for Deaf students?

How can we use it as a fruitful means for learning mathematics?

Background

Signers think differently: Iconicity

(Grote, 2010)

Iconicity:
Sign language signs can have an *iconic relationship to their reference object* by evoking some kind of similarity

- Iconicity of language signs *influence cognitive structuration* and conceptual understanding
- features reflected in the iconic moment of the sign have a *specific relevance for the whole semantic concept*

Iconicity and learning math

Iconicity:
Sign language signs can have an *iconic relationship to their reference object* by evoking some kind of similarity

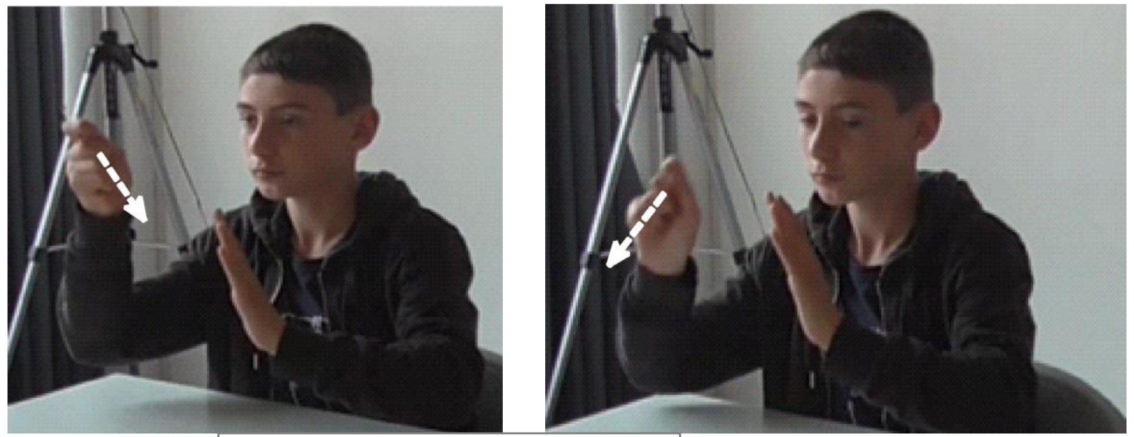
(Grote, 2010)

- Iconicity of language signs *influence cognitive structuration* and conceptual understanding
- features reflected in the iconic moment of the sign have a *specific relevance for the whole semantic concept*

Sign language sign used to refer to a mathematical can influence conceptual understanding of this idea

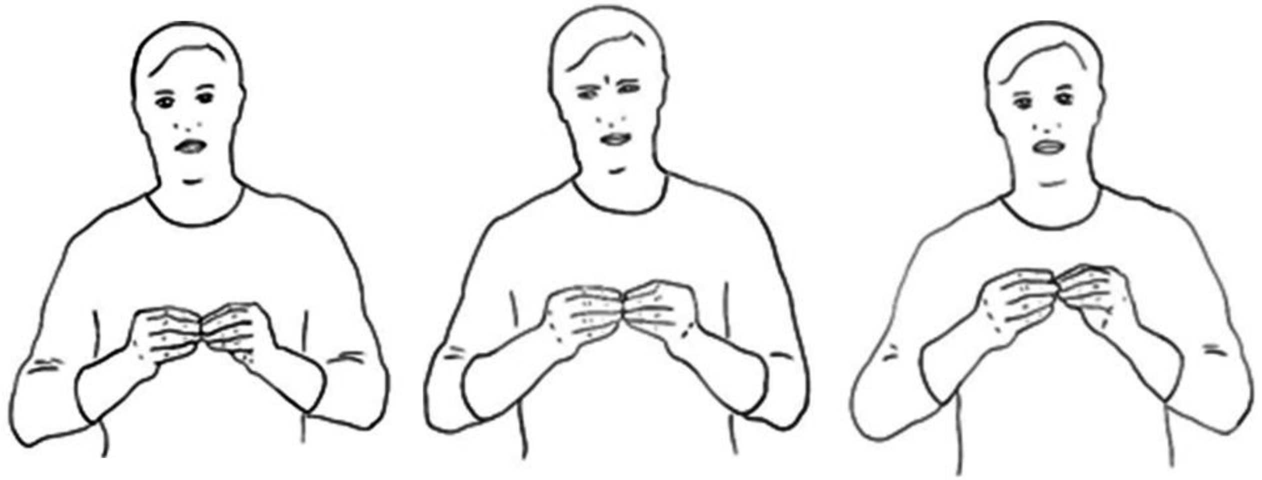
(Krause 2017a, b, 2019, Krause & Wille, 2021; Kurz & Pagliaro, 2020)

Iconicity and learning math



iconic-physical

iconic-symbolic



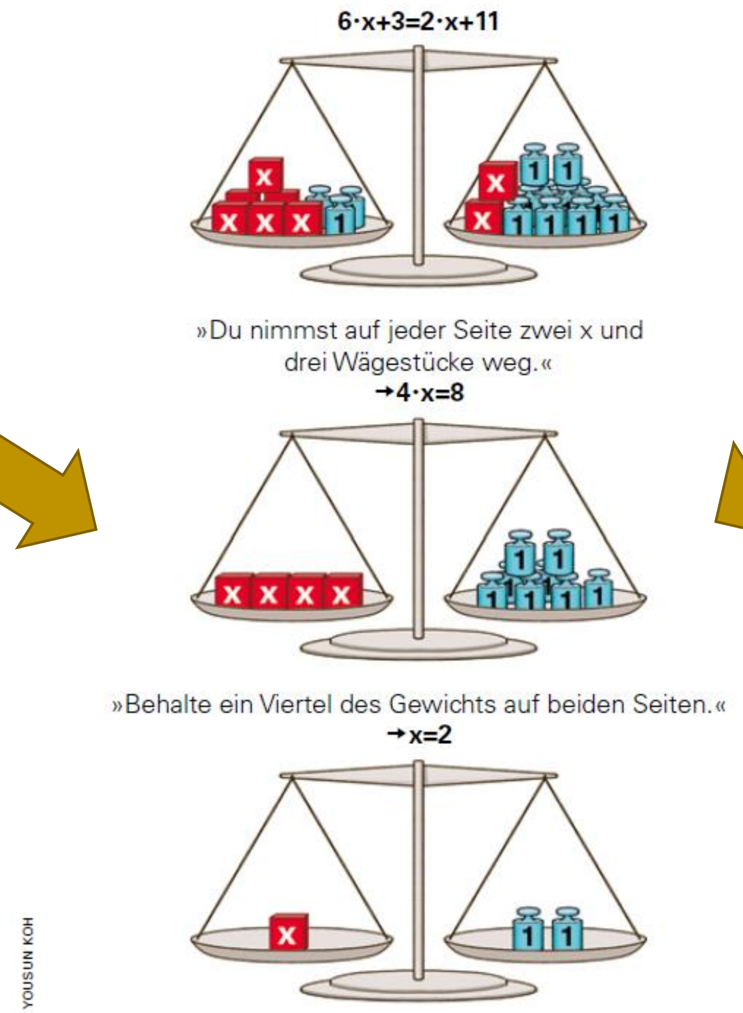
Innerlinguistic iconicity / phonologically similar (Krause, 2017) / indexicality (Wille, 2020)

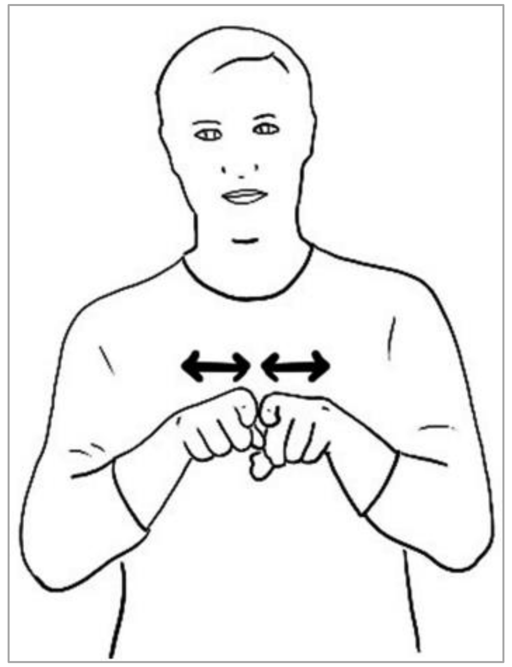
(see also Kurz & Pagliaro, 2020)

(examples from: Krause, 2017, 2019; Krause & Wille 2021)

The embodiment of mathematical language?

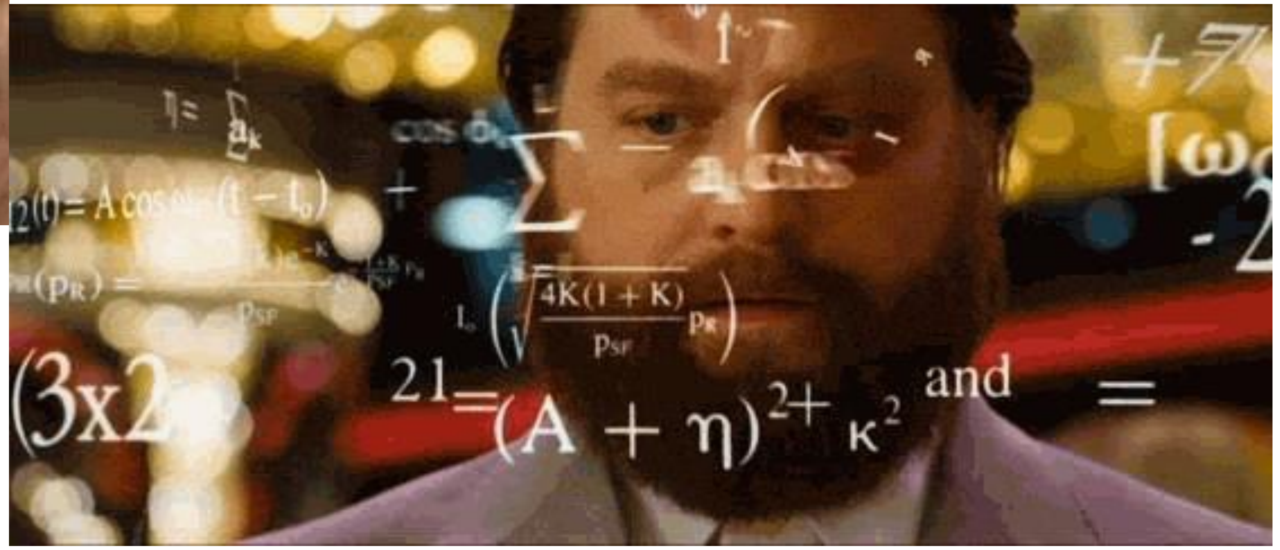
(Krause & Wille, 2021)



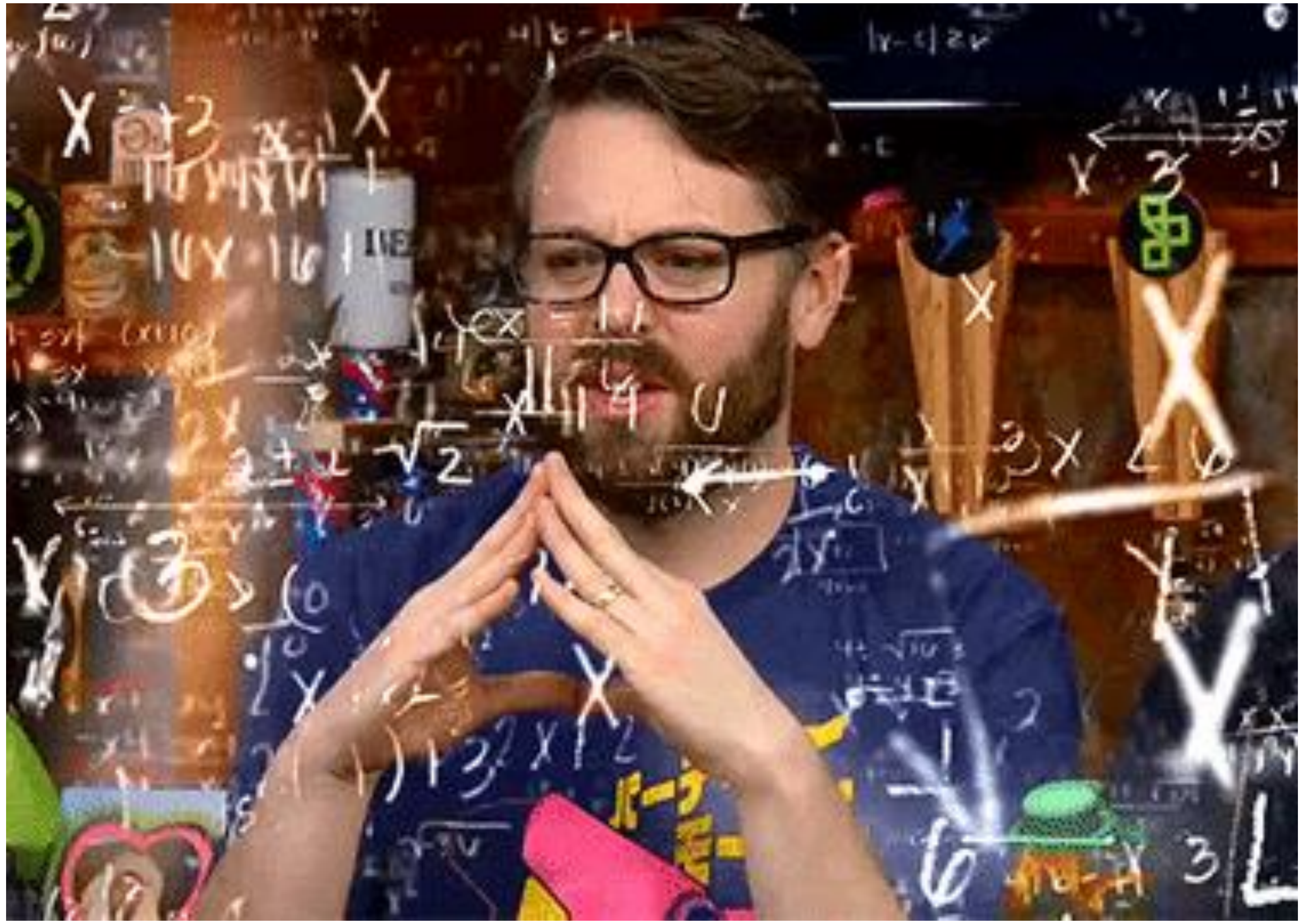


GLEICH (ÖGS)
(*equal*)

What math not is



… but maybe rather something close to this…

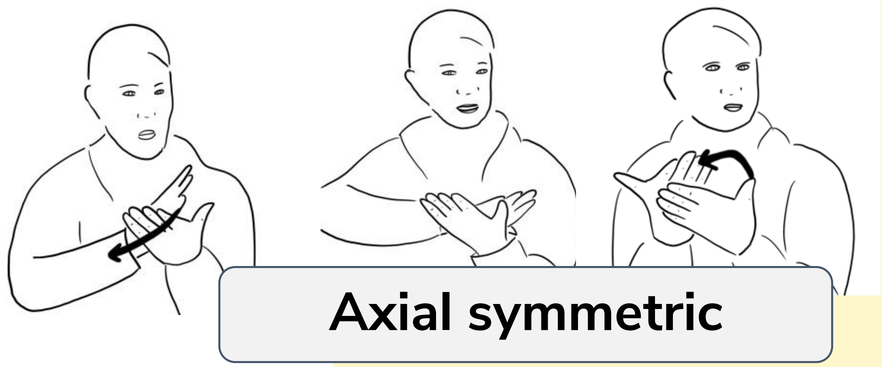


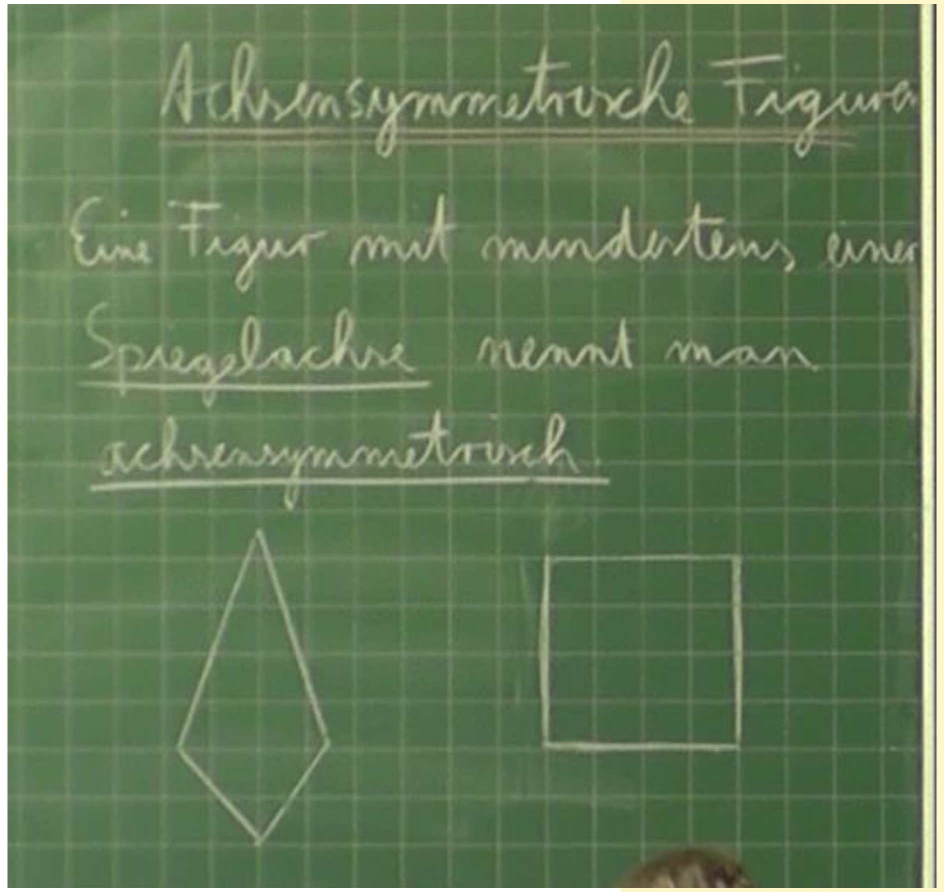
(no sound)

Establishing iconic relationships actively

(Krause, 2018, 2019)

Sorry, no permission to upload video ☹



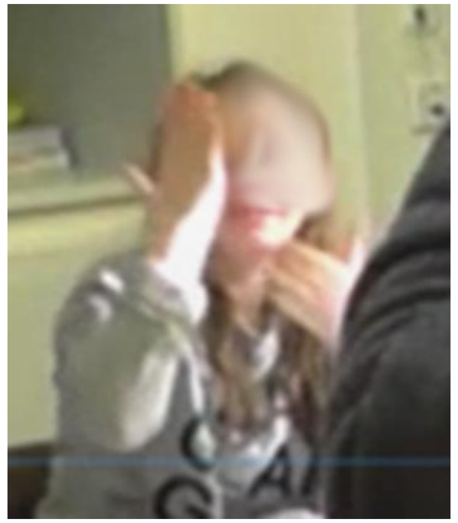


Axial symmetric figures
„A figur with at least one mirror axis is called axial symmetric"

(Krause, 2018, 2019)

folding

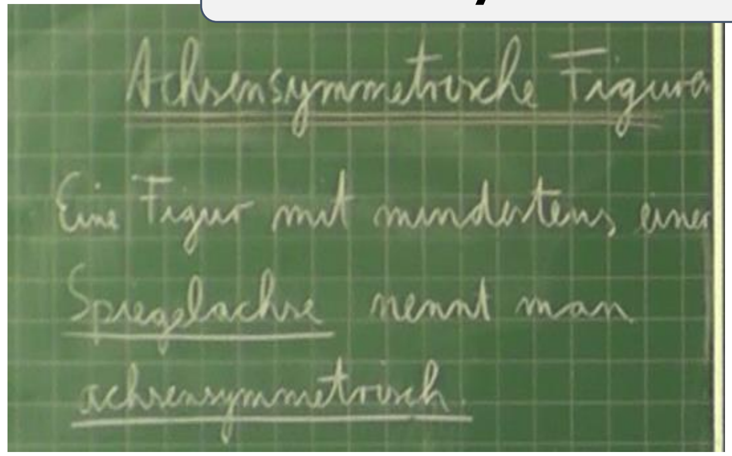
Iconic-physical



SPIEGEL (mirror)

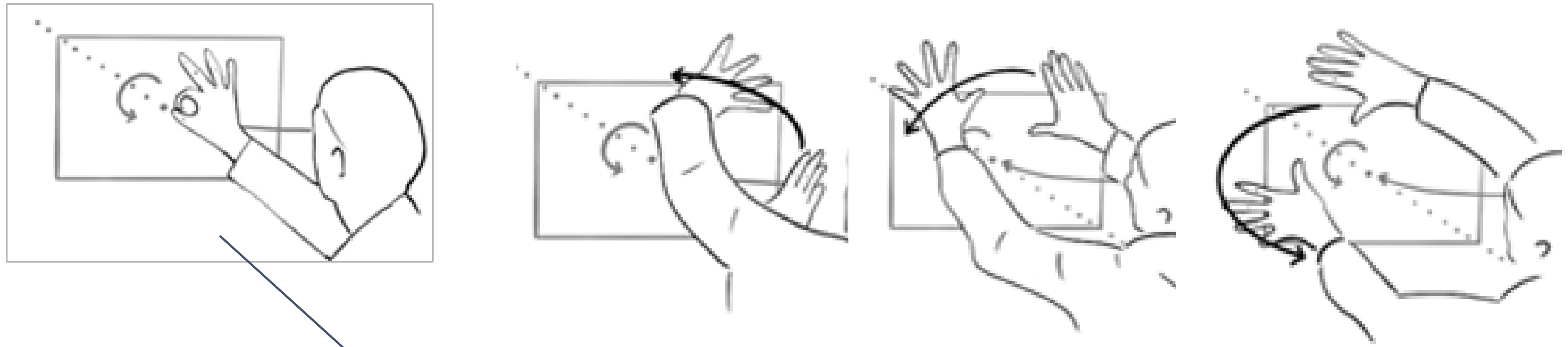
Innerlinguistic iconicity

Axial symmetric



mathematical concept ⟷ **Language (signed and written)**

(Krause, 2018, 2019;
Krause & Wille, 2021)



PUNKT
point

rotating

PUNKTSYMMETRISCH
(point symmetric)

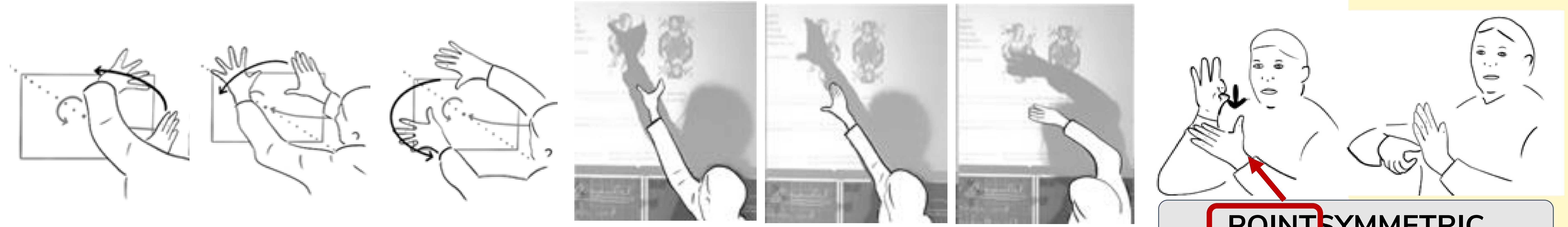
- Mathematical signs often develop ‘spontaneously’ or locally conventionalized
- Iconicity of mathematical signs
- Modal hybridity of gestures and sign

(Alibali & Hostetter, 2008)
(Kurz & Pagliaro, 2020)
(Pagliaro, 2010)

Grounding language in action

(Krause & Abrahamson, 2021; *in preparation*; Tancredi, Chen, Krause et al., 2021)

ACTION → GESTURE → SIGN



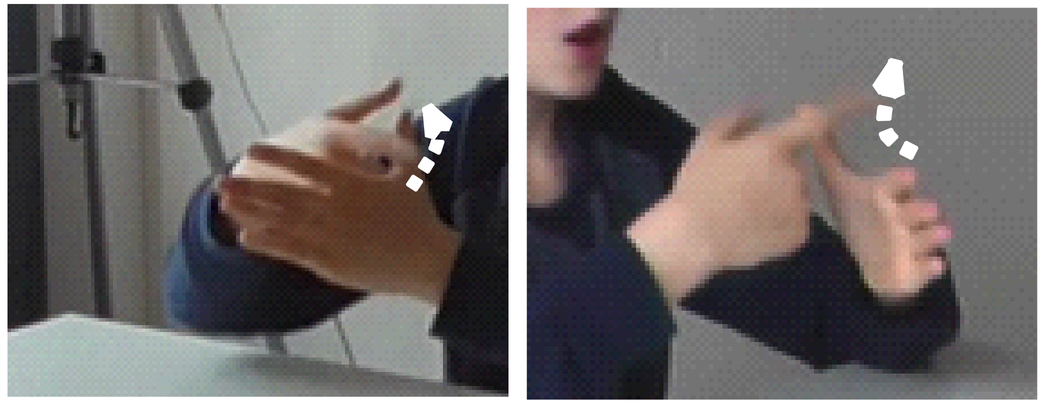
POINT SYMMETRIC

Iconisation of the sign

Another result: Pluralism of mathematical signs

(Krause, 2017, 2019)

An example: Signs for ‚Zähler' (numerator) in a German grade 6 classroom

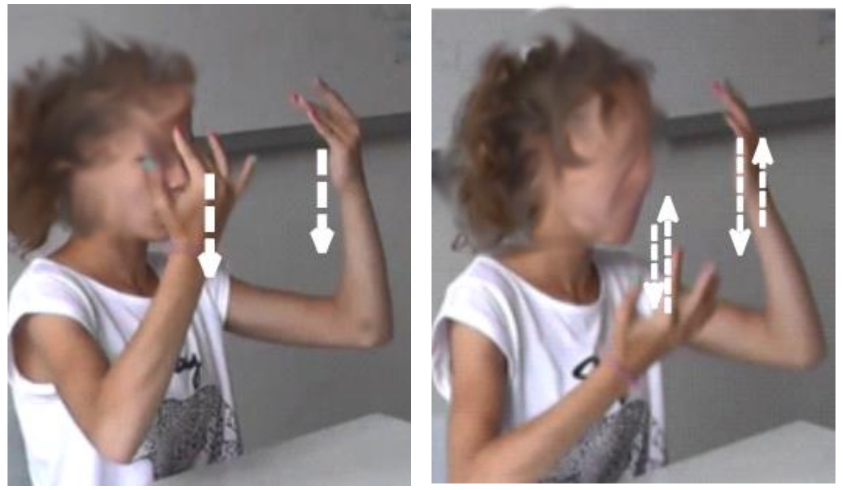


"Zähler" (numerator) **based on "zählen"** (counting)

→ similarity of (written) words

→ possible link: 'counting' the given number of the parts the whole is divided in

→ fractions as 'part of a whole' (e.g. Kieren, 1980; Lamon, 2012)



"Zähler" (numerator) **based on "Zahl"** (number)

→ similarity of (written) words

→ more general link to the Zähler being a number, than to an understanding of 'Zähler' within the concept of fractions

→ innerlanguage iconicity of sign for "Zahl" *(number)* to sign for "rechnen" *(calculating)*

Zähler

numerator

Another result: Pluralism of mathematical signs

(Krause, 2017, 2019)

Pluraslism as a benefit?

→ Expresses and influences different understandings

→ Can be a point of discussion

→ Can appreciate different (conceptual) angles,

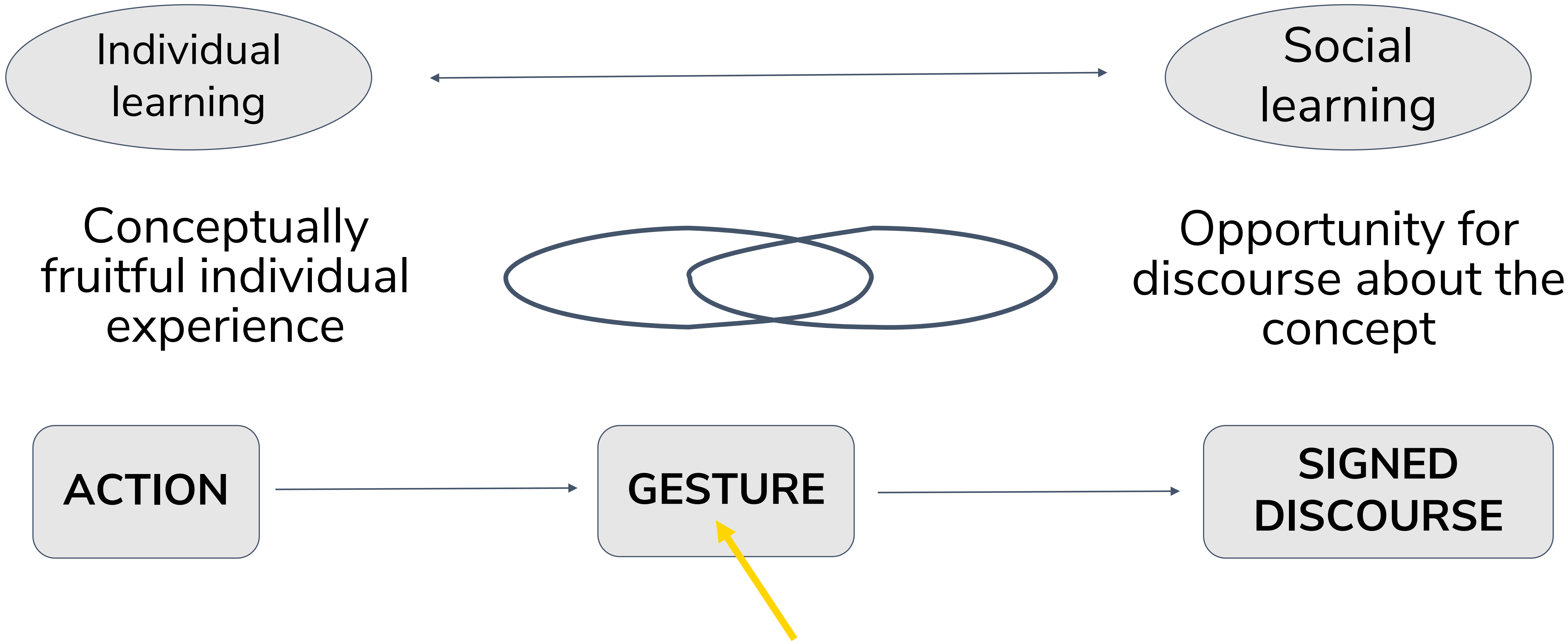
E.g., for fractions:

- Fraction as part of a whole
- Fraction as quasi-cardinality
- Symbolic notation of a fraction

→ Requires deep didactical content knowledge in preparation

From research to practice

(Krause & Abrahamson 2021, *in prearation*)

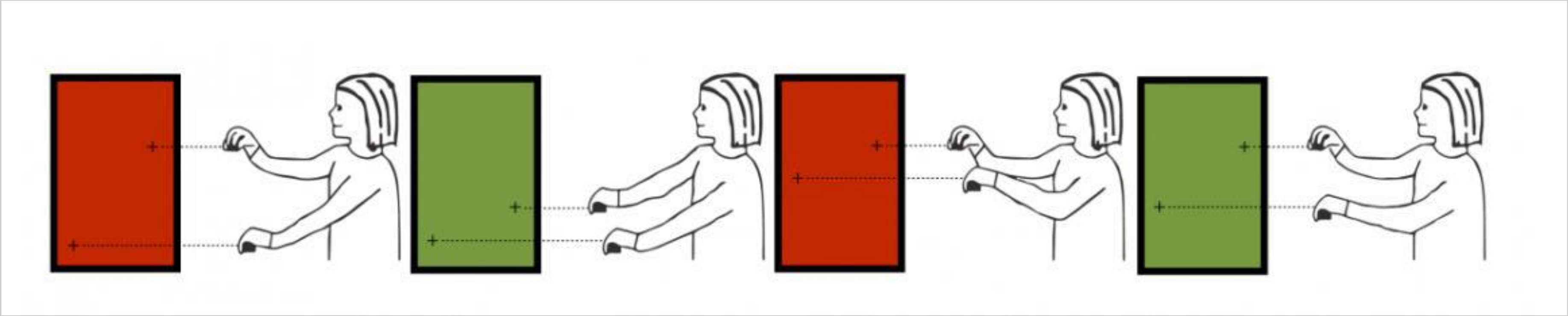


- Gestures as simulated actions (Hostetter & Alibali, 2008)
- Reflect conceptual understanting
- Can have self-directed functions that support thinking (Kita et al., 2017)

Project SignEd|Math: Designing for modal continuity

(Krause & Abrahamson 2021, *in prearation*)

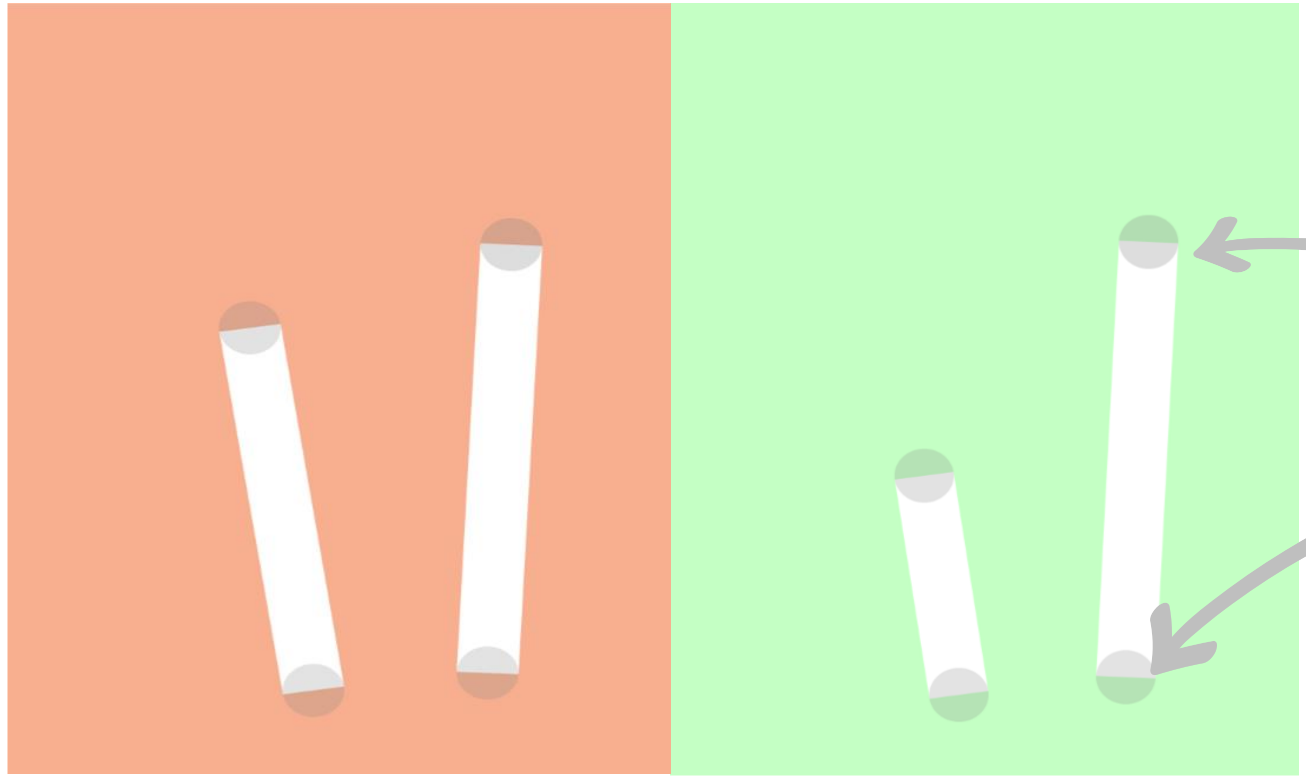
Original design



height of left hands
:
height of right hand

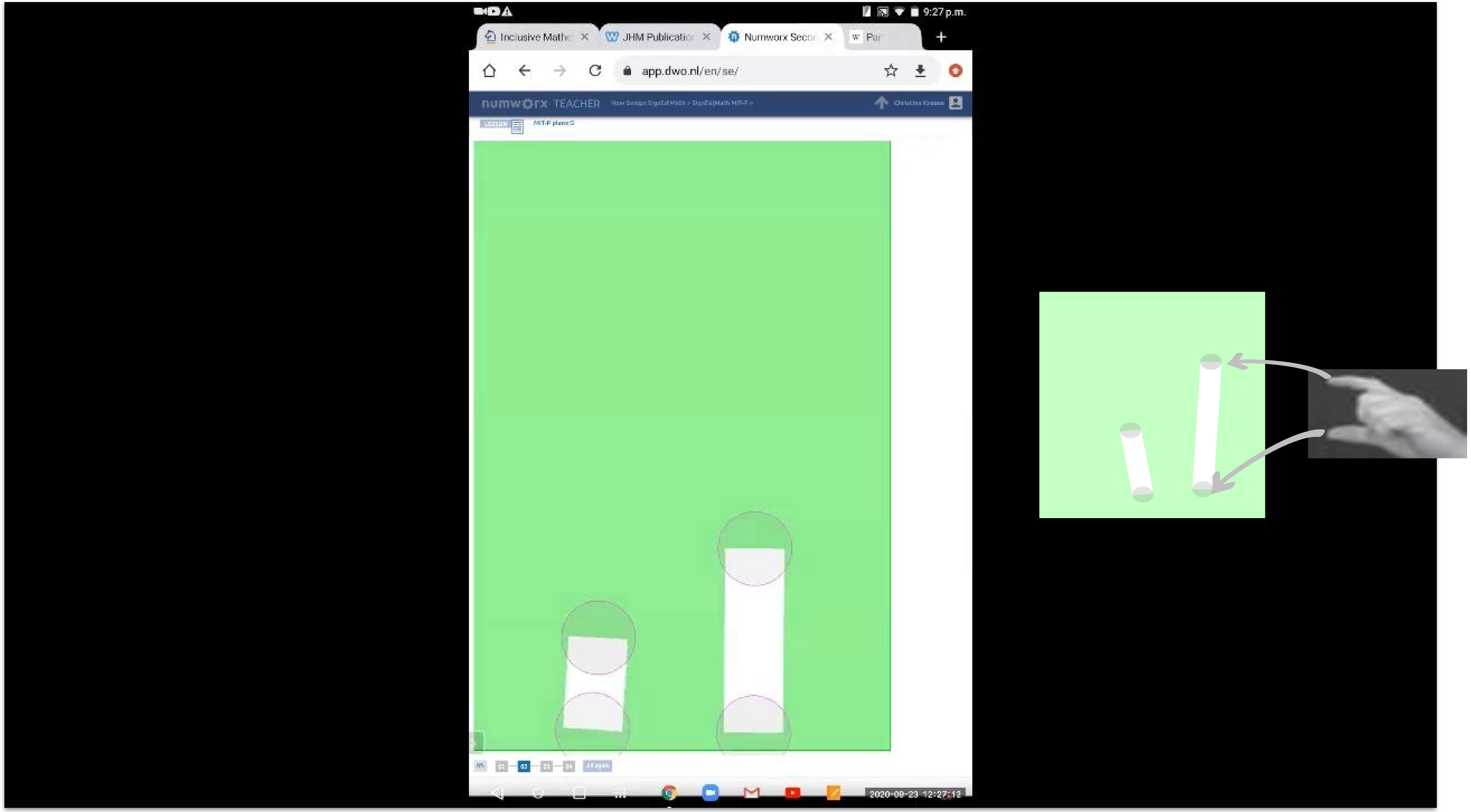
project
SignEd|Math

Prototype
design adapting for handshape



distance between fingers of left hands
:
distance between fingers of right hand

Prototype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numworx TEACHER
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First step: Individual embodied context
Providing embodied experience for conceptual development

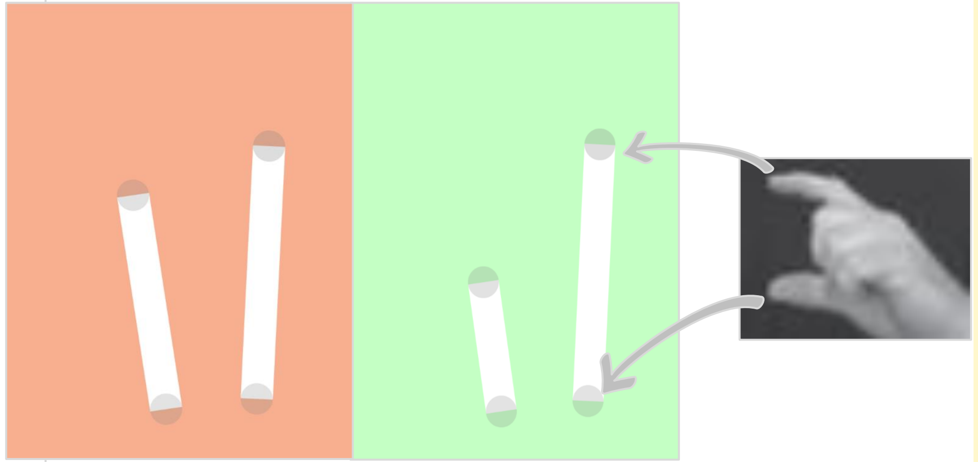
Individual work with the learning environment

Goals:

- Providing an occasstion to develop perceptuo-motor schemes and reflect on them
- Building embodied understanding of the concept of ration and proportions

How:

- Interactive movement problem that integrates handshape
- Interview towards reflection
- Stepwise addition of mathematical symbolic means to reflect on



Second step: Social context
Providing occassions for mathematical conversation

Collaborative work on transfer problems

Goals:

- Providing an occasion to negotiate mathematical meaning through signed conversation
- ***deepens or widens*** the engagement with the (proportion) concept

How:

- Transfer problem, based on shared embodied experiences
- Prompts discourse about the concept (of proportion) towards the solution of the transfer problem

For example, in this case:

1. Collaboratively working on another ratio problem in the digital learning environment
2. Task that provides a link to related concepts, like fractions

Modal continuity as methodology in the classroom

A

Using the digital learning environment as means in the classroom → Initiating conversation in classroom discussion

B

Providing conceptually rich (embodied) experiences to integrate into signing about math → Initiating conversation in classroom discussion → Reflecting on signed expressions themselves

Modal continuity as methodology in the classroom

B

Providing conceptually rich (embodied) experiences to integrate into signing about math → Initiating conversation in classroom discussion → Reflecting on signed expressions themselves

Modal continuity as methodology in the classroom

B

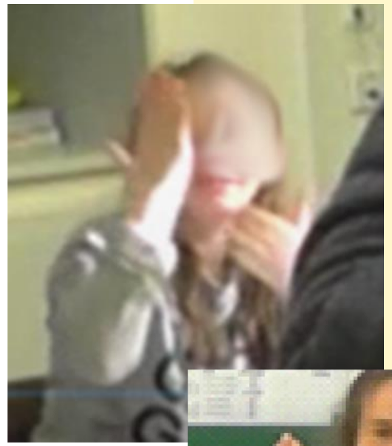
Providing conceptually rich (embodied) experiences to integrate into signing about math

Initiating conversation in classroom discussion

Reflecting on signed expressions themselves

Negotiating (signed) mathematical language related to a concept

Context algebra / ***variable***:
"n is a secret number"
(Fernandes & Healy, 2014, 55)



Characteristics of conceptually rich experiences

- Provide activity to develop viable mathematical conceptualisations
- Hands-on / interactive
- Ground language that provides additional conceptual support

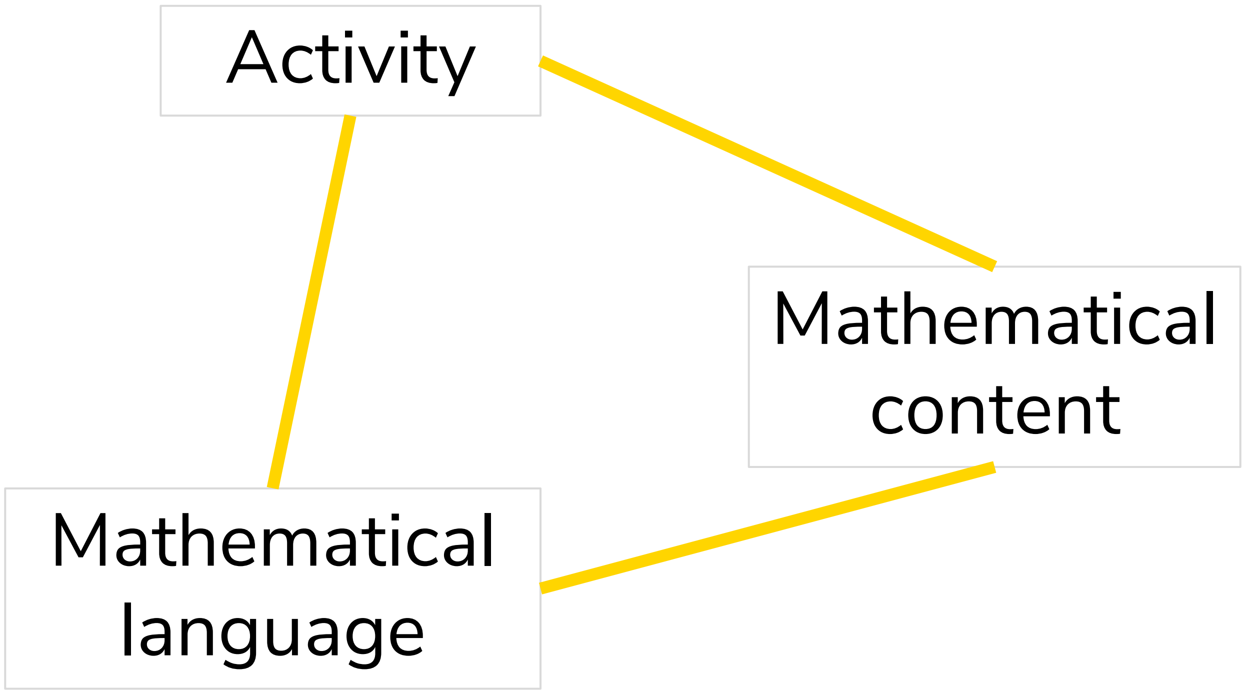
→ Needs reflection of the learning content and of the language from a didactical and a linguistic perspective!

→ Best done in teams.

Where to go from here? Implications and conclusions

Implications

- Sign language can be a rich resource in the mathematics classroom
- Mathematical understanding and meaning of mathematical signs can be grounded in the same conceptually rich experience



Conclusions and future directions

Just a start!

We need to know more about using sign language as a resource of and for Deaf learners of mathematics!

Designing a pool of conceptually rich experience

Researching their influence on mathematical conversation in different settings

Thank you!

More about me and my work:

tinyurl.com/ChristinaKrause