DZLM Deutsches Zentrum für Lehrerbildung Mathematik

PADERBORN UNIVERSITY
The University for the Information Society

Deutsche Telekom Stiftung

Professional development of teachers and mentor teachers:

A case study from the German Center for Mathematics Teacher Education in the domain of teaching probability and statistics

Rolf Biehler | Paderborn University & German Center for Mathematics Teacher Education (DZLM)

Weizmann Institute, Rehovot, 1 June 2016

1. Introductory example and overview

10-20-test activity

Project Stochastics@Arnsberg

The following example is taken day 1 of a 5 - day PD course

Topic: **Teaching probability and statistics in grade 10-12**

referring to

- new state curriculum
- prescribed use of digital tools (graphic calculator)

Project Stochastics@Arnsberg

- Building on a tried and tested PD course of the DZLM
- Scaling up with 5 (+10) additional mentor teachers (teacher leaders)
- Aiming at about 120 schools in the Arnsberg region

How do we manage scaling up?

How do we collaborate with the mentor teachers?

What knowledge do they need?

How can we support them?

The „10-20-test“ activity

Students can choose between two multiple choice tests with two choices in each question (one choice is correct)

Test 1: 10 questions

Test 2: 20 questions

A test is passed if at least 60% of the questions are correctly answered.

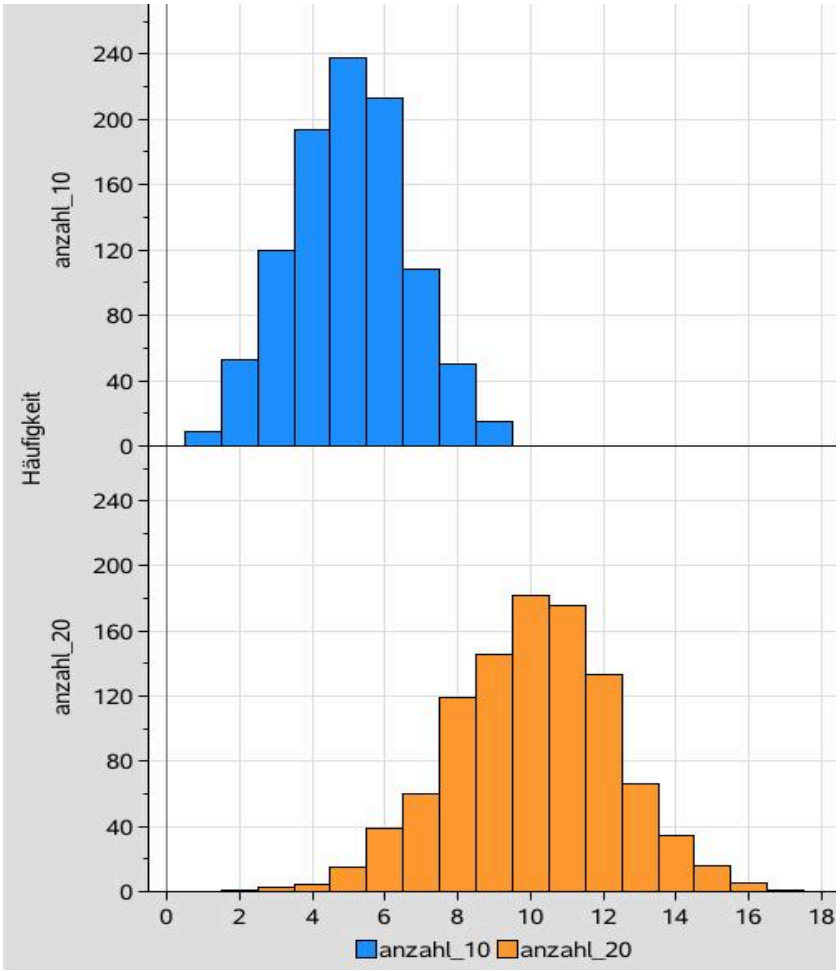
If a student just guesses: Which test is easier to pass?

O Test 1 O Test 2 O Equal chances

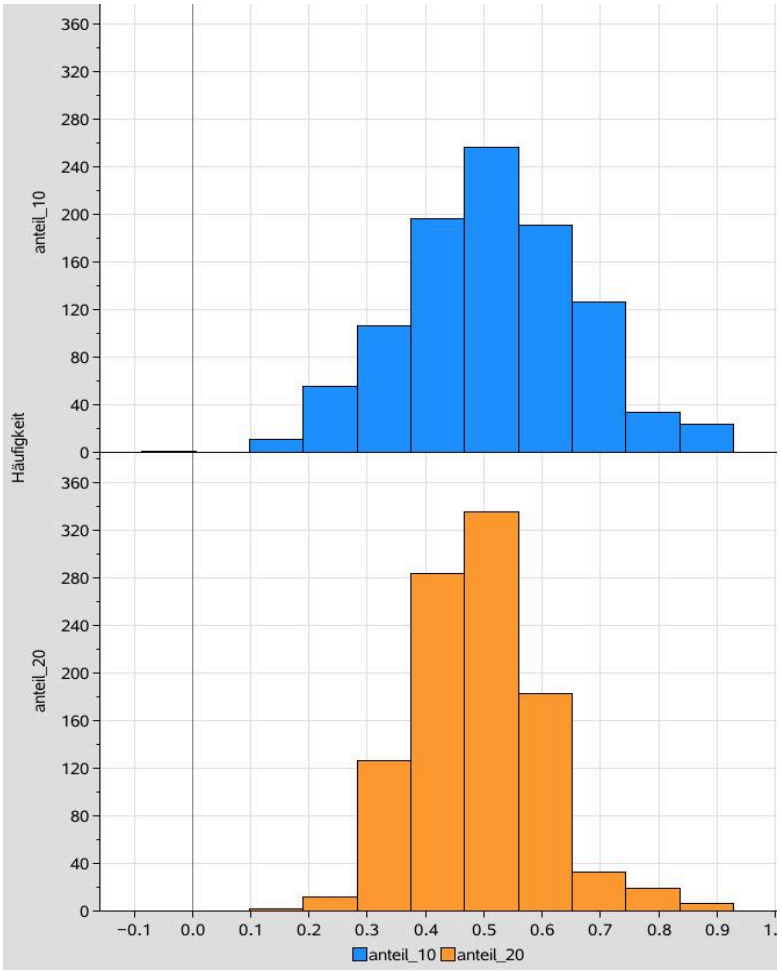
Recommendations for the classroom

- Let students guess intuitively
- Organize some initial discussion
- Use simulation to decide the question
  - Simulation by hand (with a coin)
  - Computer based simulation to get more precise results
    - Estimate the passing probability
    - Visualize the distribution of “proportion of correctly answered questions”
- Support the building of intuitive mental models (“secondary intuition”, Ephraim Fischbein)

Results of simulation with TI ‘Nspire



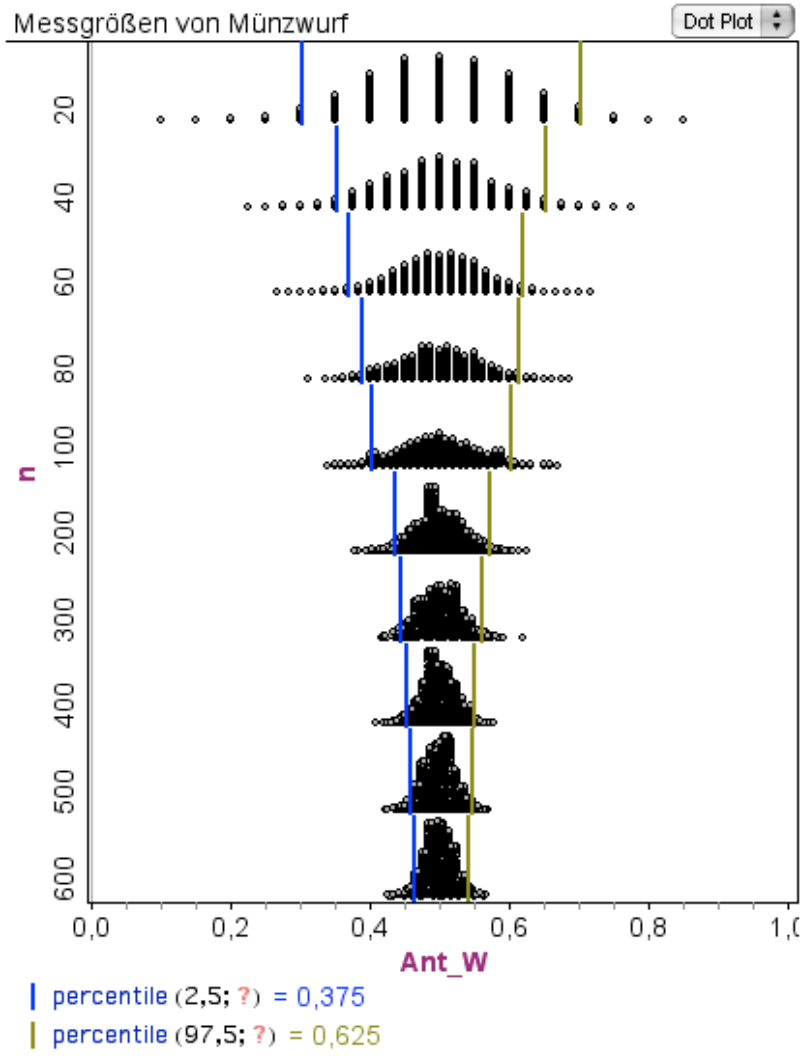
Number



Proportion

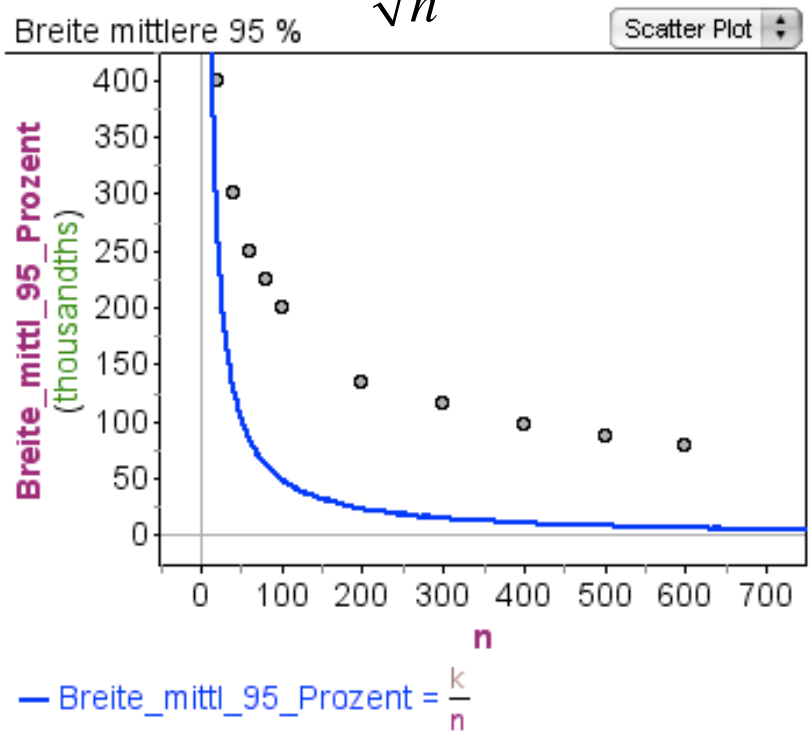
of correctly answered questions

Elaboration: Throwing coins and the laws of large numbers



Discover the role of

$$\frac{1}{\sqrt{n}}$$



Width of the middle 95%-prediction-interval

Facets of knowledge for teachers

Competence model for teachers (cf. Ball, D.L. et al)

Maternity ward problem: Kahneman & Tversky

Research in psychology

Maternity ward problem

A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50% of all babies are boys. The exact percentage of baby boys, however, varies from day to day. Sometimes it may be higher than 50%, sometimes lower.

Which hospital do you think is more likely to find on one day that more than 60% of babies born were boys?

- Quoted from p. 36/37 of Sedlmeier, P., & Gigerenzer, G. (1997). Intuitions about sample size: the empirical law of large numbers. *Journal of Behavioral Decision Making, 10*(1), 33-51.
- Original work: Kahneman, D., & Tversky, A. (1972). Subjective probability: a judgment of representativeness. Cognitive Psychology, 3, 430-454

Non representative survey of n = 1163 students (grade 5 - 12), North-Rhine Westfalia 2014

	% Grade 5 - 9	% Grade 10 -12
Test 1	16	18
Test 2	41	27
Equal chance	43	55

(similar results: Kahneman & Tversky, 1972; Maxara & Biehler, 2010; Meyfarth, 2008; Sedlmeier & Gigerenzer, 1997)

„Insensitivity of sample size“
„Belief in the law of small numbers“

Improvements by means of education?

After 4 weeks of teaching in grade 12

	pre	post	Pre: correct reasoning	Post: correct reasoning
Test 1: %	26	77	18	59

- Item „maternity ward problem“
- n = 39

Prömmel, A. (2013). *Das GESIM-Konzept - Rekonstruktion von Schülerwissen beim Einstieg in die Stochastik mit Simulationen*. Heidelberg: Springer Spektrum, p. 493

Facets of teacher knowledge / competence

- Background knowledge in didactics of mathematics
  - Studies in psychological decision research (on this example)
  - Design research (with using this example)
- Classroom implementation competence
  - Expected student solutions / misconceptions
  - Managing classroom discussions

Facets of teacher knowledge / competence

- Mathematical background knowledge and beliefs
  - Mathematical modelling with binomial distribution possible
  - Distinguishing between the distribution of the "number of correct guesses" and the "proportion of correct guesses"
  - Probability simulation as a legitimate mathematical method
- Horizon knowledge
  - Potential relevance of example for later steps: binomial distribution; hypothesis testing (P-value)
  - Emphasis on distribution not just on the "passing probabilities"

Facets of teacher knowledge / competence

- Knowledge about relation of example to curriculum: justification of importance
  - consistent with new curriculum but probably not “required” to pass final examinations
- Beliefs
  - Example is an important contribution to relevant goals of prob & stat
- Beliefs about teacher’s identity and role
  - Teacher as a dependent **curriculum implementation service provider** vs.
  - Teacher as a **personality with own value systems** with regard to a topic to be taught

Outline of the talk

1. Introductory example and overview
2. Teacher education in Germany and the DZLM
3. The precursor DZLM PD course “Stochastics compact NRW”
4. The project Stochastics@Arnsberg
   - 4.1 Design of project
   - 4.2 Collaboration and support of mentor teachers
5. Concluding remarks

2. Teacher education in Germany and the DZLM

Two (three) stage teacher education in Germany's 16 states

University

- 3.5 - 5 years
- subject matter / didactics of subject matter / educational sciences
- may include "practice semester"

School practice education centre

- 1.5 years
- "theoretical education" at the centre
- Teaching obligations at school
  - less than 50%,
  - partly supervised and assessed

In-service education (non obligatory)

- School admin (state, region, local) providers
- Free providers (teacher networks, universities)
- Collaboration between free and official providers (e.g. DZLM)

School admin driven PDs: Varying hot topics

- inclusive education / dealing with heterogeinity / individualized support
- Multi language education / refugees
- securing minimal competence levels (dealing with students at risk)
- improving „teaching quality“ in general
- **implementation of curricula (national and state standards) - supporting school and classroom development**
- **improving the level of math and science education (due to TIMSS and PISA shocks)**

DZLM (2011 - 2019), funded by the Deutsche TelekomStiftung

First nation-wide operating institute for mathematics teacher education

DLZM Universities:

HUMBOLDT-UNIVERSITÄT ZU BERLIN

Freie Universität Berlin

RUB

technische universität dortmund

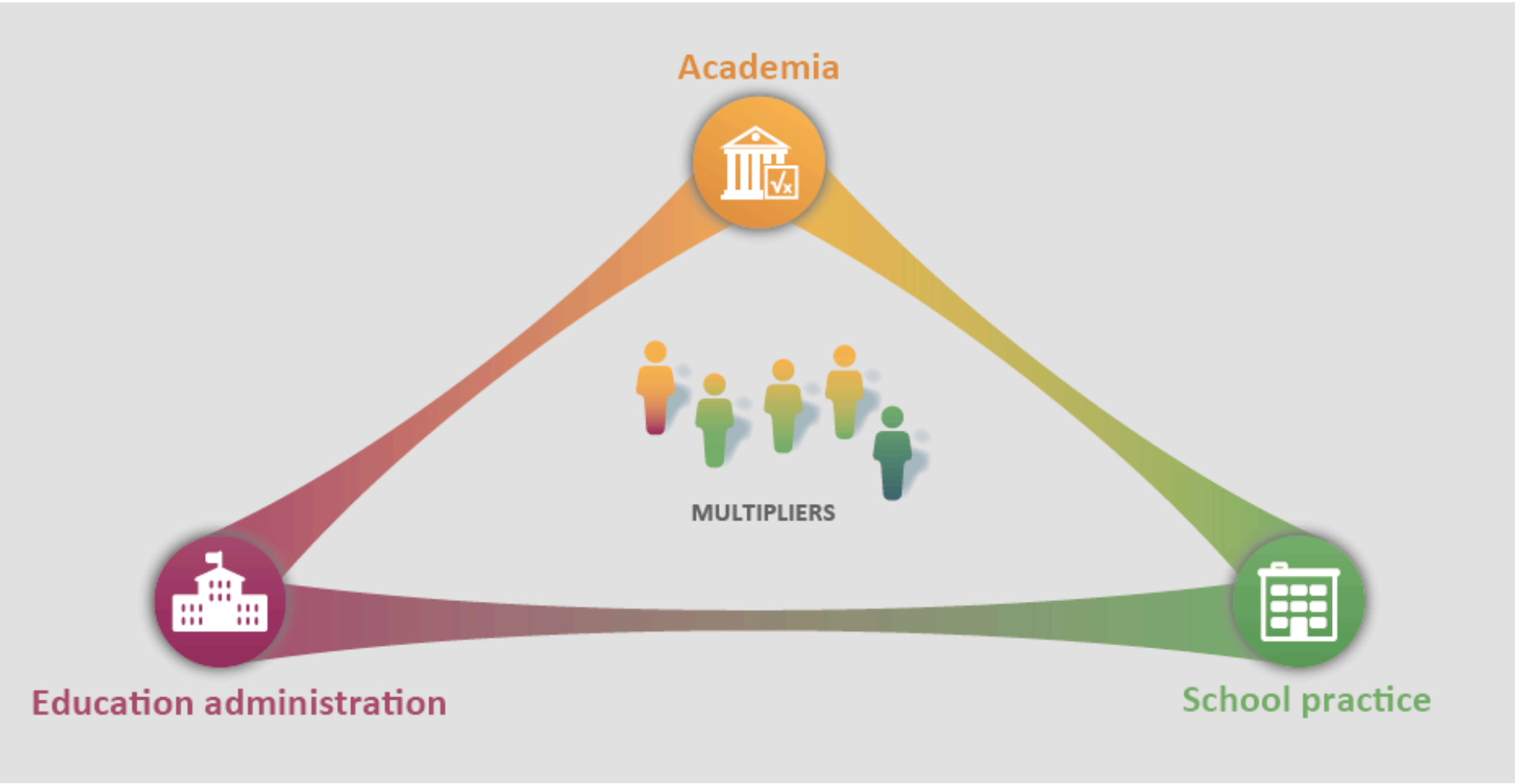
Pädagogische Hochschule Freiburg
Université des Sciences de l'Education · University of Education

UNIVERSITÄT DUISBURG ESSEN
Offen im Denken

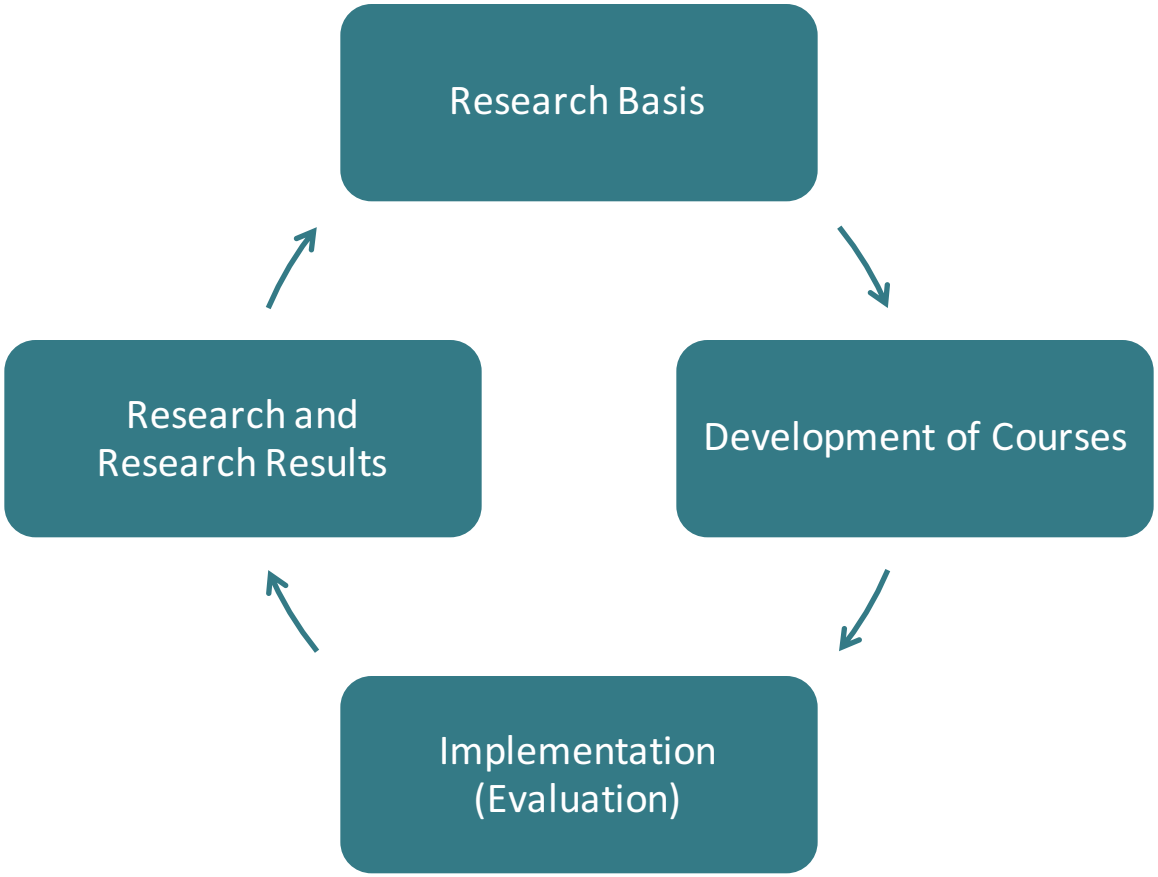
UNIVERSITÄT PADERBORN
Die Universität der Informationsgesellschaft

Program lines of DZLM

1. Qualification and master degree program for **mentor teachers**
2. Qualification programs for **out-of-field teachers and educators**
3. In-service teacher education for **all teachers**
4. Information and communication **platform**

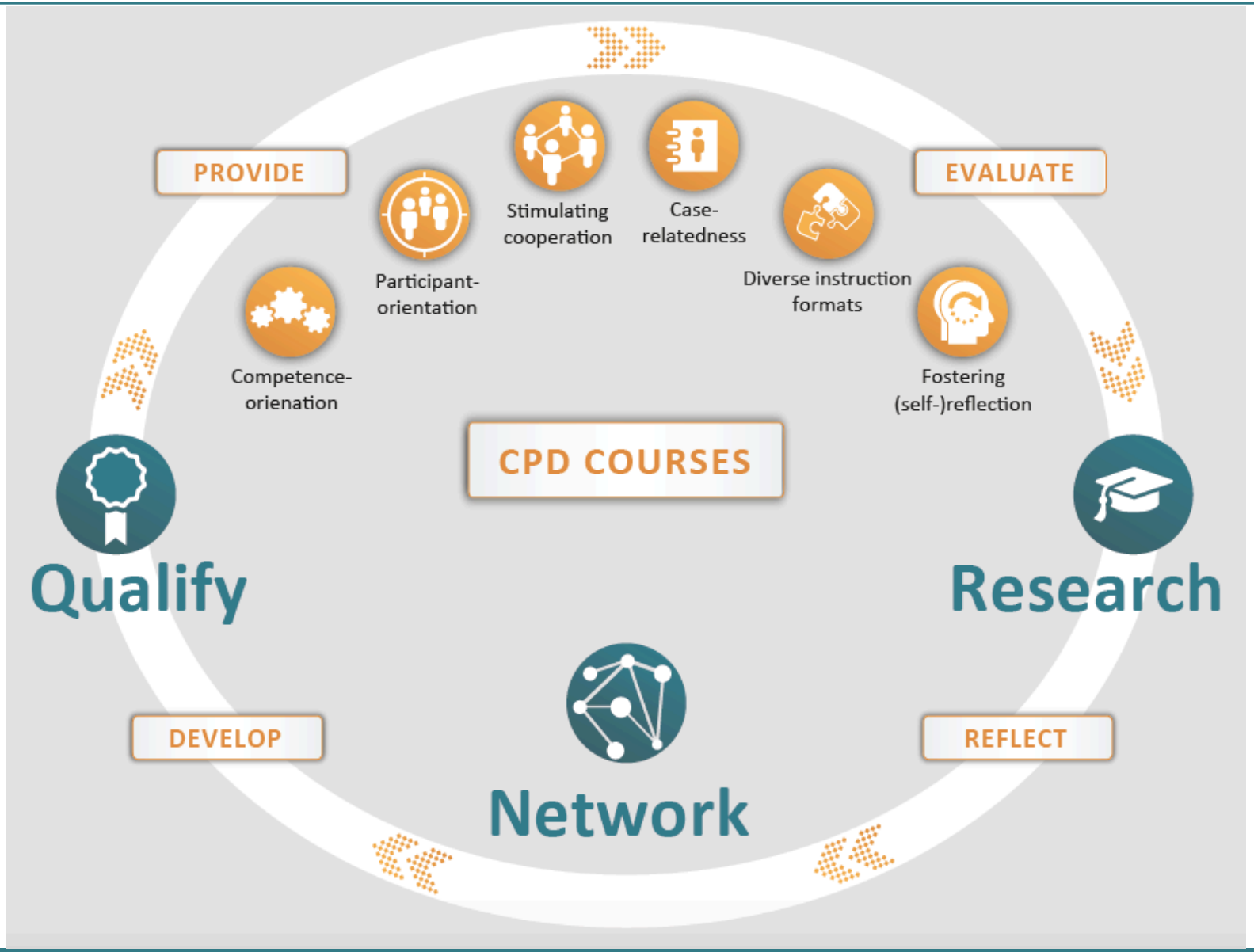

Academia
MULTIPLIERS
Education administration
School practice

Development cycle of PD courses



Goal:
Reusable material for several federal states

How the DZLM works



3. The precursor DZLM PD course “Stochastics compact NRW”

North-Rhine Westfalia (NRW) 2013-2015

3.1. Design of *Stochastics compact NRW*

The various versions of the course were designed by the DZLM team in Paderborn including Janina Niemann (Oesterhaus), Steffen Lünne, Ruben Loest, Ralf Nieszporek, Hauke Friedrich, and myself, partially in collaboration with Michael Casper from the Maria-Sibylla-Merian-Gymnasium, Krefeld.

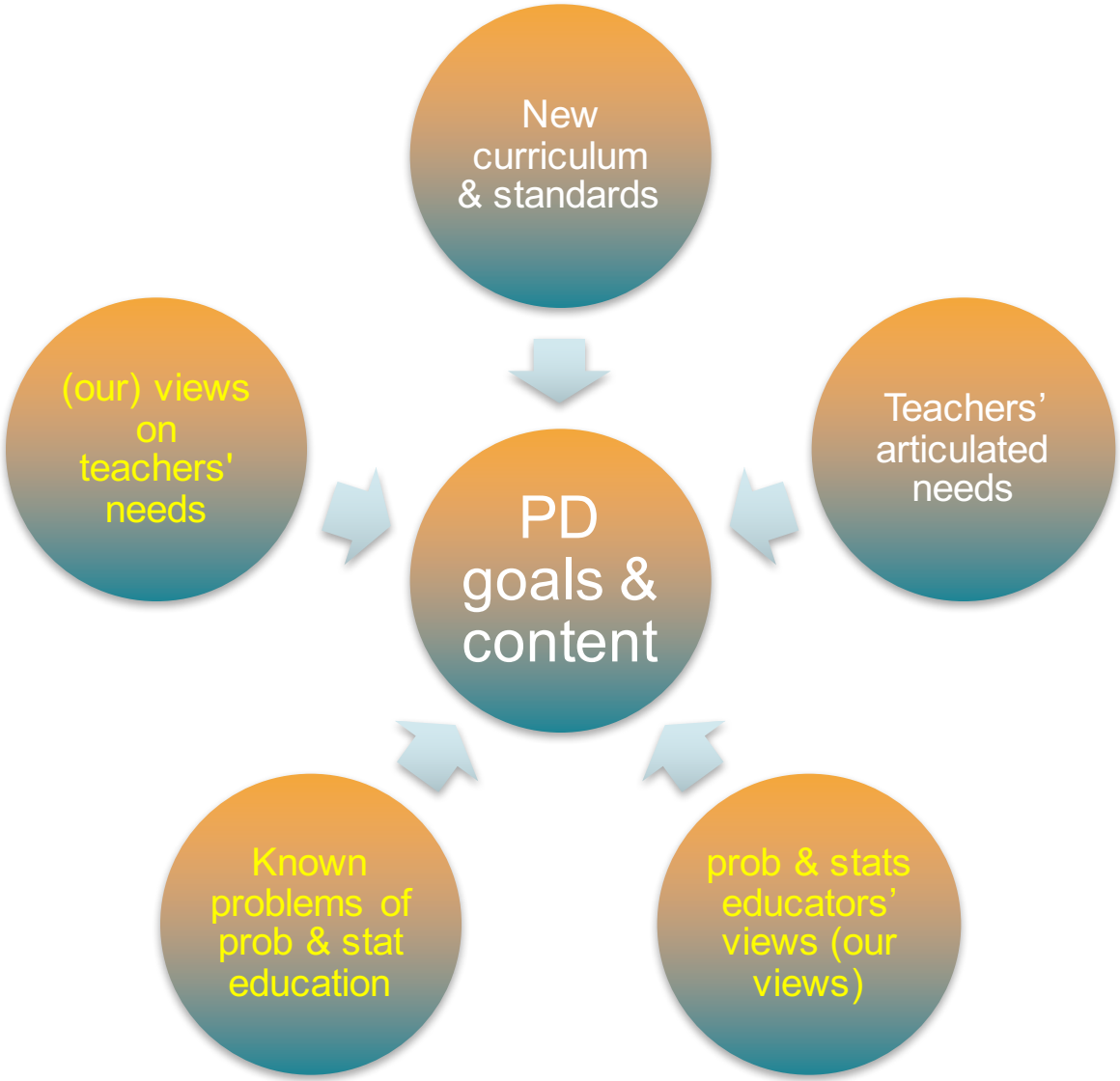
“Stochastics compact NRW”

NRW: North-Rhine Westfalia
17 million inhabitants

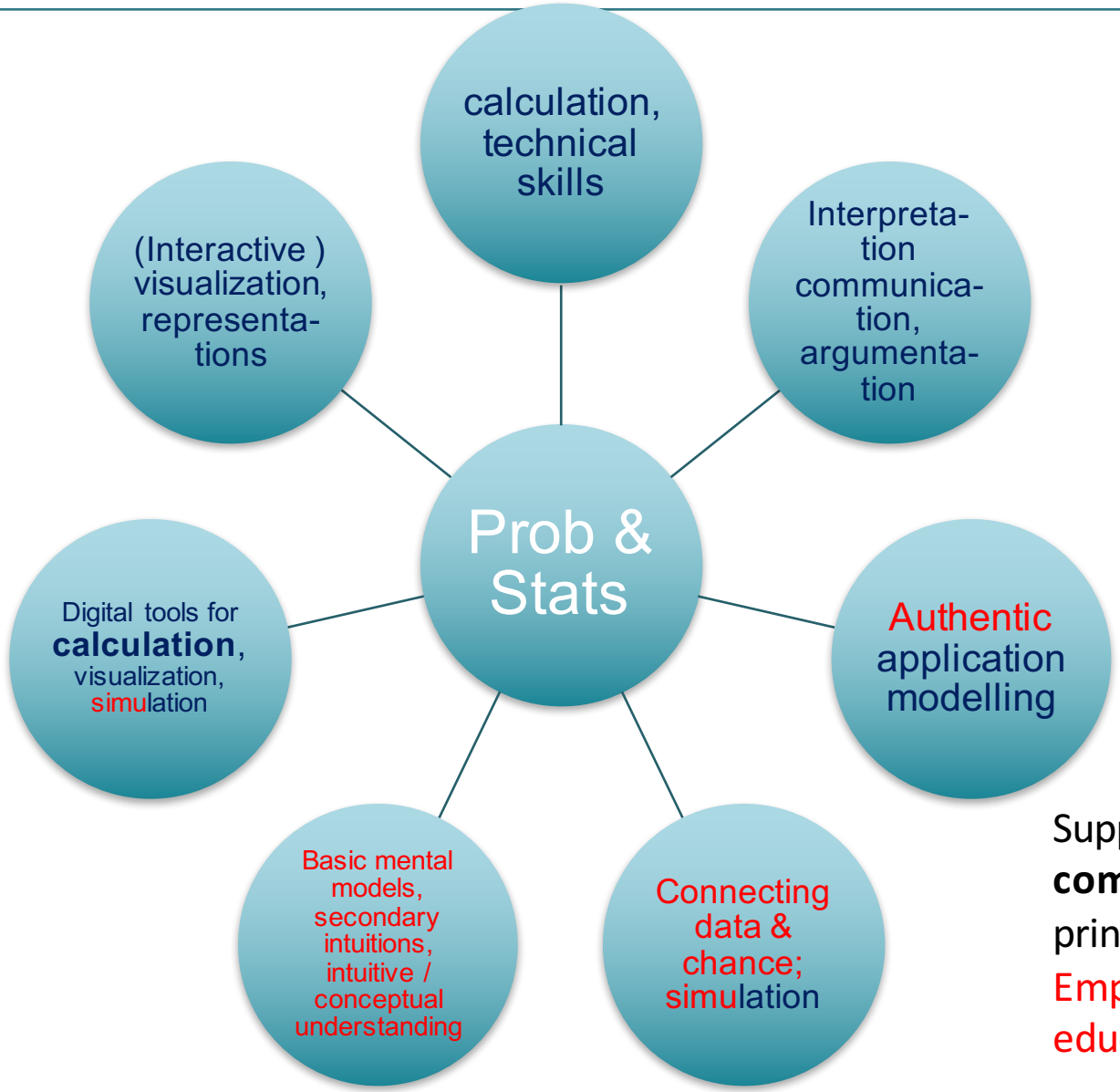
The innovation supporting setting in NRW for grades 10 - 12

- 2012: New national standards for the end of high school (Gymnasium, grade 12/13)
- 2012: The "Graphic calculator (GC) decree" in NRW: compulsory use for supporting better understanding of maths
- 2014: New state curriculum in NRW: obligatory prob & stats (content for about half a school year)
- 2014 - 2017: Intermediate first stage adaptation to the new situation
  - Several competing factors influence new practice
  - New text books, new official support material, new model tasks for the final examination, new professional development offers
- 2017 First final examination with probability & statistics and GC use

Factors influencing our PD goals & content



Components of prob & stats competence/knowledge



Supported by the standard's **competence orientation** (in principle)

Emphasis from prob & stat education

Stochastics compact as a DZLM “intensive course plus”

- Four complete days, spread over about 4 months
- Some work to do in between the 4 PD days

- Three cycles: 2013/14; 2014/15; 2015/16
- 90 = 3*30 participants in each round (3 locations)
- Continuous evaluations and adaptations

“Stochastics compact”: course content for the 4 days

1. Connecting data and chance (probability and relative frequency, laws of large number, concept of probability)
2. Stochastic independence as a modelling assumption, Bayesian reasoning with percentages and probabilities
3. Expected value, Binomial distribution as a model (process or sampling with replacement)
4. Hypothesis testing (including two kinds of errors, P-value, statistical power)

Types of course material (provided in moodle)

For teachers

- PPT: Powerpoint presentations
- WST: Worksheets for teachers (sometimes plus model solution)
- HAT: Handouts for teachers with background information

For students

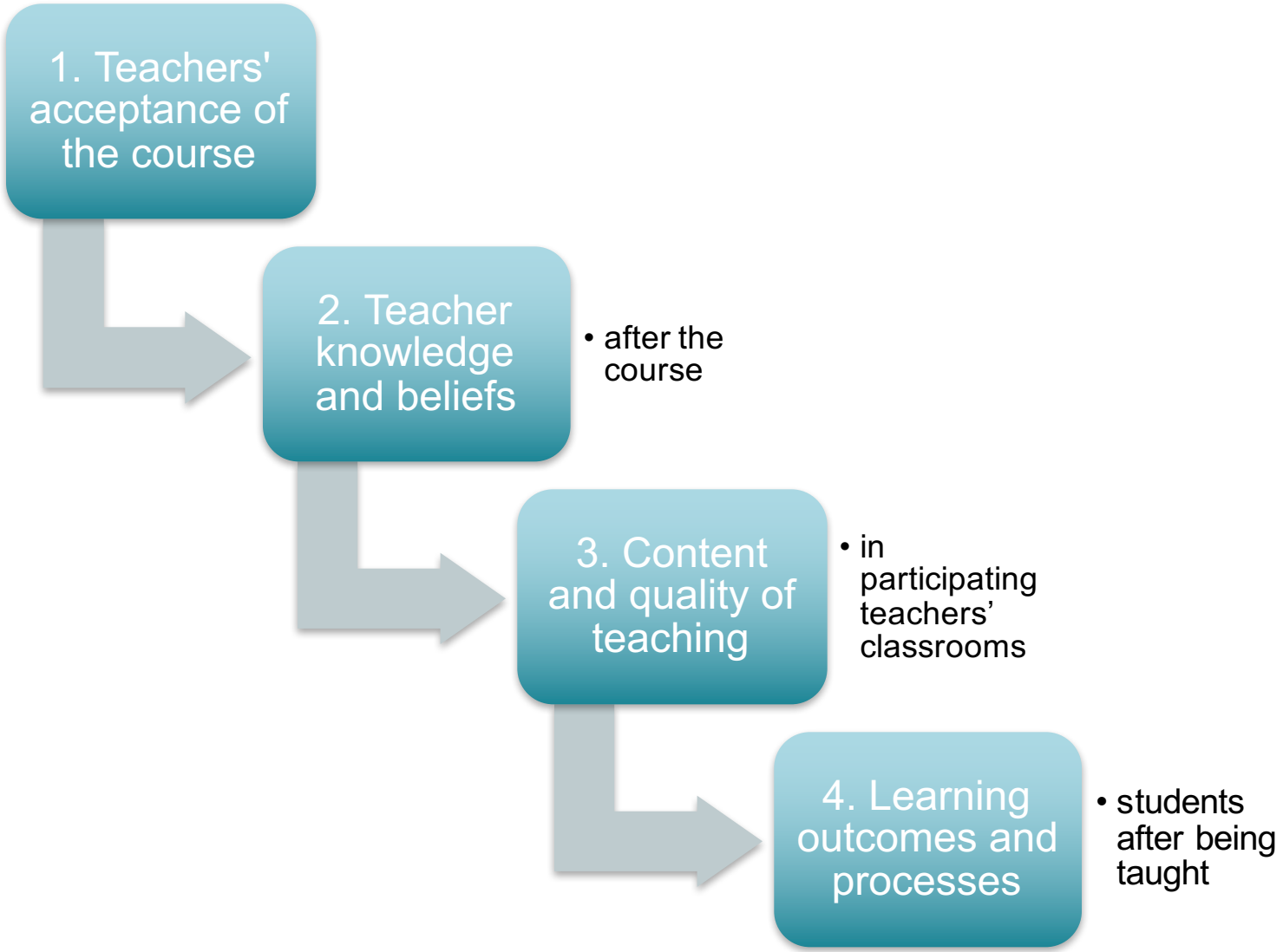
- WSS: Worksheets for students (plus model solution for T)
- HAS: Handouts for students
  - Knowledge summaries
  - Guiding schemes for work, such as “simulation scheme”; “hypothesis testing scheme”

For both

- DTG: Digital tool guides (text or video clips)

3.2 Accompanying research

The “chain of impact” in DZLM’s research agenda



Our objects of our research (level 2)

- Teachers' interests and experiences before the course
- Teachers' competence after the course
- Teachers' beliefs after the course on
  - use of digital tools
  - teaching prop & stats in general
  - "status of concern" with regard to the innovation (Hall & Hord 2001)

Assessing teachers knowledge and competence

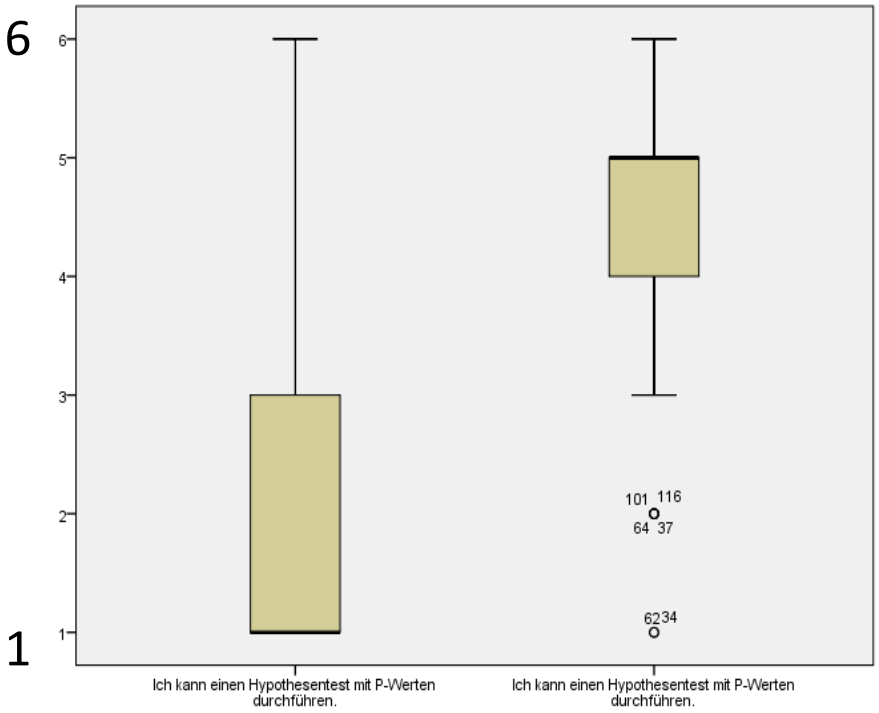
Ethical and time constraints for the assessment ->

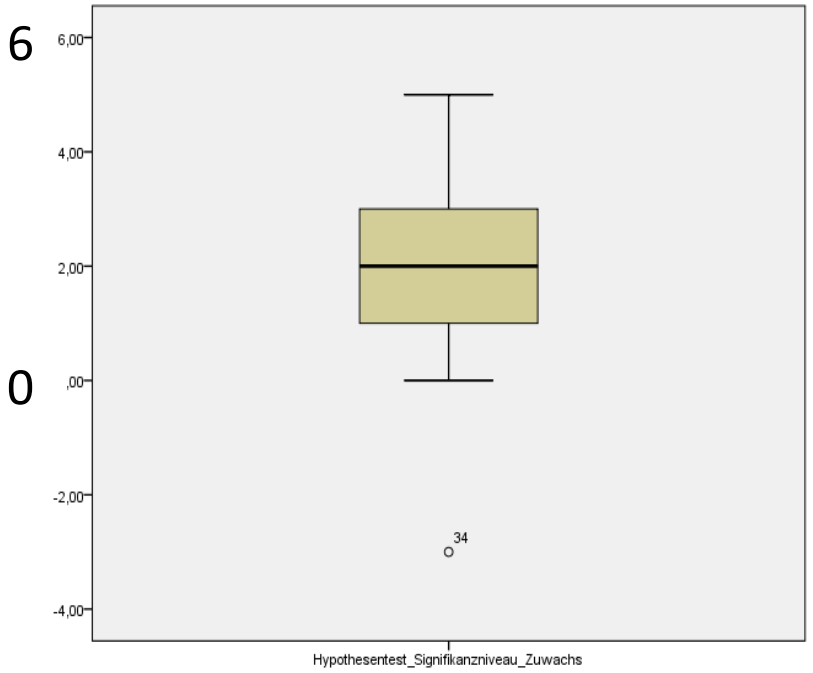
- *Subjective retrospective competence growth assessment*
  - School related content knowledge
  - Pedagogical content knowledge
- *Subjective prospective teaching self-efficacy assessment*

Thanks to Hauke Friedrich and Ralf Nieszporek for the collaborative data analysis of the following results for the 2015 course (n = 60 to 80).

Subjective retrospective competence growth assessment

School related content knowledge: I can construct and perform a hypothesis test with fixed significance level?





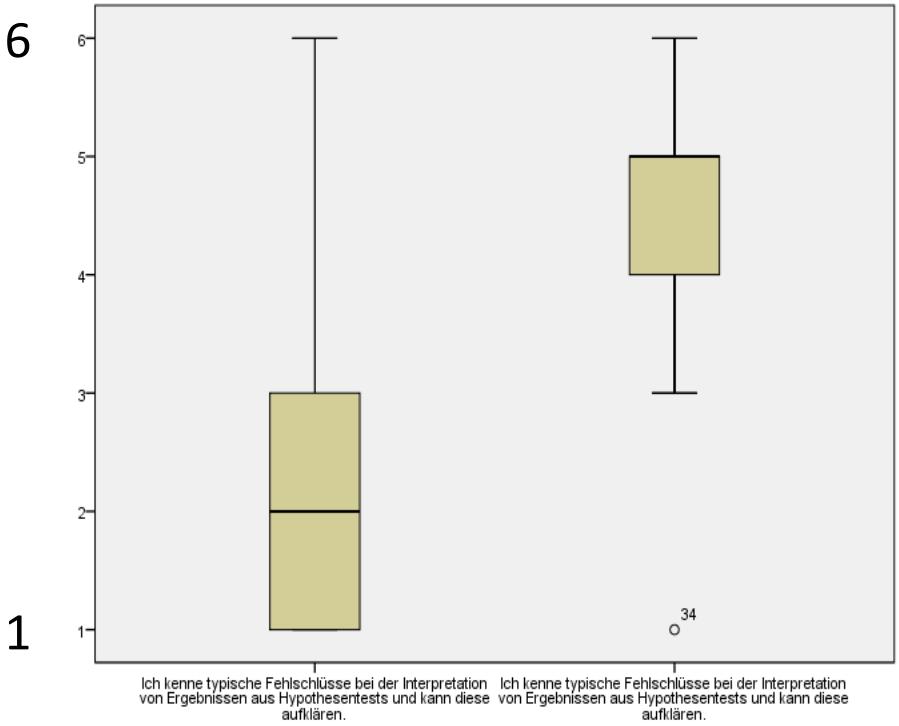
before after

difference in competence

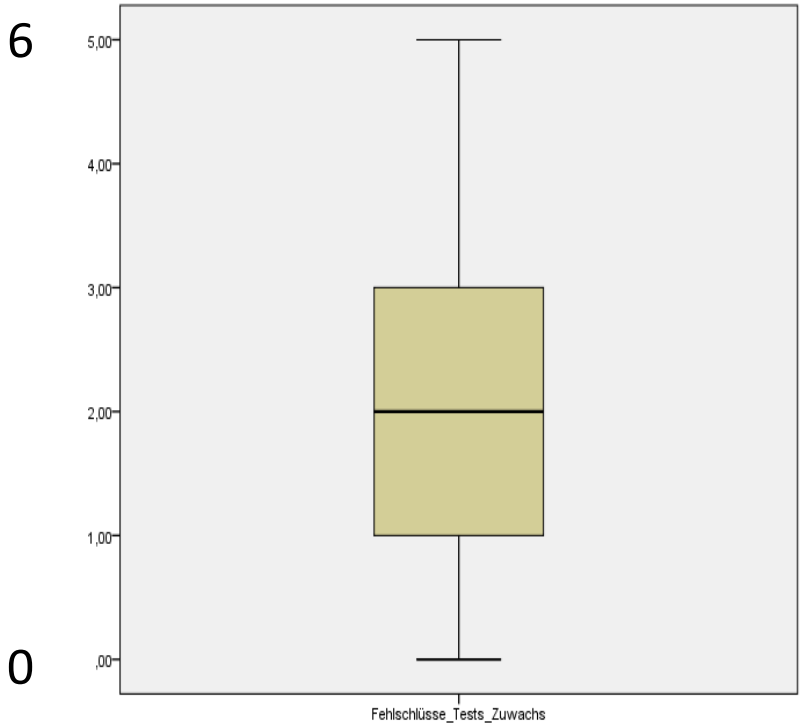
1: strongly disagree; 6 strongly agree

Subjective retrospective competence growth assessment

Pedagogical content knowledge: I know typical misinterpretations of hypothesis tests and can elucidate/clarify them?



before after

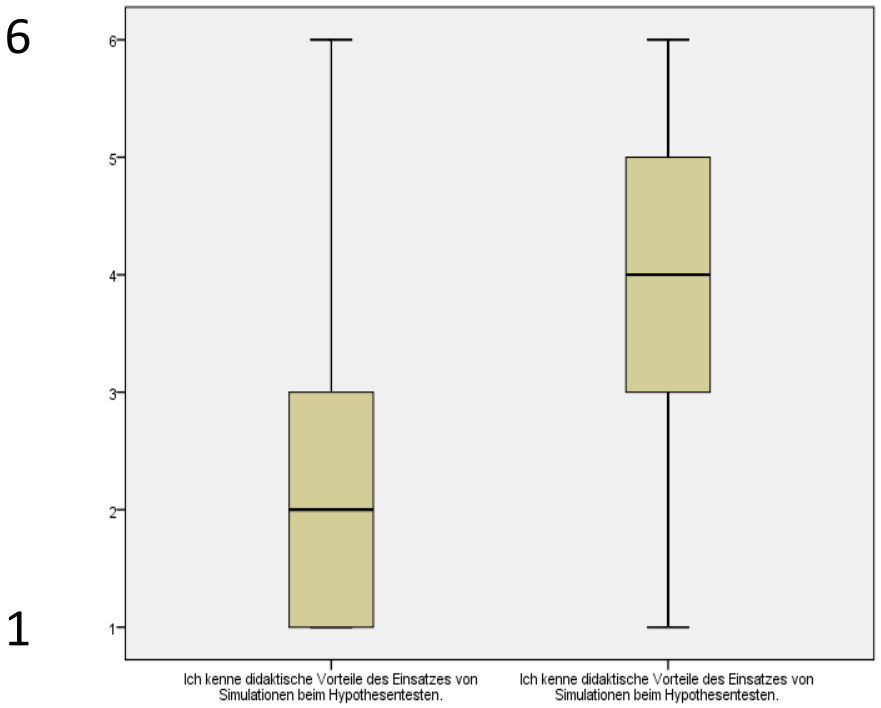


difference in competence

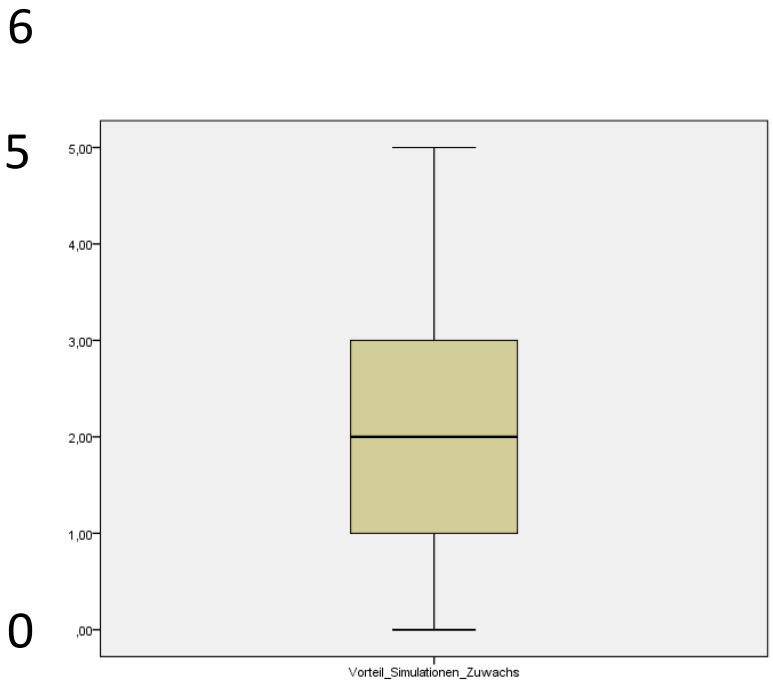
1: strongly disagree; 6 strongly agree

Subjective retrospective competence growth assessment

Pedagogical content knowledge: I know educational gains of using simulation when teaching hypothesis testing?



before after



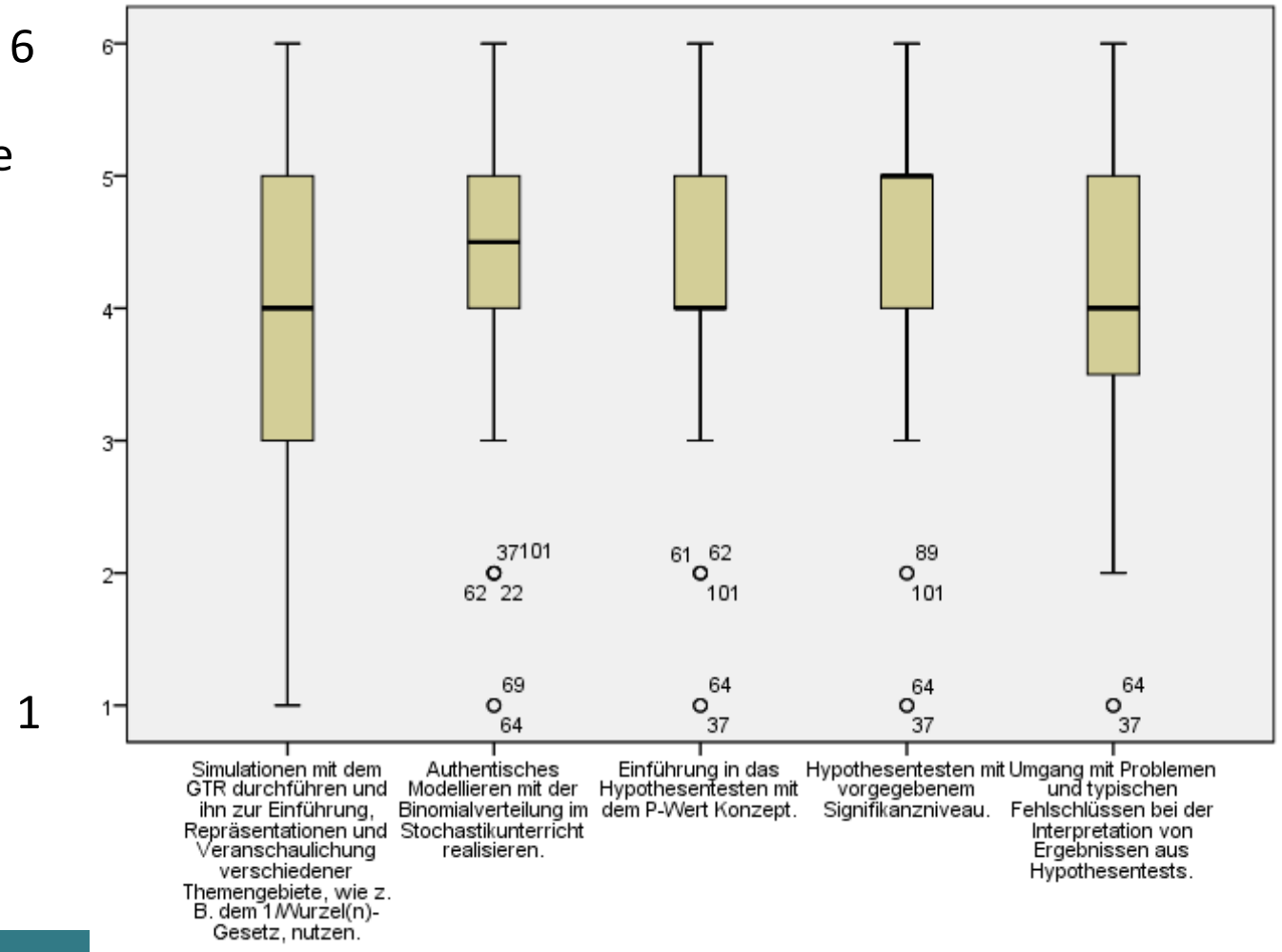
difference in competence

1: strongly disagree; 6 strongly agree

Subjective prospective teaching self-efficacy expectation assessment

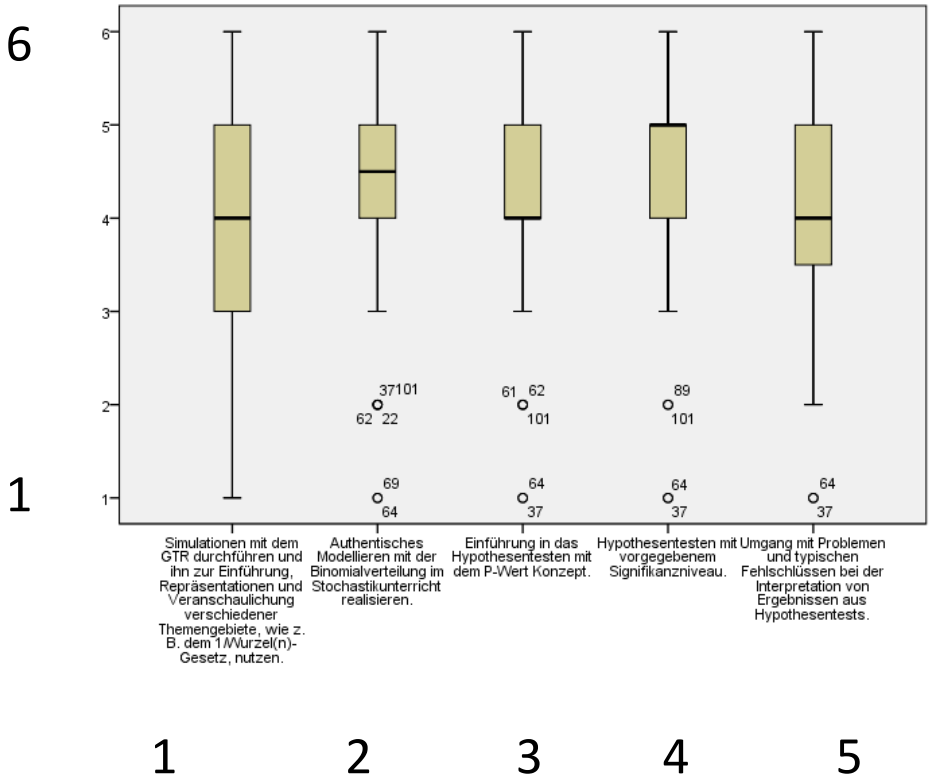
"By participating in the course, I have developed sufficient competencies and have received enough inputs, encouragements and stimuli for the (further) development of materials for my concrete classroom practice"

1: strongly disagree
6: strongly agree



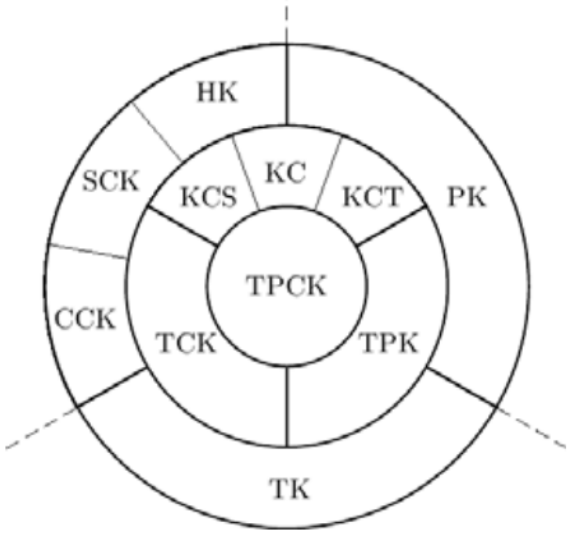
Subjective prospective teaching self-efficacy assessment

1. Simulation, $\frac{1}{\sqrt{n}}$ - law
2. Authentic binomial modelling
3. P-value testing
4. Fixed level testing
5. Misinterpretations of hypothesis tests



Plan: Assessing a two dimensional competence model with different facets of PCK

- technology use (TCK, TPCK)
- adequate tasks (KCT)
- assessing students' knowledge and misconceptions (KCS)
- knowledge representation for students (SCK, CCK)



Wassong & Biehler 2010, relating to work of Ball, D.L. et al.

Figure 1. Components of teacher knowledge and competencies

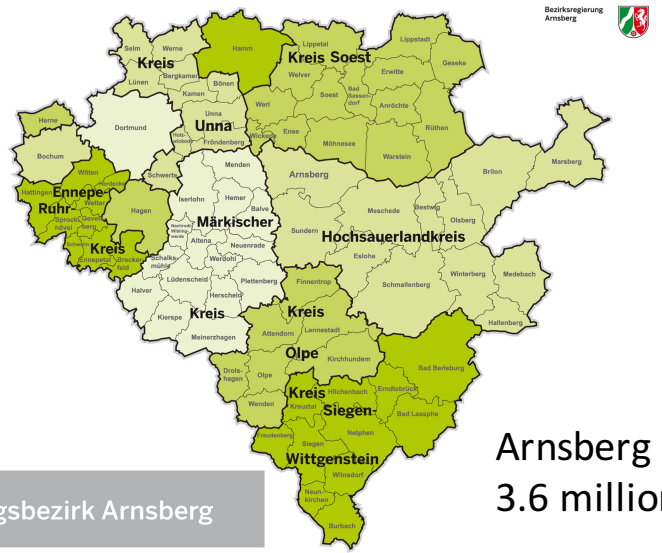
4. The project Stochastics@Arnsberg

Scaling up to 120 schools with new mentor teachers

4.1 Design of the project

The project Stochastics@Arnsberg

North-Rhine Westfalia
17 million inhabitants



Regierungsbezirk Arnsberg

Arnsberg region:
3.6 million inhabitants

Our (typical) collaborators: „Teachers being part time mentor teachers“

... are supposed to do PD and support school and classroom development

- school teachers with reduced teaching load (10-15%)
- recruitment generally is „pragmatic“
- their MT professional development: occasionally but generally no relation to subject matter
- time for their own professional development has to come from their reduced teaching load
- not independent PD providers but dependent on administrative leaders

The project Stochastics@Arnsberg 2015 - 2017/18

Project group

- DZLM: 1 professor, 1 doctoral student, 1-2 teacher researchers (university based)
- Arnsberg: 5 in-service “project” mentor teachers (**PMTs**),
- Arnsberg: 2 administration leaders from the regional administration (partially)

The project Stochastics@Arnsberg 2015 - 2017/18

Goal

- Collaborative design and implementation of a 5 day PD course, based on the DZLM precursor course
- Collaborative design process is also regarded as a professional development opportunity for the participating 5 PMTs
- Collaborative design process will lead to quality materials which are to be used by further 10 -15 MTs

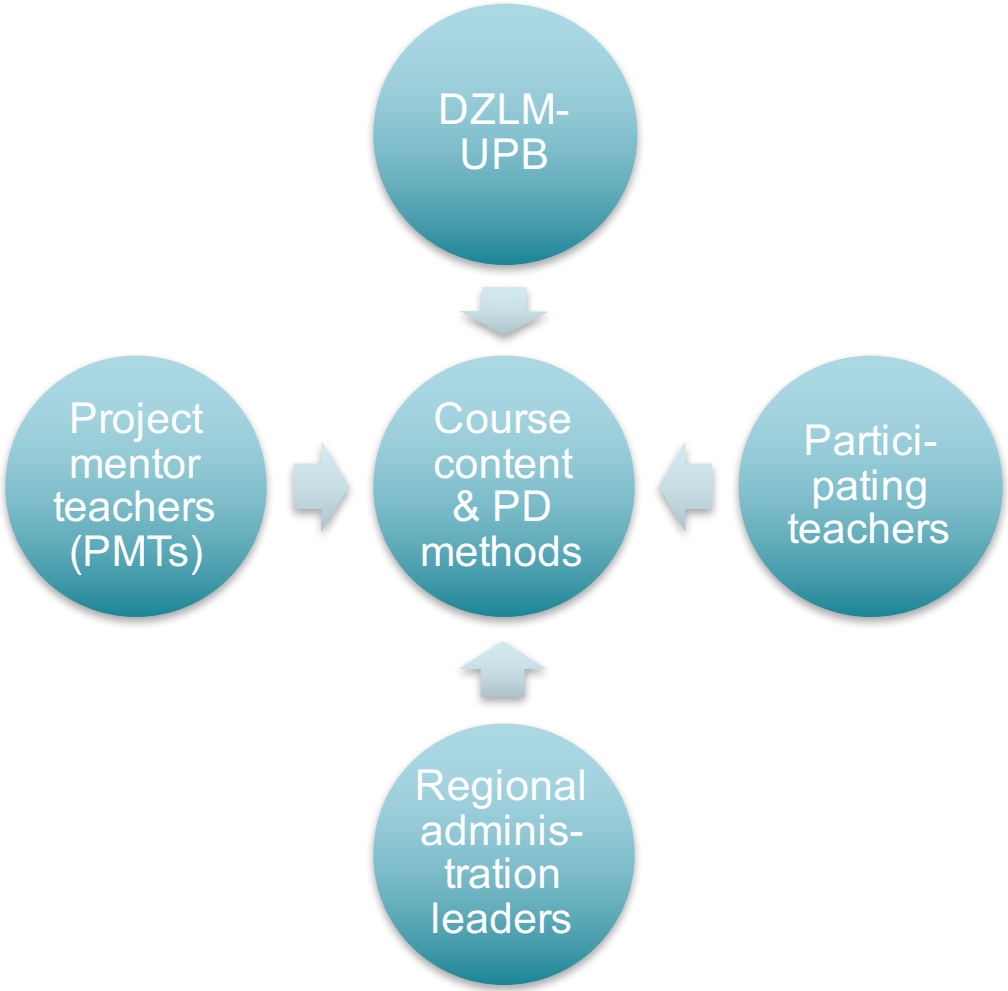
	PD Phase	Time	PD moderators	Development	Research
1	Development	2015/16		Course: DZLM & PMT	
2	Piloting	2016	DZLM & PMT	Revision: DZLM & PMT	Observers: DZLM & PMT
2	Collaboration	2016/17	Tandem: DZLM & PMT	Draft moderator material: DZLM	Research on teachers: DZLM
	Intermediate: Educating further MTs	2017	DZLM & PMT	Revision of moderator material: DZLM	
4	Regular	2017/18	PMT & MT		Research on teachers and (P)MT: DZLM
	School development and implementation	*2017/18 (?)*	*PMT & MT as supporters*		*Classroom research: DZLM*

PMT: project team mentor teachers; MT: „normal“ mentor teachers

Structure for developing a single 1-day module

	Actions	Type of collaboration
1	Looking at the previous module version	Individual/partner work
2	Revision plan and division of labour for one module (comprising 4 units)	Workshop 1 (half-day)
3	Rewriting the units of the module	Individual/partner work / Skype meetings
4	Discussing / rewriting	Workshop 2 (one day)
5	Rewriting the units of the module	Individual/partner work / Skype meetings
6	Piloting the module	PMT and DZLM both present units
7	Reflection / revision plan	Workshop 3 (half-day)
8	Overall planning of collaboration phase	Two-day workshop
….	…..	…..

How did our PD course change by the collaboration?



Impact of participating teachers

- Different participating teachers
  - Mathematics department heads of the schools
  - Not all completely free to participate
- Greater heterogeneity
  - Less interested in innovative topics
  - More examination oriented
  - More skeptical concerning use of digital tools, particular Graphic Calculators

How did our PD course change by the collaboration?

PD methods and contents

- **Less input** and more collaborative and reflective activities for the teachers in the course
- More time for drafting and reflecting **“hypothetical learning trajectories”** / lesson plans
- More explicit addressing and discussion of **teachers’ beliefs** (“teaching to the test” vs. orientation at broader educational goals)
- **Outsourcing of content** into self-regulated “home work”

How did our PD course change by the collaboration?

Subject matter content in prob & stats

- More focus on those topics that have survived the "ongoing struggle for official interpretation of the curricula"
- Less focus on optional topics that are highly valued in the prob & stats education community

Stronger explicit classification of types of knowledge

- Mathematical horizon knowledge for teachers
- CK and PCK for teachers
- Mathematical knowledge for students

How did our PD course change by the collaboration?

Classroom use of digital tools

- Better distinction of different formats of classroom use
  - Teacher lesson preparation and classroom presentation
  - Students' tasks with interpreting output from digital tools
  - Prepared interactive worksheets for students use
  - Students' using digital as cognitive tools
    - calculation, visualization, simulation
- Re-integration of non GC - digital tools (Geogebra, EXCEL, ~~Fathom, Tinkerplots~~): Avoiding GC monoculture

4.2 Support for mentor teachers

Favorable conditions for PMT's development

- PD will address an urgent need of the participating teachers
- Support by the regional administration and related to the PMT's institutional role
- Qualification goal of PMTs is transparent, limited and seems achievable:
  - enabling them to run the PD courses themselves with using the collaboratively developed material
- existing (positively evaluated) DZLM material was an essential starting point as PMTs do not have the time resources to develop high quality PD materials themselves from scratch

Collaboration with our mentor teachers: Positive conditions

- We do not teach them anything explicitly, but we form a “professional learning community”
- PMTs expertise is respected: They improve and criticize our draft material and bring in their experience on three levels
  - as learning teachers (adequacy for future participating teachers)
  - as teaching teachers (adequacy for students)
  - as PD experienced mentor teachers (adequacy of PD teaching methods)

Informal observations of “necessary” knowledge for MTs

Module design workshops

- Field notes

During the 5 days of the PD pilot phase:

- Protocols of the oral comments and selected/omitted parts of elements on the slides
- Observing the PMTs (and DZLM) as discussion leader and group work moderator
  - Protocols of questions and PMT answers asked by participating teachers
  - Protocols of questions that PMT passed over to DZLM members

Add-on material for MTs

	Type of PD activities	MT Support
PPT	PowerPoint presentations	Local presentation notes
WST	Worksheets for teachers	Guides for moderation of group and plenary work
HAT	Handouts for teachers with background information	Enhanced MT background knowledge
	Plenary and group discussions	Enhanced MT background knowledge
DTG	Digital tool guides (text or video clips)	Material for enhanced DT competence of several tools; knowledge of affordances and limitations

Enhanced MT background knowledge: Examples

- Knowledge on math education research and development
  - Psychological studies
  - Specific design based research
- Context background knowledge of authentic examples as compared to reduced educational examples
  - Risks with HIV tests, overbooking of airplanes, Sally Clark scandal, lost girls around nuclear waste deposits, albinism of barn swallows from Chernobyl

Enhanced MT background knowledge: Examples

Hypothesis testing and its practical (mis-) uses

- Neyman - Pearson vs. R.A. Fisher approach
- Relation to confidence intervals
- Guideline for correct practical application
  - Ronald L. Wasserstein & Nicole A. Lazar (2016):
    The ASA's statement on p-values: context, process, and purpose,
    The American Statistician, DOI: 10.1080/00031305.2016.1154108

Open questions

- What kind of support has to be provided for our MTs that have not collaborated as PMTs?
- What quality of scaling up possible, just on the basis of PD material with MT enhancements?

Thank you very much for your attention!

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