Instructionally Sensitive Classroom Assessment

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CAESL San Francisco

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Assessment is not an add-on to teaching and learning, it can be integral.

Richard Shavelson

Overview

I. Current issues in Educational Assessment –

The Classroom Assessment Environment
The German Research Program „Models of Competence“
Project „Coca“ and Research Questions on Classroom Assessment

II. Designing assessment which is both instructionally sensitive and aligned with overall standards –

The Theorem of Pythagoras as an example

Classroom assessment environment

as defined by Stiggins & Conklin (1992):

Teachers practices
- assessment purposes, methods (including grading), criteria, quality

Feedback

Teacher background in assessment
- beliefs, knowledge, perception of pupils

Assessment policy environment

Everyday practice in Math Instruction

Program for International Student Assessment (PISA) 2003 (OECD)

School questionnaire; % agree (weighted data)

	GER	JAP	NL	UK	US
Never use standardized tests	55	42	23	27	2
Teacher-made tests > 1 per month	44	3	67	18	88
Compare to national standards	21	18	61	87	90
Compare to other schools	17	12	45	95	92
Teacher require high achievement (strongly agree)	32	29	21	64	56

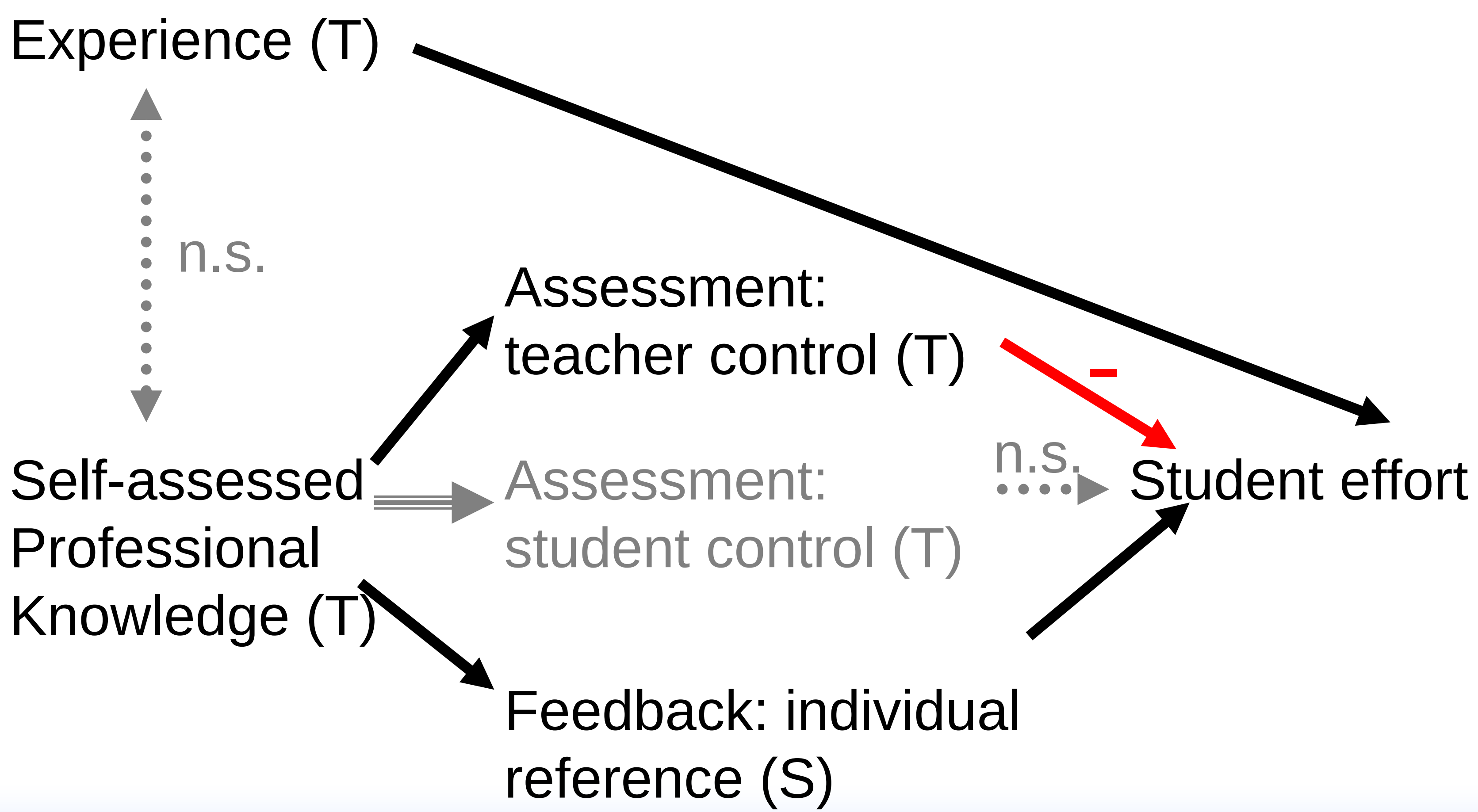
Everyday practice in Math Instruction

Teacher survey in Hesse 2008; Buergermeister, Klieme et al. in prep.

Type of asssment and feedback	Overall frequency	experienced teachers	„high profess. Knowledge“
Teacher-controlled assessment	often		+
Student-controlled assessment	seldom		++
Reference: individual	Tendency: yes		++
Reference: criterion	Tendency: no	+	
Explaining grading criteria to students	always	+	

Everyday practice in Math Instruction

Teacher survey and linking study in Hesse 2008



Feedback in Math Instruction

Predicting student motivation and achievement, controlling for input and context factors

Swiss-German study; Rakoczy, Klieme et al. 2008

	Dependent variable	
	Motivation	**Achievement**
Predictor	*Beta*	*Beta*
Evaluative feedback (correct)	**0.23****	**0.01**
Evaluative feedback (incorrect)	**0.06**	**0.01**
Informational feedback	**0.17***	**0.00**

Grading in Math Instruction

Swiss-German data; Rakoczy, Klieme et al. 2008

Predicting grades (HLM, controlling for country effects)

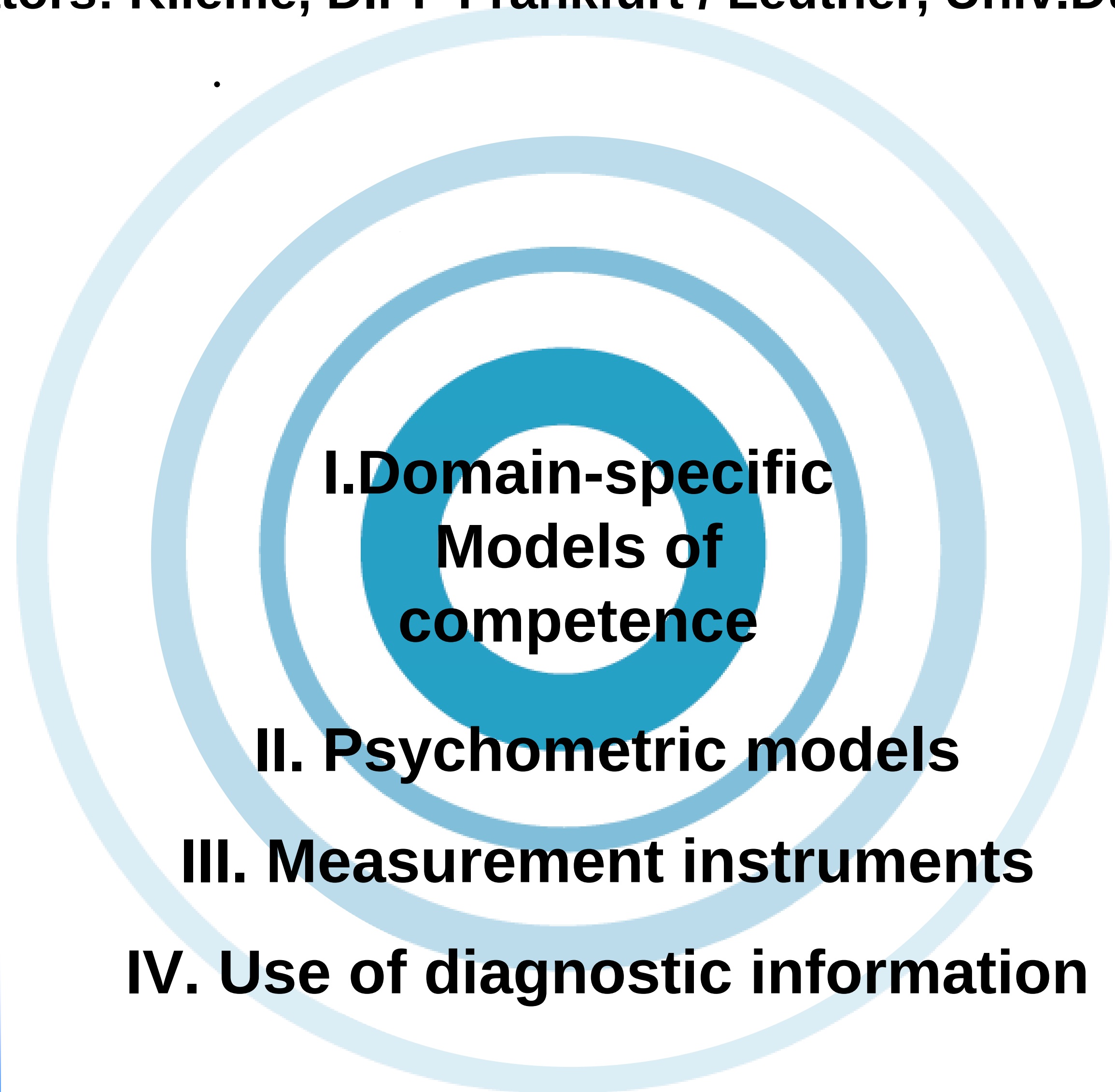
Predictor	Model 1	Model 2
General Achievement (TIMSS-like)	**.24****	**.23****
Deep Understanding (Proof)	**.09****	**.09****
Impact of **individual frame of reference** on regression weight for General Achievement		**.10***
Impact of **Constructivist teacher beliefs** on regression weight for Deep Understanding		**.06****

Current issues in Educational Assessment

Pellegrino at al. 2001: “Knowing what students know”,p. 284

I. Development of cognitive models of learning that can serve as the basis for assessment design
II. Research on new statistical measurement models and their applicability
III. Research on assessment design

German Research Society (DFG):
Priority Program on Modeling of Competencies, 2007 - 2013
(Coordinators: Klieme, DIPF Frankfurt / Leutner, Univ.Duisburg-Essen)



23 inter-disciplinary projects, Principal Investigators:

Artelt; Baumert; Boegeholz; Bogner; Bruder; Dickhaeuser; Fischer; Frederking; Frey; Funke; Graesel; Hardy; Hartig; Hasselhorn; Holling; Horz; Huber; Klieme; Köller; Krolak-Schwerdt; Leuders; Leutner; Moeller; Nickolaus; Pant; Prenzel; Rudinger; Rupp; Schmitz; Schneider; Schnotz; Schwippert; Seidel; Sodian; Soellner; Stanat; Sumfleth; van der Linden; Watermann; Wilhelm; Wirth; Wirtz

International partners:
Beno Csapó (Szeged), Mark Wilson (Berkeley)

3. Measurement instruments

4. Use of diagnostic information

Project Coca

2007- ongoing

Part of section 4: Use of diagnostic information

Researchers:

Eckhard Klieme, Anika Bürgermeister (Educ. Science)
Katrin Rakoczy, Birgit Harks (Ed. Psychology)
DIPF, Frankfurt

Werner Blum, Dominik Leiss (Math didactics)
University of Kassel

Large scale assessment

Context:	accountability
Goal:	evaluation of teachers, schools (& students)
Coverage:	broad, competence-oriented
Sensitivity:	for educational quality in general
Testing schedule:	large intervals

Classroom assessment

(see, e.g., Popham et al., 2005; Shavelson et al., 2007;
Smith et al., 2006; Wilson, 2008)

Context:	instruction
Goal:	describe students‘ learning progress
Coverage:	specific content area
Sensitivity:	for quality of domain-specific instruction
Testing schedule:	multiple measurements with a unit
Interpretation:	criterion-referenced

Research questions

Developing instructionally sensitive CA

Can we develop assessments that measure student understanding on a microlevel (e.g. within two lessons)?

Do assessment results reflect the quality of instruction? (pedagogical quality / content quality)

Implementing it in classrooms

Does instructionally sensitive CA fit into everyday instruction and assessment, including feedback and grading practices? Can we train teachers to use CA-based feedback?

Which impact does it have on student motivation & learning?

Linking it to LSA

Is it possible to link those microlevel, content-specific tests to broader, standards-based tests?

Can we prohibit negative effects of LSA by using an integrated CA/LSA-framework?

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The Theorem of Pythagoras as an example

Developing classroom assessment which is both instructionally sensitive and aligned with overall standards – The Theorem of Pythagoras as an example

I. Understanding the Domain
II. Developing content-specific tests as well as LSA tests
III. Proving instructional sensitivity

} 2000-06 Swiss-German project

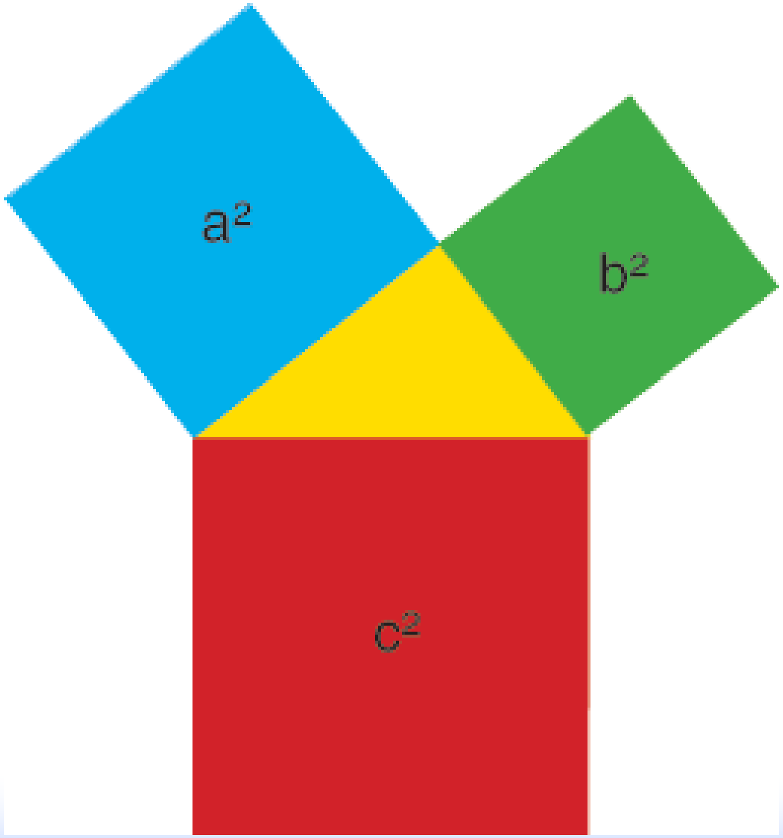
IV. Developing a measurement structure
V. Linking to national standards
VI. Training teachers to implement CA/LSA and provide feedback for students
VII. Studying the impact on student motivation and learning

} Coca 2007-13

Step I: Understanding the Domain

The Pythagorean theorem

Let ABC be a triangle with sides a, b, and c.
If ABC is rectangular and c is the Hypotenuse, then
$a^2+b^2=c^2$.



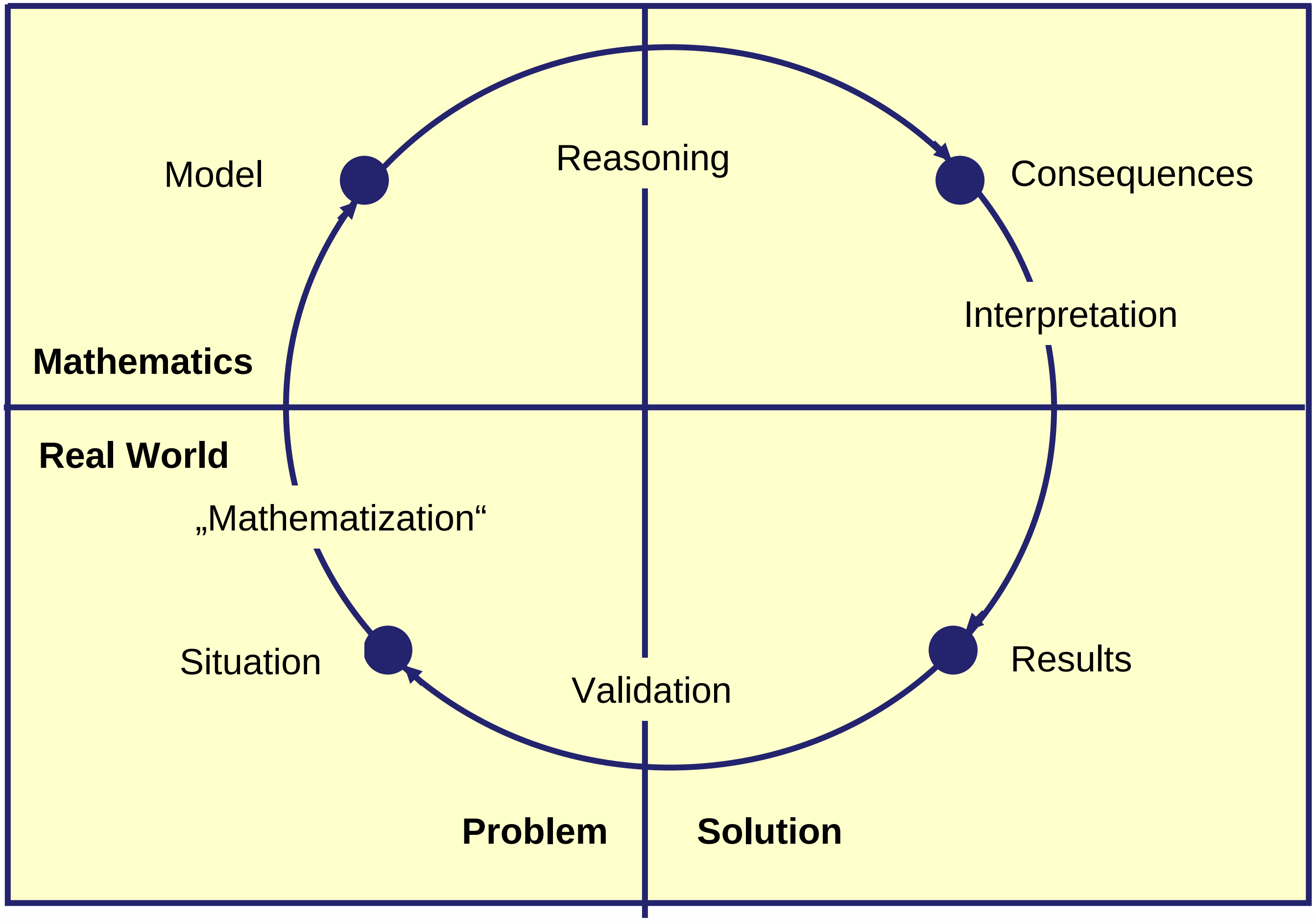
Core unit in school mathematics:

- First non-trivial theorem in Euclidian Geometry
- Link between Geometry and Algebra
- Embedded in a network of mathematical theorems:
  equivalent theorems, inversion („if and only if"), generalizations.
- Wide applications within mathematics
- Wide applications in everyday „mathematical modelling"

List of content elements for understanding the theorem

- Core figure: triangle
- Condition: rectangle
- Rectangle is necessary condition
- (Typical) diagram
- Two types of sides
- Catede vs hypotenuse
- Letters may be changed
- Orientation may change
- Statement about the length of sides
- Statement about areas
- Statement about Pythagorean tripels and quadratic numbers
- Formula
- History: Pythagoras; people who invented it
- If-then-statement
- Validity to be checked

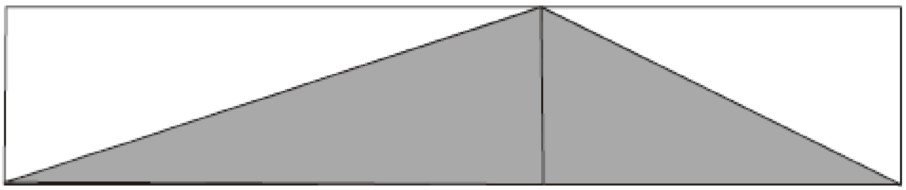
The heart of mathematical competence: Modeling



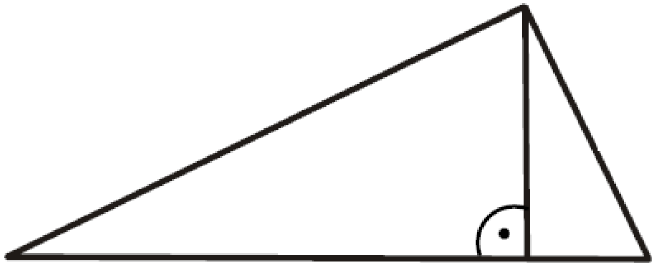
Step II :
Developing content-specific tests

CA1: Prerequisites for Pythagorean Theorem

The big recctangle has an area of 20 cm². How big is the shaded area?



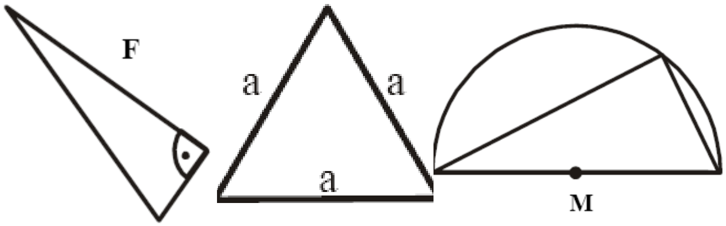
Please indicate sides a,b,c and angles α,β,χ!



Which of the following numbers are quadratic numbers?

1 2 3 4 5 6 7 8 9 10 100 1000 10000

Which of the following triangles is/are rectangle(s)?



Solve for a!

$a = (2+3)^2$	a = ___
$30 = 10 + a$	a = ___
$200 + a^2 = 300$	a = ___
$a = \sqrt{9+16}$	a = ___
$a = b^2 + c^2$ für $b = 2$ und $c = 3$	a = ___

CA2: Immediate learning outcomes from first encounter with Pythagorean theorem:

(i) Qualitative understanding

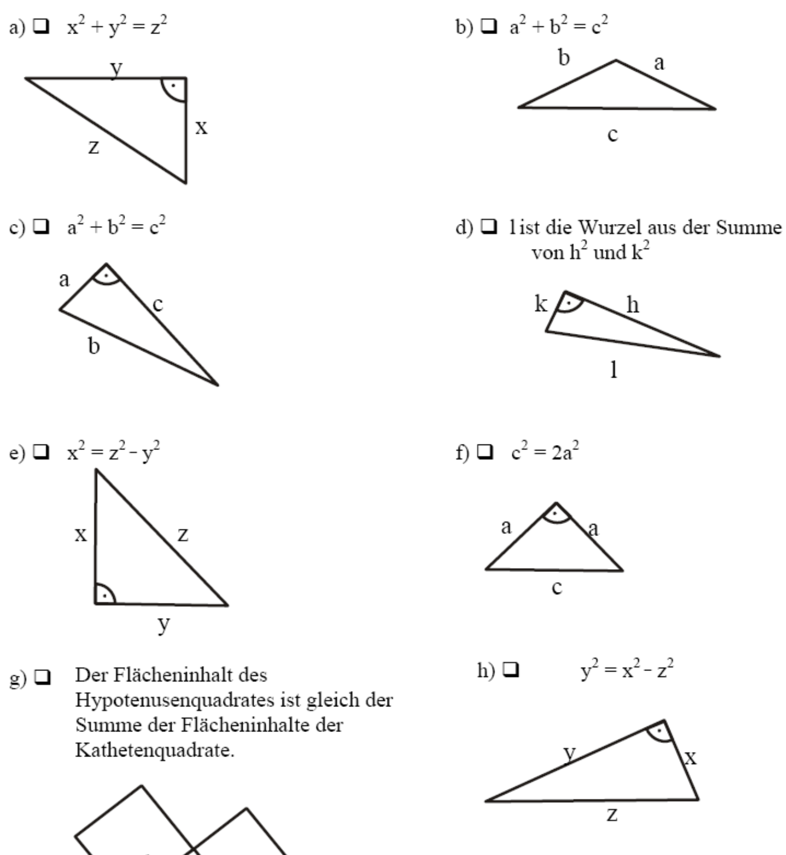
The theorem of Pythagoras has to do with….

- Length of lines
- Areas
- Quadratic numbers
- Rectangular triangles

CA2: Immediate learning outcomes from first encounter with Pythagorean theorem:

(ii) Knowledge

Which graph(s) show the Theorem of Pythagoras?



a) ❑ $x^2 + y^2 = z^2$

b) ❑ $a^2 + b^2 = c^2$

c) ❑ $a^2 + b^2 = c^2$

d) ❑ l ist die Wurzel aus der Summe von h^2 und k^2

e) ❑ $x^2 = z^2 - y^2$

f) ❑ $c^2 = 2a^2$

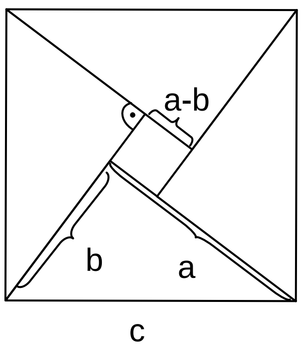
g) ❑ Der Flächeninhalt des Hypotenusenquadrates ist gleich der Summe der Flächeninhalte der Kathetenquadrate.

h) ❑ $y^2 = x^2 - z^2$

(iii) Modeling

Lisa brought chop sticks from China for her friend. They are 35 cm long. Can she post them within an envelop that has length 32 cm and width 23 cm?

CA3 Understanding Proof



4 „student proofs“: formal correct, formal circular, narrative correct, inductive
Questions: Bug? Generalizable?

(adapted from Healy & Hoyles 1998)

		Aussage:	Begründung:
(1)	c^2	$= (a-b)^2 + 4 \bullet \frac{a \bullet b}{2}$	Das große Quadrat hat die Fläche c^2. Es setzt sich aus dem kleinen Quadrat mit der Fläche $(a-b)^2$ und den 4 Dreiecken zusammen. Jedes der Dreiecke hat die Fläche $\frac{a \bullet b}{2}$.
(2)	c^2	$= a^2 - 2ab + b^2 + 4 \bullet \frac{a \bullet b}{2}$	nach binomischer Formel ist $(a-b)^2 = a^2 - 2ab + b^2$
(3)	c^2	$= a^2 - 2ab + b^2 + 2ab$	Umformung von (2)
(4)	c^2	$= a^2 + b^2$	$-2ab + 2ab = 0$

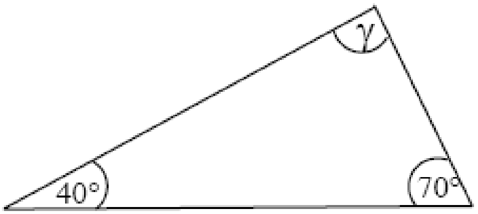
Die Behauptung ist also wahr!

LSA: General achievement (TIMSS/PISA-like)

(i) Knowledge and procedural skills

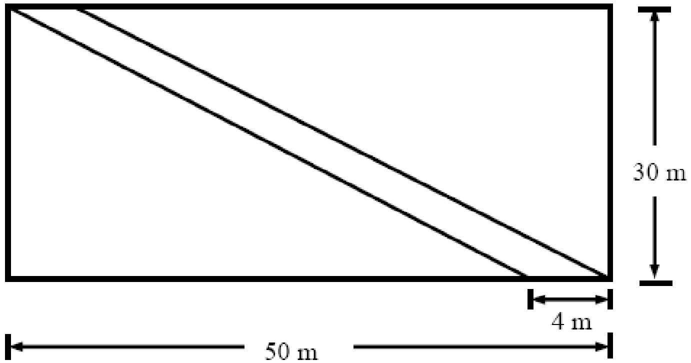
Calculate the missing angle!

- ☐ 60°
- ☐ 30°
- ☐ 110°
- ☐ 70°
- ☐ 90°



(ii) Mathematical modeling (TIMSS/PISA - like)

Calculate the area of the acre without the path that leads through.



(Abbildung nicht maßgenau)

Step III :
Proving instructional sensitivity

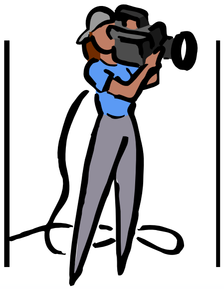
Swiss/German study

(Klieme, Pauli, Reusser, Lipowsky, Rakoczy, et al. 2000ff.)

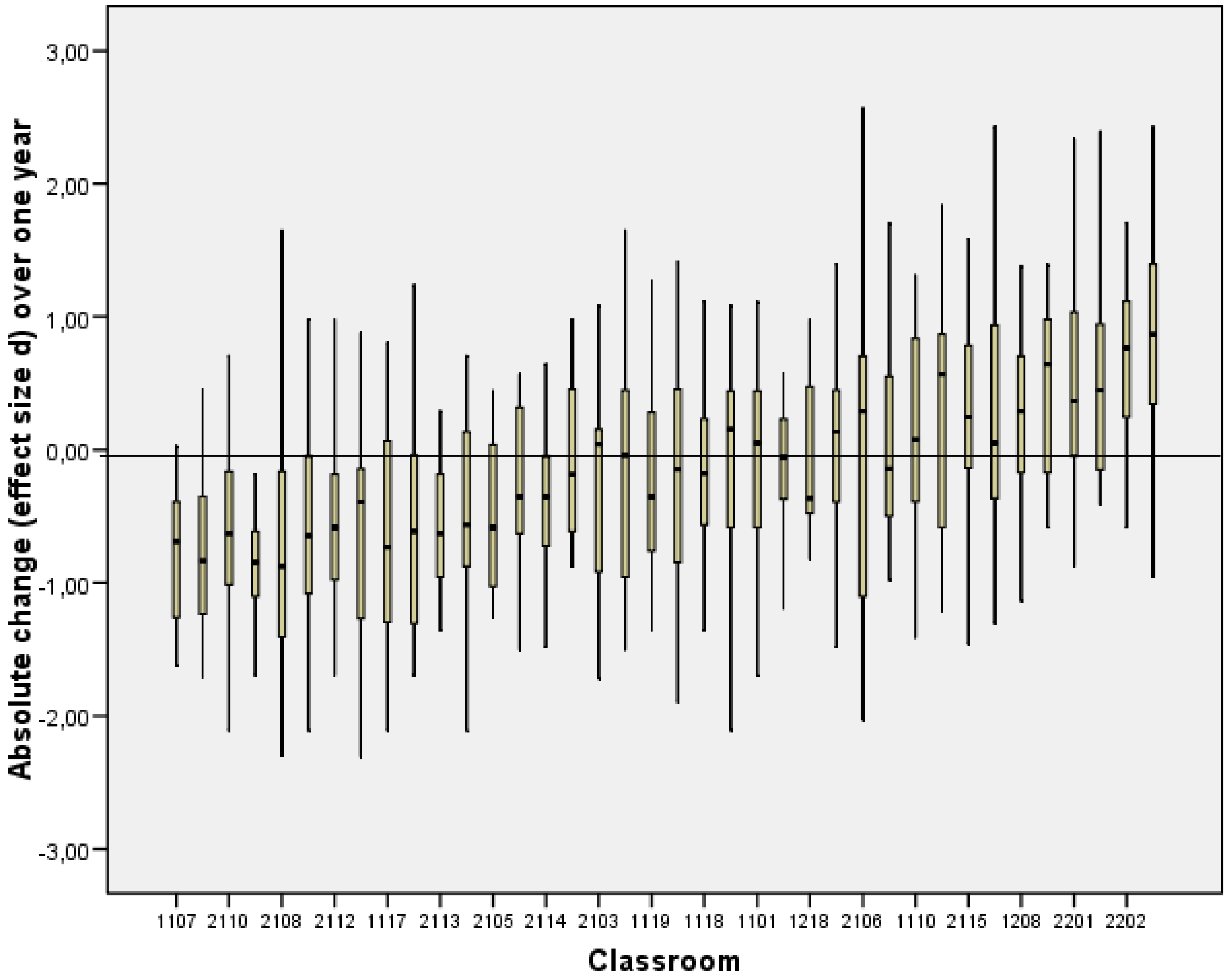
40 classrooms, 8th/9th grade

LSA/CA3 CA1 -------- CA2------------------------CA3‘ LSA‘

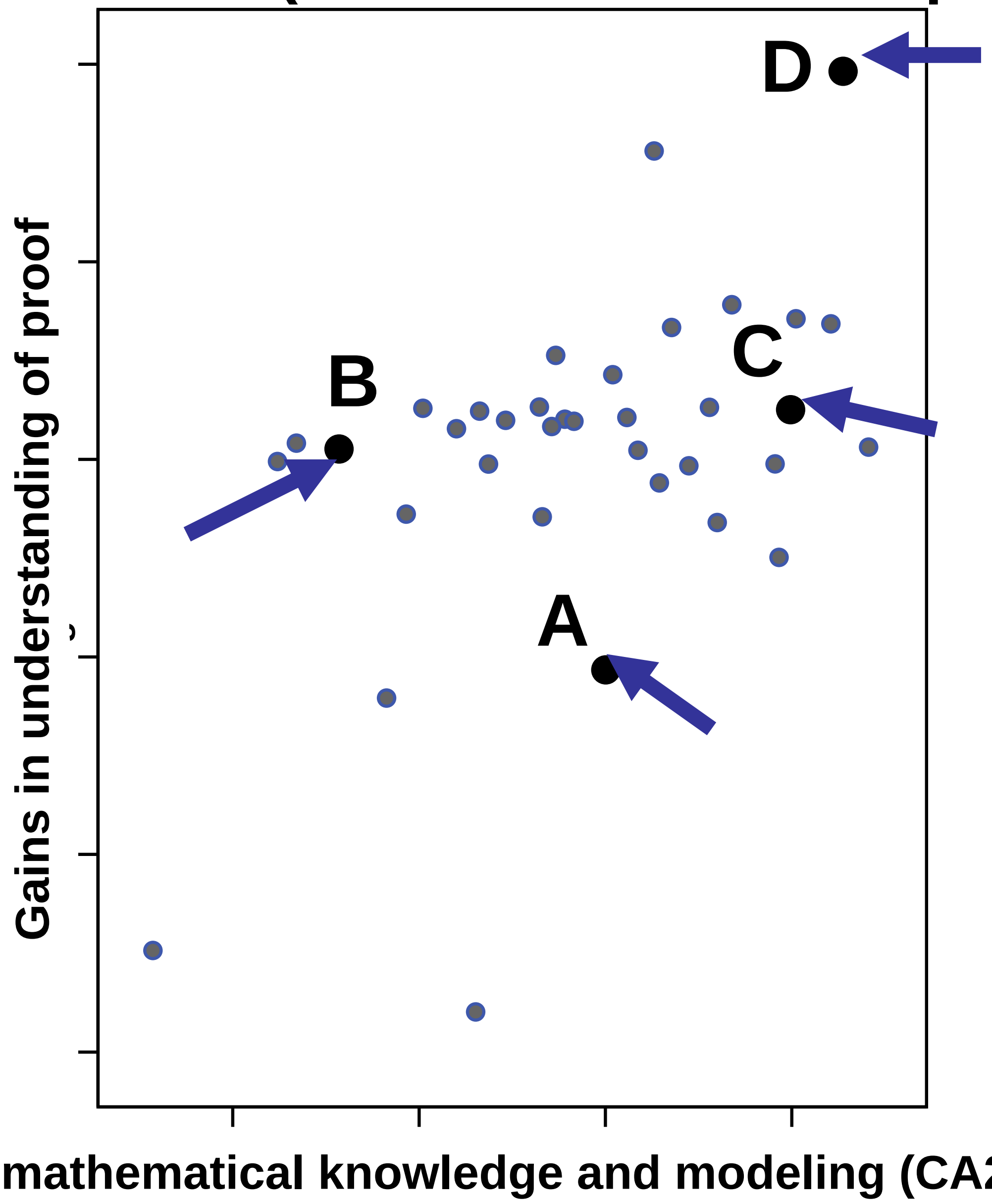
Sept. [Introduction to Pythagoras = 2 lessons] [Rest of unit on Pythagoras = ca. 15 lessons] June



Overall change in achievement over a year measured on a LSA-scale



Microlevel effects (over two lessons resp. over the unit)



Student understanding of pythagorean theorem

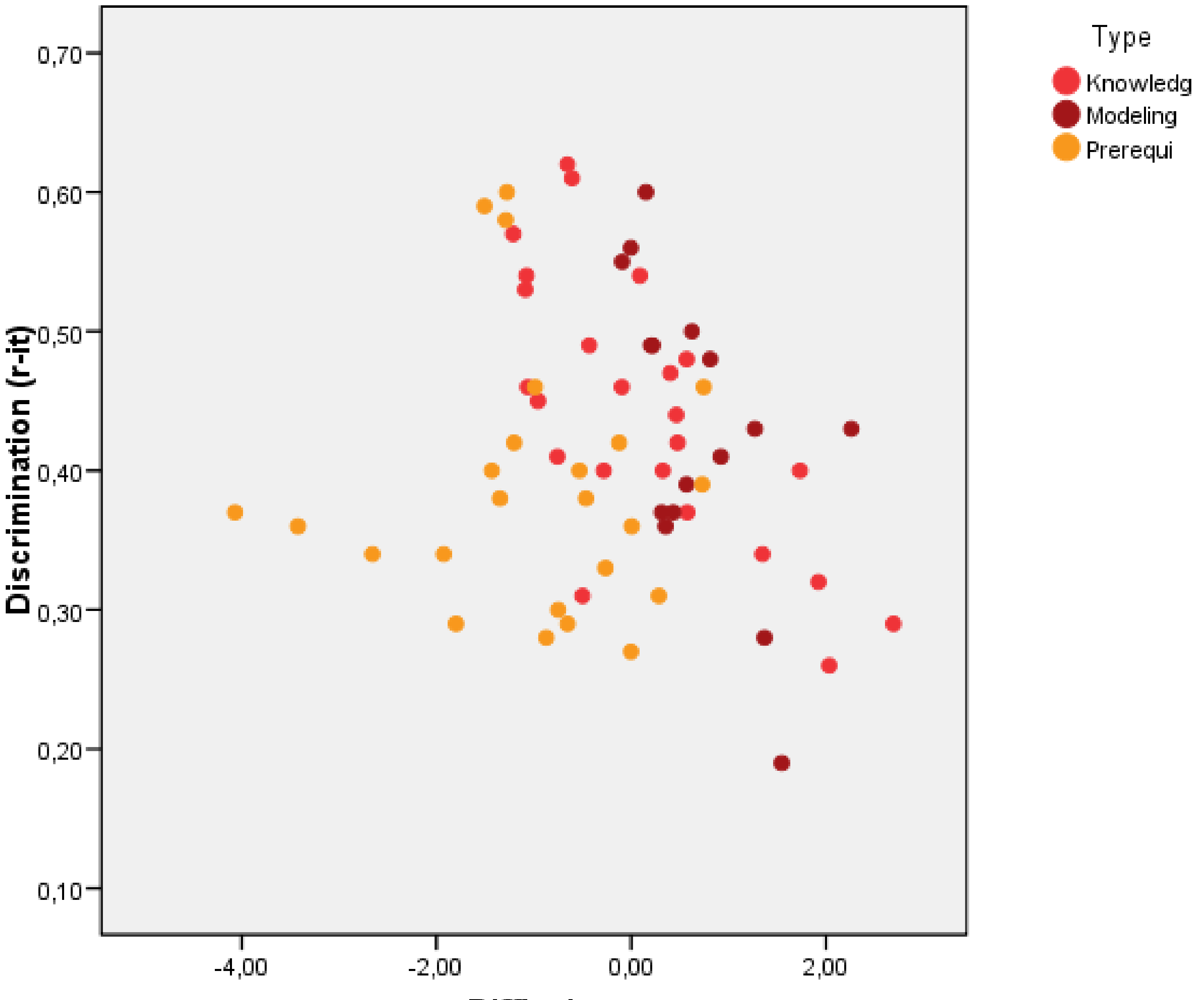
	A	B	C	D
Has to do with rectangular triangles (%)	81	49	92	95
Has to do with area (%)	42	44	54	95
Diagram sketched(%)	12	8	13	71
Formula written down (%)	42	44	8	24

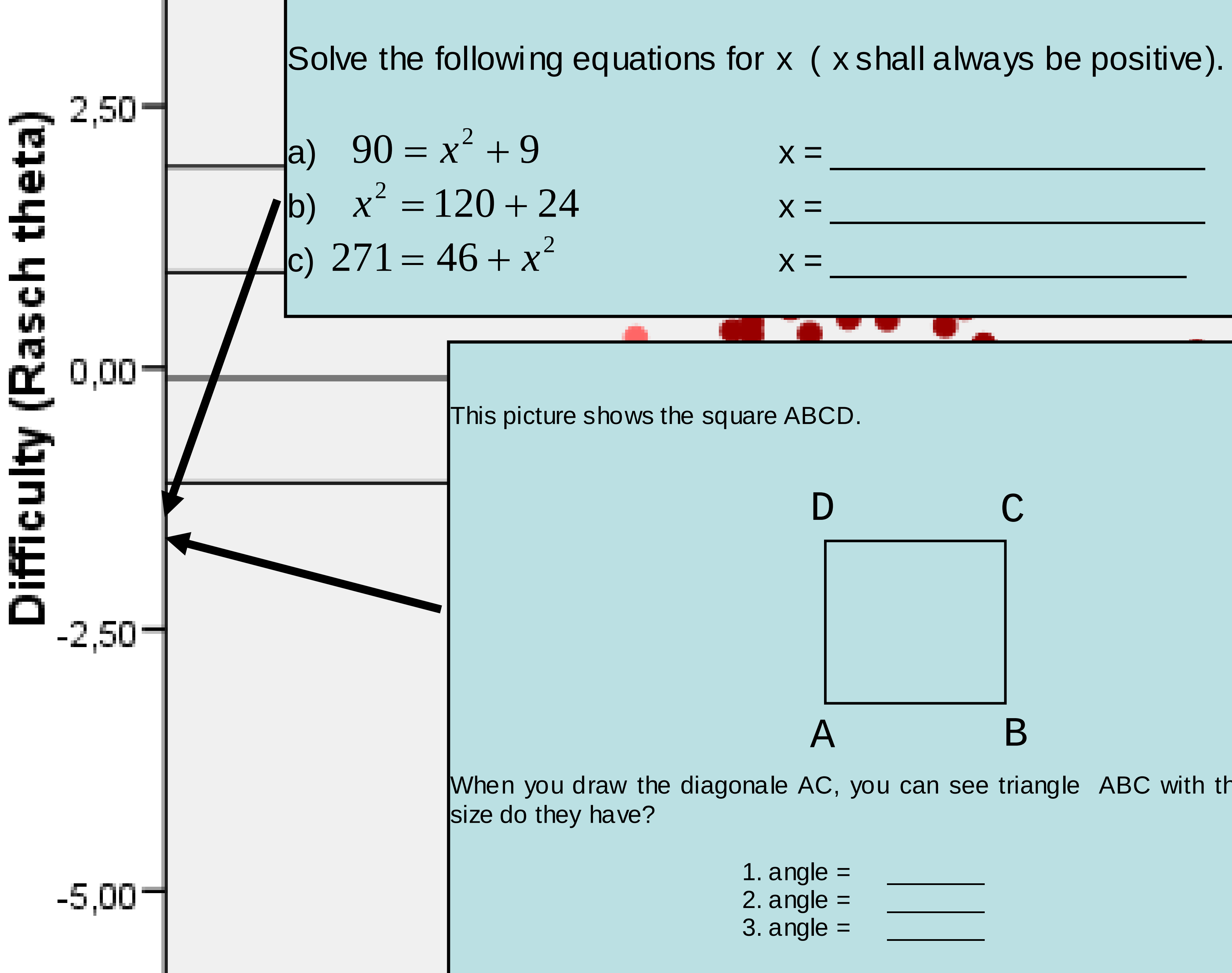
Correlation between **Student understanding (proportion of students holding view x) and didactical approach (video codes)**				
Video Codes	Length of line	Areas	Quadratic numbers	Rectangular triangle
Content elements Mentioned (event coding)	Algebraic Formulation Pythagorean number-triples Labelling of traingle	Typical figure Relation between algebra and geometry		Triangle Right angle Reverse theorem

Predicting cognitive development: Different patterns

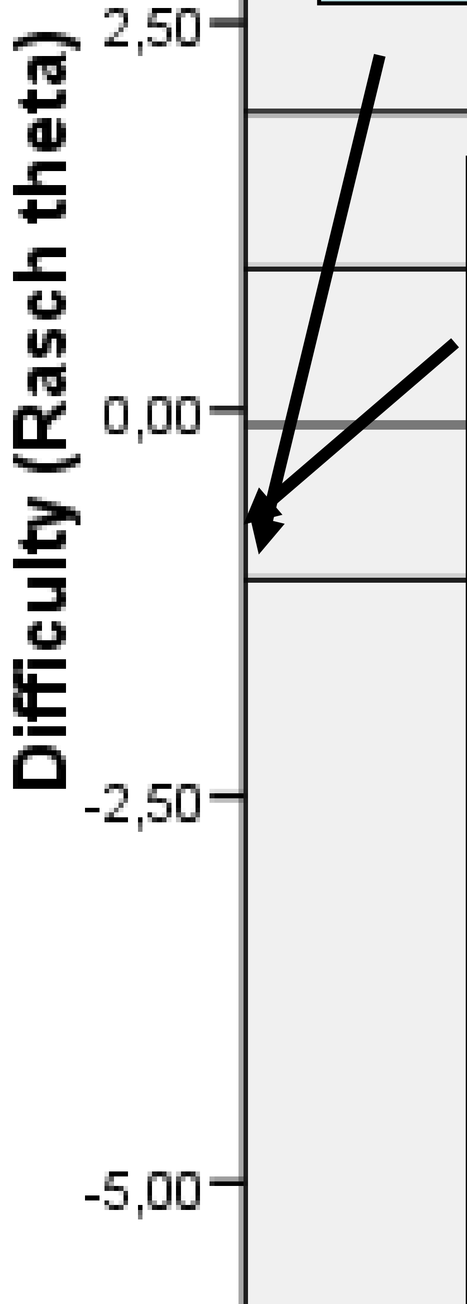
Predictor	Prediction of residual outcomes (adjusted for input and context factors)	
	CA over 2 lessons	**LSA over 1Year**
	Criterion: Basic Knowledge of Pythagorean Theorem	Criterion: General Achievement
Student ratings for		
Structure:		.47 **
Support:		.49 **
Cogn. Activation:		.52 ***
Video Rating: Class-room management	.32 *	.31 *
Video Rating: Math. structure	.58 **	.48 **
Video Codes: Math. concepts covered	.42 **	

Step IV :
Developing a measurement structure:


Type
Knowledg
Modeling
Prerequi
Discrimination (r-it)
0,70
0,60
0,50
0,40
0,30
0,20
0,10
-4,00
-2,00
0,00
2,00

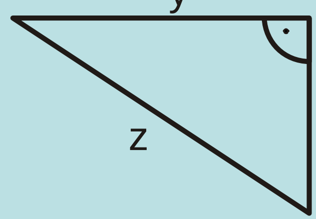

Difficulty (Rasch theta)
2,50
0,00
-2,50
-5,00
Solve the following equations for x (x shall always be positive).
a) 90 = x² + 9 x = ____
b) x² = 120 + 24 x = ____
c) 271 = 46 + x² x = ____
This picture shows the square ABCD.
D
C
A
B
When you draw the diagonale AC, you can see triangle ABC with th
size do they have?
1. angle = ____
2. angle = ____
3. angle = ____

The sides of a rectangle have lengths 12 cm and 5 cm, respectively. How long is the diagionale?

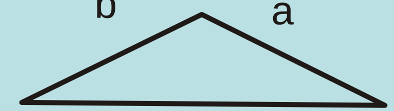


Mark every description that shows the Theorem of Pythagoras!

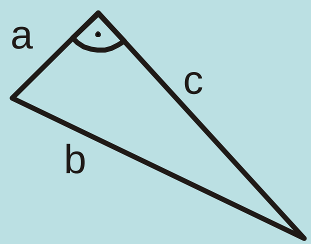
a) ❑ $x^2 + y^2 = z^2$



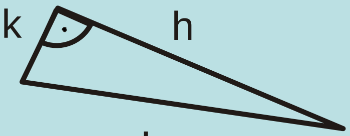
b) ❑ $a^2 + b^2 = c^2$



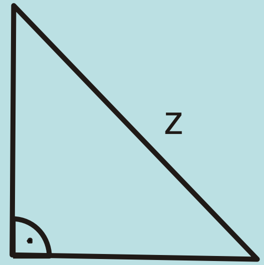
c) ❑ $a^2 + b^2 = c^2$



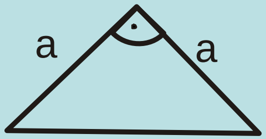
d) ❑ l is the square root of the sum of h^2 and k^2

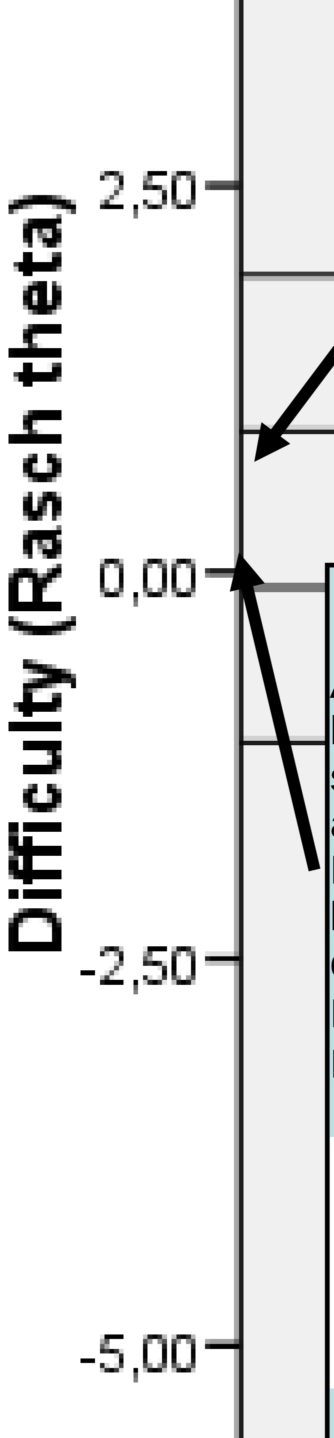


e) ❑ $x^2 = z^2 - y^2$

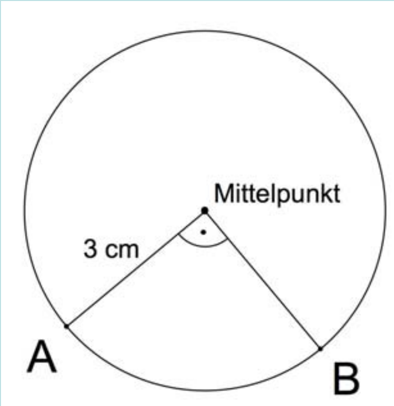


f) ❑ $c^2 = 2a^2$



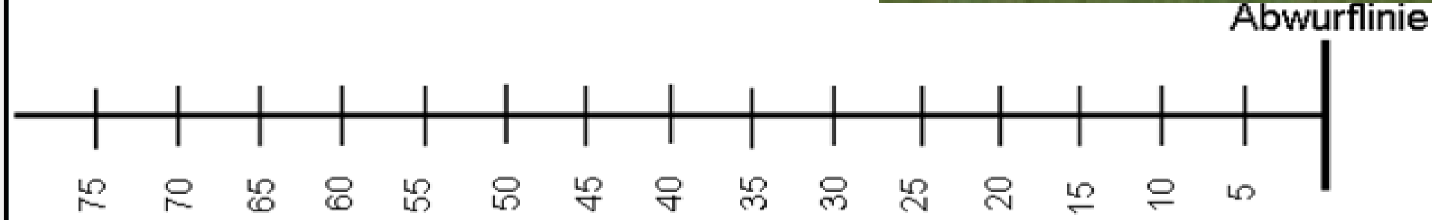


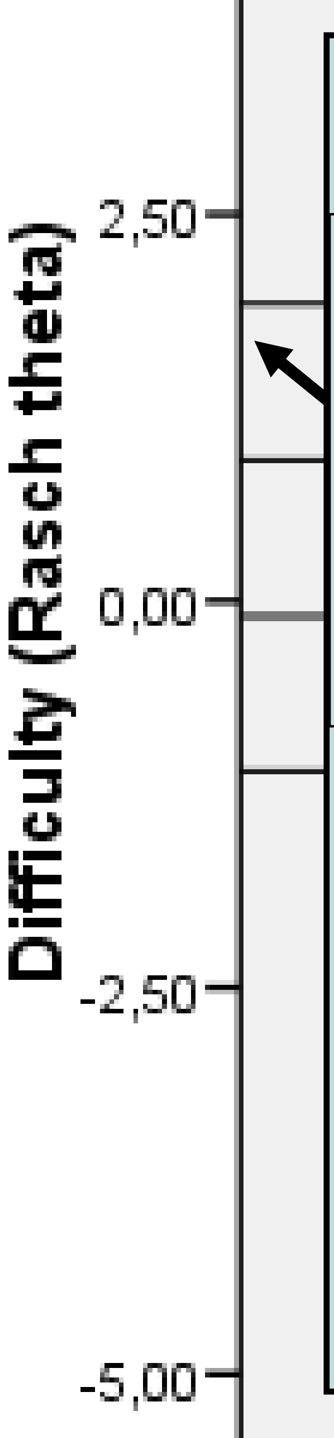
Let A, B be two points on a circle with radius 3 cm.



Determine the distance between A and B.

At this years sports festival, Max throws his ball from the center of the starting line so the the ball hits ground in a distance of about 15 meters from the 65-m-mark.
Max claims a correction of his result, because his classmate Joanne has documented no more than 65 m for him.
How far did Max actually throw the ball? Describe your solution.





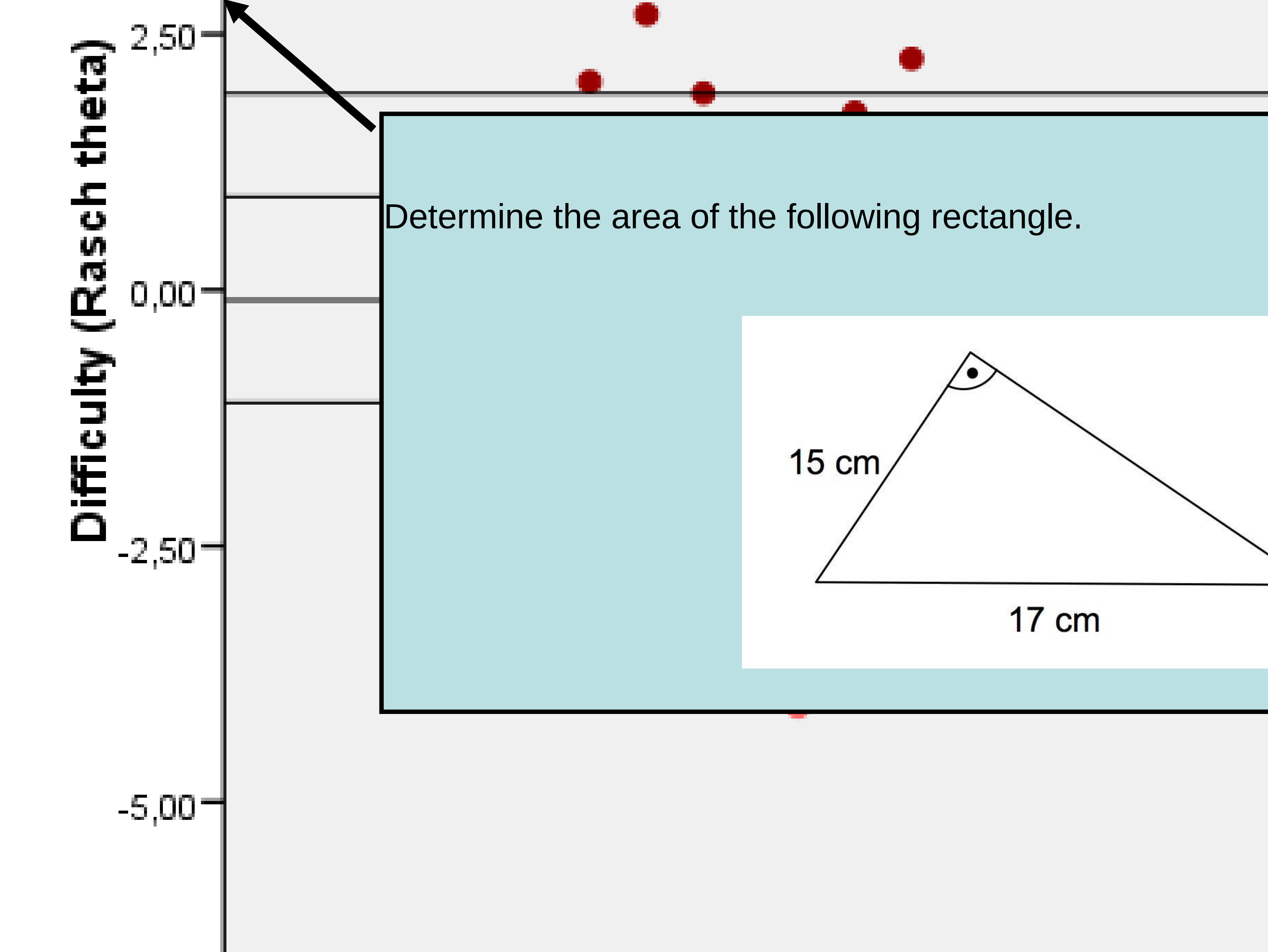
Just start reading the following problem statement. Do don't have to solve the problem!

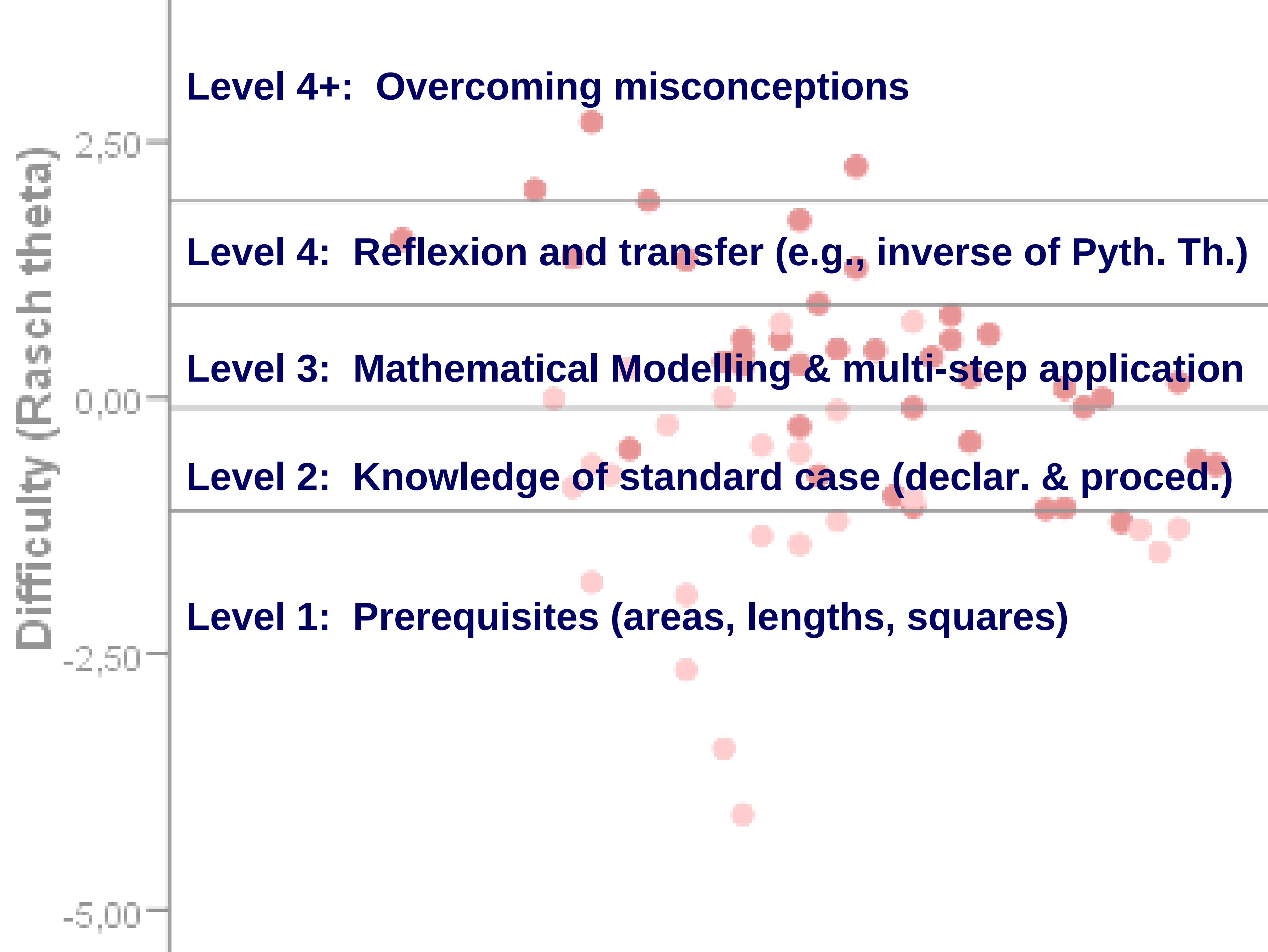
The two-masts sailing ship „Safier" is heading for a well known anchoring spot in the Baltic Sea, which is 2 km from the coast. When arriving in the anchoring area, the captain sets the anchor of the „Safier" which fixes itselv on the ground level, about 20 m below sea. The anchor chain, which is 25 m long, has to be fully used for the maneuver. .

How far from ist anchoring position can the ship be driven by the wind? Describe your solution.

Whioh assumptions should be made – among others – in order to solve this proble using the Theorem of Pythagoras? Mark **all** necessary assumptions. .

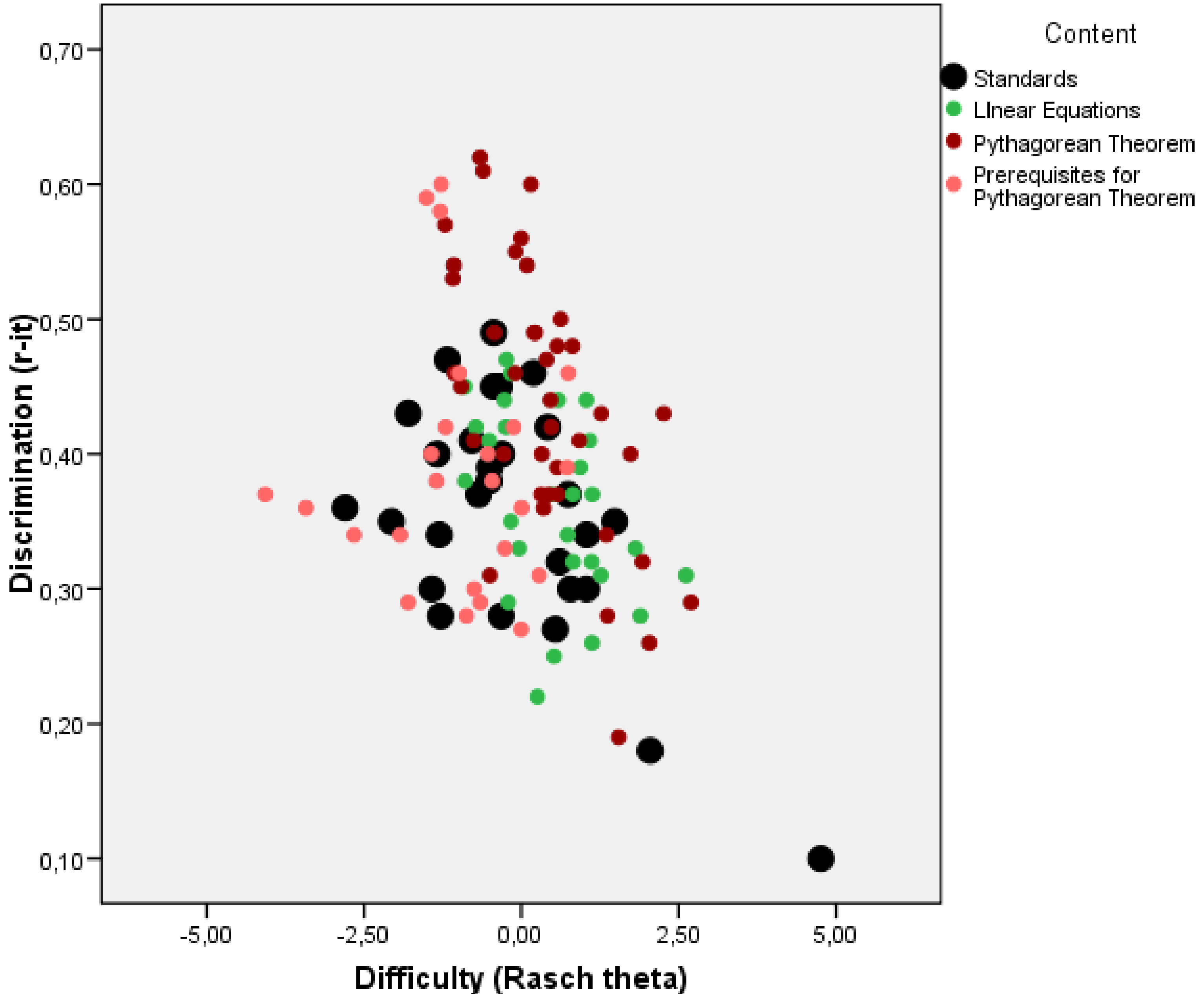
- ☐ The maximal distance from the anchoring position will be erached when the anch chain is held straight.
- ☐ The anchoring place is at a distance of 2 km from the coast of the Baltic Sea.
- ☐ The anchor chain is fully used.
- ☐ The sailing ship in fact has two masts, not just one.
- ☐ The anchor is fixed on the ground, so that the water straem may not loosen it.


2,50
0,00
-2,50
-5,00
Difficulty (Rasch theta)
Determine the area of the following rectangle.
15 cm
17 cm



Difficulty (Rasch theta)
2,50
0,00
-2,50
-5,00
Level 4+: Overcoming misconceptions
Level 4: Reflexion and transfer (e.g., inverse of Pyth. Th.)
Level 3: Mathematical Modelling & multi-step application
Level 2: Knowledge of standard case (declar. & proced.)
Level 1: Prerequisites (areas, lengths, squares)

Step V :
Linking to National Standards


Content
Standards
LInear Equations
Pythagorean Theorem
Prerequisites for Pythagorean Theorem
Discrimination (r-it)
0,70
0,60
0,50
0,40
0,30
0,20
0,10
-5,00
-2,50
0,00
2,50
5,00
Difficulty (Rasch theta)

Pythagoras described CA scale		P62 on national scale (m=500)	National Educational Standards described LSA scale	
	Overcoming misconceptions	800		
		700	Reflecting about complex procedures	
672	Reflexion and transfer			650
		600	Developing multi-step arguments / models	
588	Mathematical Modelling & multi-step application			570
			Modeling in well-known contexts	
505	Knowledge of standard case (declar./proced.)	500		490
			Elementary declarative knowledge & standard procedures	
421	Prerequisites			410
		400	Very simple facts/procedures	

Next Research Question

Stage of instruction as a moderating variable for measurement structure?

Summary

There is a clear relation between professional knowledge, experience of teachers and assessement/feedback practices.

Informal and positive-evaluative feedback in clasroom talk as well as an individual norm of reference in assessment do have a positive impact on student motivation,

It is possible to develop a microlevel assessment that helps describe student learning over a single unit in a qualitative way.

Microlevel CA vs. long-term LSA are sensitive to different aspects of instructional quality: content-specific vs. general.

It is possible to develop a measurement scale linking
(a) a described scale for content-specific learning and
(b) a described scale for standards-based LSA.

Further research will address
(a) stage of instruction as a moderator
(b) implementation in CA via teacher training
(c) impact on students (laboratory studies/field experiment)

Thank you for your attention!

Please send comments to

klieme@dipf.de