

Developing Adaptive Teaching Competency through coaching

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ABSTRACT

The research project Adaptive Teaching Competency seeks to conceptualise the processes of tuning teaching to individual students' learning needs and to empirically test, within the field of science teaching, to what extent Adaptive Teaching Competency can be fostered through teacher education. 32 primary and secondary teachers took part in an intervention to foster their Adaptive Teaching Competency based on content-focused coaching whilst 18 teachers formed the control group. Teachers receiving the coaching increased their Adaptive Teaching Competency with regard to planning and their students showed a higher learning outcome compared to the control group.

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1. Introduction

1.1. Teachers' knowledge and student learning outcome

Teachers are faced with multitasking and highly complex work (Brante, 2009). Major individual differences amongst any group of students attending the same class demand highly adaptive teaching (Helmke & Weinert, 1997). Teachers are challenged to meet diverse learning needs and to adapt their teaching to heterogeneous academic ability as well as to multiple interests and motivations. We suggest the concept of Adaptive Teaching Competency to gain an understanding of the complex processes and determinants of adjusting lesson planning and lesson implementation to the diverse needs of the students. This research project seeks to empirically explore the concept of Adaptive Teaching Competency as well as its relevance to student learning outcomes and to determine, whether Adaptive Teaching Competency can be fostered in teacher education. Science education at primary and secondary schools was chosen for an intervention study.

Since decades the interactive relationship between instruction and the individual learning preconditions of the students with regards to learning outcome has been at the centre of educational

research (see Reimanis, 1972). ATI (Aptitude \times Treatment Interaction) research has been systematically applied to determine such interaction (Cronbach & Snow, 1977; Snow, 1989). ATI could not inform teaching at large because of the low ecological validity of the studies as well as the specific treatments; treatments were effective in experiments but not when implemented in real school practice (Helmke & Weinert, 1997). The interaction between teaching and student learning outcome is more complicated. A variety of teaching patterns are linked to high student learning outcome (Helmke & Weinert, 1997; Lipowsky, 2006). Furthermore, the seemingly same teaching method can be more or less successful depending on the characteristics of the learners (Corno & Snow, 1986). In the research literature, a variety of teacher factors have been found to be linked to student learning outcome, such as teachers focusing their interaction on learning for understanding and classroom management (Helmke & Weinert, 1997), teachers' learner-centered teaching style and good classroom management (Opdenakker & Van Damme, 2006) teachers' content knowledge and teacher motivation (Kukla-Acevedo, 2009), as well as teachers' interpersonal behaviour in their interaction with the students (den Brok, Brekelmans, & Wubbels, 2004). Baumert, Stanat, and Demmrich (2001) present a model to explain student learning outcome which helps to situate the focus of this research project: interactions between teachers' expertise, instruction and students' individual learning preconditions and students' learning outcomes are examined. Other factors included in the model such as the influence of parents, media and peers are not analysed in detail within our project. The construct of Adaptive Teaching Competency

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takes into account that it is not appropriate to recommend a certain fixed method of teaching but to focus on the competency of the teacher in adjusting teaching to his or her students.

Professional experience is expected to have an influence on the quality of teachers' professional competencies. Research based on cognitive psychological approaches which compare the competencies of experts and novices illuminated the cognitive competencies needed for effective teaching. Expert teachers build on a better organised and more effective knowledge than novice teachers and are able to use their knowledge in difficult situations, acting more flexibly (Berliner, 1991; Bromme, 1992). Saying that teaching competency does not increase in a linear way according to the duration of teaching experience as other aspects such as fixation on teaching routines or burnout might have a negative impact. It is therefore crucial for good learning outcomes of students that teachers continue to develop their professional competency not only 'by doing' but also through teacher education. In this study an intervention of teacher education was implemented in order to examine to what extent Adaptive Teaching Competency could be fostered and whether students are benefiting in relation to their learning outcomes.

1.2. Adaptive Teaching Competency

Drawing on the concept of teachers' pedagogical content knowledge (Gess-Newsome & Lederman, 2001; Shulman, 1986) and on concepts of dimensions of teachers' competencies (Wang, 1980; Weinert & Helmke, 1996) we conceptualise four aspects of teacher competency that are particularly linked to students' learning outcomes. These are subject knowledge, diagnosis, teaching methods and classroom management. Wang (1980) defines the demands on teachers as follows:

- Diagnosis of students' learning pre-conditions in relation to the curricular subject and the ongoing diagnosis in monitoring the learning processes.
- Curricular decision-making with regards to the learning objectives.
- Selection of teaching and learning arrangements which take the learning preconditions, the individual learning process, the learning objective into account and foster active learning.
- Classroom management which supports the accomplishment of the above mentioned demands.

The concept of Adaptive Teaching Competency is defined as follows: a teacher with high Adaptive Teaching Competency succeeds in teaching in such a way, that

- demands of subject knowledge are met (dimension of subject knowledge);
- the diverse pre-conditions and learning processes of students are taken into account as well as situational aspects of topical themes (dimension of diagnosis);
- the benefits of diverse teaching methods are made fruitful for learning (dimension of teaching methods);
- students and the class are supported in the regulation of learning processes and activities are managed (dimension of classroom management).

Adaptive Teaching Competency therefore consists of the four dimensions: subject knowledge, diagnosis, teaching methods and classroom management.

Teachers seek to co-ordinate these four dimensions in order to foster learning for understanding and to initiate and sustain students' engagement with the curricular subject. The term 'adaptive'

emphasises the process. An adaptive teacher is aware of the diversity of learning pre-conditions, and the learning and problem-solving behaviour of students. Students' prior knowledge needs to be integrated in to the learning process in order for them to develop conceptual understanding in science (Asoko, 2002). An adaptive teacher notices lack of understanding, diminishing of concentration, and the onset of disruptions and acts accordingly, adjusting the course of the planned lesson during implementation. Being adaptive also entails anticipating learning processes during planning. An adaptive teacher foresees individually diverse paths in learning, and possibly includes alternatives within the lesson planning. Diagnosis of student learning is crucial as emphasised in the research literature on the potential of formative assessment. Black and William (1998) highlight in their extended review of research the potential of formative assessment, as many findings link formative assessment with positive student outcomes. Many studies found, however, that teachers only rarely use formative assessment in a systematic way to inform their teaching, for example the choice of task set for the students (Black & William, 1998). Yin et al. (2008) found that formative assessment did not have the expected impact on students' motivation, achievement and conceptual change; they noticed that teachers have difficulties to implement formative assessment and to use the information from formative assessment to modify their teaching.

Adaptive Teaching Competency does not imply a specific method of instruction or a didactic model for teaching. In conceptualising Adaptive Teaching Competency as a competence – and not as a specific tool – it is assumed, that a variety of teaching methods are used. Ideally a teacher plans student-centered and teacher-centered phases adaptively, taking learning goals and the students' needs and interests into account. High Adaptive Teaching Competency possibly results in a teaching style, which involves a variety of teaching methods; Kyriakides, Creemers, and Antoniou (2009) describe such a teaching style as being advanced and prove the empirical link to better student outcomes.

In order to examine these different aspects of adaptive teaching, we distinguish two types of knowledge regarding Adaptive Teaching Competency: Adaptive Planning Competency and Adaptive Implementation Competency. Adaptive Planning Competency draws closely on teaching objective, subject knowledge and includes the anticipation of how the lessons will ideally develop. Adaptive Implementation Competency requires adjusting teaching methods or strategies of classroom management as well as the diagnosis of students' understanding and need of support. Of course, both competencies are linked, as the planned course of teaching is modified but rarely completely abandoned (Shavelson & Stern, 1981).

1.3. Fostering Adaptive Teaching Competency through content-focused coaching

There can be a wide gap between knowledge and action, in particular where action is pressurized through fast decisions in moments of crisis, theoretically-based knowledge will not be employed and teachers seem to resist change. Knowledge acquired in settings of teacher education, initial teacher education as well as in-service teacher training, is often not applied to the classroom (Wahl, 1991, 2000, 2001).

According to Dann (1994) and Wahl (2001) subjective theories can only be changed, if

- pre-existing knowledge is activated;
- co-construction of knowledge and meaning is sought, for example, in working with other teachers or in the contrasting of subjective theories with research-based educational theories;

- the processes of change are embedded in a context of action, where the newly constructed knowledge is proven to be more effective than the old routines for meeting the demands;
- a close connection is established with the context of teaching in order to transfer the new competency into practice.

A variety of approaches could be envisaged to foster adaptive teaching competencies, for example, supervision (Ehinger & Hennig, 1994; Pallasch, Reimers, Kölln, & Strehlow, 1993; Snow-Gerono, 2008), coaching based on the concept of the reflective practitioner (Handal & Lauvas, 1987; Schön, 1983), mentoring (Niggli, 2003), reciprocal peer coaching (Zwart, Wubbels, Bolhuis, & Bergena, 2008) or content-focused coaching (West & Staub, 2003).

Within this research project, we chose to examine the potential of content-focused coaching (Staub, 2001; West & Staub, 2003) for fostering Adaptive Teaching Competency within science education. Content-focused coaching has been developed for mathematics education and adapted for science education for this research project. Coaches who employ content-focused coaching need to be competent in teaching the particular subject and have an in-depth knowledge of the didactics of the subject as well as general teaching methods. Coach and teacher meet before the lesson and discuss the planning. Coach and teacher enter in a process of co-construction with the aim of implementing the lesson together. During the lesson, the teacher implements the lesson, but the coach might also teach, depending on the agreement between teacher and coach. Post-lesson discussion is aimed at drawing conclusions about the learning processes of the students and the consequences for the next lesson. Content-focused coaching therefore requires one-to-one intervention in the school itself. Unlike many traditional models of teacher training, content-focused coaching emphasises planning, to ensure the adjustment to the subject at hand (dimension of subject knowledge) as well as the pre-conditions of learning (dimension of diagnosis). The reflection and effort put into these pre-lesson discussions will enhance a lesson which will be taught (dimension of teaching methods and classroom management). In its emphasis on pre-lesson discussion and on co-construction for teaching, content-focused coaching differs profoundly from the traditional mode of teacher education, which mostly involves the in-depth reflection of the observing expert on a lesson, which will never take place again in the same way.

Content-focused coaching fulfils the criteria mentioned above (Dann, 1994; Wahl, 2001): content-focused coaching builds on teachers' plans for a lesson, existing knowledge is activated and included. Teacher and coach are involved in a process of co-construction. Teacher and coach aim at putting their discussions and considerations into action together, as pre-lesson coaching aims at lesson implementation. Content-focused coaching supports teacher learning in their own classroom, being as close as possible to the daily setting.

We considered the following characteristics of content-focused coaching as particularly important for our aim:

- Content-focused coaching centres clearly on the learning processes of the students.
- Coach and teacher enter a process of co-construction of teaching in their pre-lesson reflections, which can also result in episodes of co-teaching during the lesson.
- Coach and teacher follow the process of teaching through a sequence of planning and implementing, which allows fostering both, Adaptive Planning Competency and Adaptive Implementation Competency.
- Content-focused coaching acknowledges the relevance of the subject or content taught.
- Content-focused coaching allows for adaptive teacher education in a one-to-one coaching situation so that the coaching can

be adjusted to the processes in the given class and the competencies and the focus of the individual teacher.

2. Methodology

This research project examines to what extent Adaptive Teaching Competency of teachers can be fostered and what effect Adaptive Teaching Competency has on students' learning. A quasi-experimental design has been chosen to examine these two research questions.

2.1. Sample

50 classes in total, 27 classes at primary (10 and 11 year old students) and 23 classes at secondary (13 and 14 years old students) level participated in this study. The experimental group included 32 teachers and 623 students and the control group 18 teachers and 353 students. The study was conducted in the Eastern region of Switzerland. The teachers were recruited through adverts in a regional teachers' bulletin and chose to participate in the study. 19 women and 31 men took part. Years of teaching experience ranged from 2 to 35 years, with an average of 15 years. 10% of the teachers worked part-time, the great majority had full-time posts. Experimental and control group did not differ with regard to these characteristics.

2.2. Research design

It was decided on an intervention with the view to enhancing teachers' Adaptive Teaching Competency. The effects of the intervention were examined in a research design with pre-test and post-test and with a comparison between the experimental group and the control group (Table 1).

2.3. Intervention

The 32 teachers of the experimental group participated in an intervention consisting of two parts:

- A two-day seminar on Adaptive Teaching Competency to discuss research findings relating to the four dimensions of Adaptive Teaching Competency (subject knowledge, diagnosis, teaching methods and classroom management).
- Nine three-hour sessions of content-focused coaching whereby the coach visits the teacher in their classroom (Staub, 2001; West & Staub, 2003).

2.3.1. Content-focused coaching

The recruitment of the coaches was based on their professional experience as teachers of either primary or secondary schools and on their experience and/or qualification in a coaching capacity (mentors for teachers, coaches). They received two additional training days in content-focused coaching with Staub and took part in the two day seminar on Adaptive Teaching Competency. Coaches were assigned to co-construct teaching with primary and secondary school teachers in their regular classrooms. They were instructed to hold nine sessions of approximately three hours consisting of pre-lesson reflection, team teaching, and post-lesson reflection. As a general aim, coaches were asked to improve teaching in co-construction, to coach adaptively and to focus issues based on the teaching they observed and the needs formulated by the teachers. Staub also provided a set of questions to serve as guidelines for the content-focused coaching (adapted from West & Staub, 2003, p. 11):

Table 1
Overview on the research design.

	Experimental group (32 classes)	Control group (18 classes)
Beginning of school year	Pre-test Video test, vignettes, scientific literacy test	
Autumn and winter term	Intervention seminar 'Adaptive Teaching Competency' (2 days) and content-focused coaching (9 sessions of 3 h each)	
Spring term	8 lessons taught by the teacher with set learning goals on a given topic (germination of seeds). Pre- and post-test on students knowledge	
End of school year	Post-test Video test, vignettes, scientific literacy test	

- “What are the goals ... of the lesson: i.e. what are the learning objectives of the lesson? What are central concepts? Are specific strategies being developed?”
- Where does this lesson fall in this unit and why: i.e. do any of these concepts and/or skills get addressed at other points in the unit? What does this lesson have to do with the concept you have identified as your primary goal?
- What are students' prior knowledge and difficulties: i.e. what relevant concepts have already been explored with this class? What strategies does the lesson build on? What can you identify or predict students may find difficult or confusing or have misconceptions about; what ideas might students begin to express and what language might they use?
- How does the lesson help students reach the goals: i.e. what grouping structure will you use and why? What activities will move students towards the stated goals? In what ways will students make their thinking and understanding public? How do you plan to assist those students who you predict will have difficulties? What extensions or challenges will you provide for students who are ready for them?”

The actual coaching time for each of the three parts and the issues discussed were recorded by the coaches in a specially designed coaching-journal. Analyses of these journals reveal (Meier, 2005) that on average the actual duration of the coaching sessions approached the intended three hours ($M = 164$ min). However, less time was spent with pre-lesson reflection ($M = 33$ min) than post-lesson reflection ($M = 46$ min). The teaching time between the reflections averaged 85 min (Fig. 1).

In their journals coaches also recorded the time spent discussing themes related to each of the four dimensions of Adaptive Teaching Competency (Fig. 2). The most time was used to discuss teaching methods; issues of diagnosis were also often a focus. Subject knowledge and classroom management received far less attention. Additional topics such as cooperation with parents and school climate were rarely discussed (Meier, 2005).

The topics at the centre of each of the three phases of coaching are also of interest:

- Pre-lesson reflection: the objectives of the lesson were discussed most frequently, followed by questions regarding central terms, themes, and models, visual aids and other materials. Questions such as “in what ways will students make their (...) thinking and understanding public?” (West & Staub, 2003, p. 12) were the least discussed, followed by questions of differentiation, i.e. how students with learning difficulties could be supported and how students who have mastered the learning objectives could be challenged.
- Lesson implementation: the learning objectives for the lesson, the application of models and central terms were well included in the teaching of the lesson. However, new ideas of students were poorly followed up in the course of the lesson, new concepts were rarely related to students' skills and their previous knowledge. Additional and challenging assignments rarely materialised.
- Post-lesson reflection: the range and frequency of topics discussed during post-lesson reflection were similar to that of the pre-lesson reflection.

To summarize, issues of teaching methods were the most frequently discussed and implemented, especially the learning objectives of a given lesson and the introduction of new terms, concepts and models. Mostly neglected were issues of differentiation, adapting to the diversity of students' skills and their pre-existing knowledge. As taking students' individual needs into account lies at the heart of the concept of Adaptive Teaching Competency, these reports on the coaching also illustrate that implementing adaptive teaching in classroom is challenging.

2.4. Tests

The effects of the intervention on teachers' Adaptive Teaching Competency and the learning outcome of their students were tested with a series of especially developed instruments. The teachers responded to a vignette (a description of a classroom scenario) testing their Adaptive Planning Competency and participated in

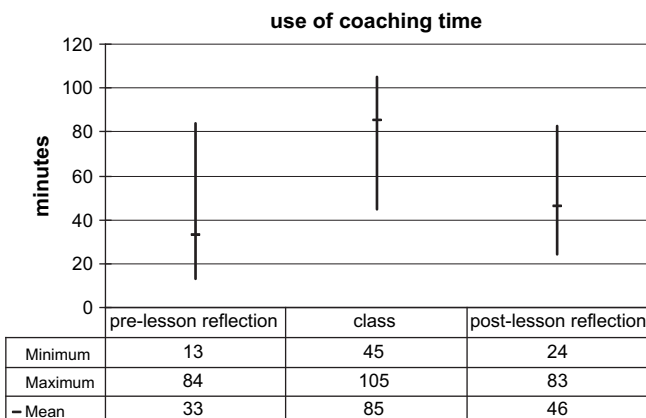


Fig. 1. Duration of content-focused coaching in minutes, mean for all coaching sessions ($N = 32$).

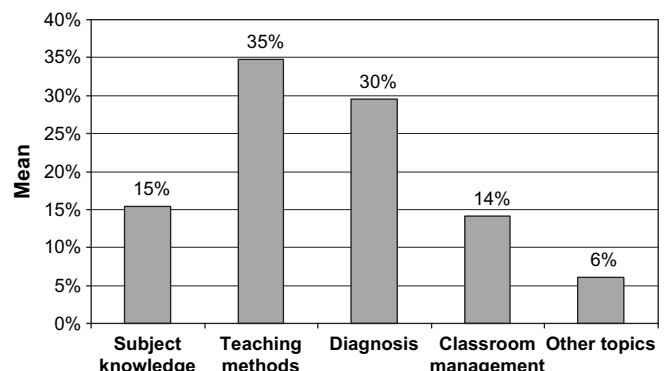


Fig. 2. Topics of conversation: average percentage by dimension ($N = 32$).

a video test to assess their Adaptive Implementation Competency. The pre-test and the post-test (before and after the intervention) included the same video test and vignette. The students' learning outcome was tested using a scientific literacy test, again with a pre-test and a post-test.

2.4.1. Vignette

In order to capture teachers' Adaptive Planning Competency an instrument was needed, which (a) explores teachers' cognitions for planning; (b) allows for in-depth analysis of the reflections in the four dimensions of Adaptive Teaching Competency; (c) provides data to compare teachers and (d) is embedded in a context as close as possible to real action. Vignettes allow for respondents to formulate their thoughts and practices in their own words but also to structure the comparison, as the impulse is identical. The vignette contextualises the question. Vignettes are responded to in writing, which corresponds with the mode of lesson planning.

The following vignette was used to assess teachers' Adaptive Planning Competency:

Vignette A

Thomas is uncertain when planning whether the students will achieve crucial learning objectives. Particularly with regard to natural science teaching he doubts whether his planning meets high professional standards. Please describe to Thomas, how he could go about planning in natural science. Include all planning steps and make your reflections transparent.

The theoretically-based construct of Adaptive Teaching Competency was the basis for developing criteria and indicators, which have been formulated for three of the four dimensions (subject knowledge, diagnosis and teaching methods). Classroom management was found to be unlikely to be explicitly included in planning considerations and was therefore left out in the analysis. On the basis of data analysis, criteria and indicators were added. The list of criteria and a selection of indicators are provided in Table 2.

In a first step, teachers' statements were categorized. Secondly, two researchers gave independently their rating and then agreed after discussion on a definite rating for each criteria. The ratings differentiated between addressing a criterion of good quality teaching (rated with one point) and addressing of a criterion in an adaptive way (rated with two points). To be considered an adaptive response, at least one of the following characteristics needs to be fulfilled:

- Orientation towards learning for understanding.
- Orientation towards individually diverse learning processes of each student.
- Depth of reflection.
- Practical realisation of highly differentiated quality.

Reliability of the scales was satisfactory (Wittenberg, 1998): pre-test Cronbach- α = 0.55 and post-test Cronbach- α = 0.66.

2.4.2. Video test

A video test was constructed with the aim of assessing Adaptive Implementation Competency. In a one-to-one situation with a research assistant, teachers were shown a video of a sequence in a science lesson. The sequence was performed by a class of 11 years old students and their teacher; the teacher and the class followed a script which was written by the research team. Purposefully non-adaptive teacher behaviour was included in the script of the sequence, where the teacher acted and communicated with the students in a non-adaptive way. These were linked to the four dimensions defined in the construct of Adaptive Teaching Competency. Teachers responding to the test were asked to stop the video

Table 2
Criteria and indicators for rating the vignette.

Dimension/criteria	Indicators (examples)
<i>the teacher...</i>	
Subject knowledge	
Ensures teacher's own subject knowledge	- Possesses or acquires the necessary subject knowledge - Provides a reflection/reasons for the selection of topics covered
Diagnosis	
Checks students' prior knowledge	- Checks what knowledge students bring from non-school contexts - Checks what knowledge students covered in school
Checks students' learning preconditions	- Checks what interests the students express - Checks what strategies for reasoning and learning the students bring
Plans for checking students' understanding during the lesson	- Asks questions to evaluate understanding - Analyses the students' contributions as indicators of their understanding - Initiates students' self evaluation of their learning
Teaching methods	
Plans the lesson	- Focus on learning goals - Estimates time required accurately - Tests experiments beforehand
Enables acquisition of new knowledge	- Tells students what the learning goals are - Enables learning in different areas: cognitive, creative, affective social, hands-on - Encourages students to formulate their hypotheses
Enables application and deepening the acquired knowledge	- Provides differentiation to meet students' diverse skills and interests - Enables self-directed projects within the topic - Initiates peer tutoring

when they perceived a non-adaptive situation, to express their perceptions and also to suggest an alternative to the teacher's action which would be more adaptive. The video test allowed a measure of competence which was standardized: all teachers in the sample responded to the same lesson on video and pre- and post-test were identical. The video test required instant decision making whilst watching the lesson unfold. The video test was developed as an alternative to video-based observation of the participants teaching their own classes; such observation would have enabled a measurement of the real implementation, however, such observations and the subsequent rating of the competencies would require resources beyond the scope of this project and would be less standardized.

The responses were transcribed and analysed by two researchers. A categorization of the sequences was developed based on the script as well as on the participants' responses. Categorization included criteria and indicators. After categorization, the responses were rated. Recognising a non-adaptive action was rated 1 for each indicator, providing an adaptive alternative to the action shown was rated 2. Table 3 provides an example from the rating manual.

The quality of the scales is satisfactory in pre-test and post-test. Cronbach- α of the unified scale for Adaptive Implementation Competency is 0.79 in the pre-test and 0.84 in post-test. Reliability for each of the dimensions lies between 0.54 (classroom management and diagnosis) and 0.79 (teaching methods). The scales with lower reliability included less items than the teaching methods scale.

2.4.3. Scientific literacy test for students

The content-specific pre-knowledge of students is an important condition for further learning achievement (Helmke & Weinert, 1997).

Table 3
Rating manual for a sequence of the video test: distinction between recognising a non-adaptive action and providing an adaptive alternative.

Video test sequence:	Teacher: Good morning everybody. Today, we will conduct an experiment on water and air pressure. We have already conducted several experiments – who can remember them? – Natasha! Natasha: We conducted an experiment where we used a spoon to separate pepper from salt. Teacher: Very good. What else? Barbara: Wasn't that the experiment with the balloon? Teacher: Exactly. How did it go? Barbara: We had to rub a ruler on a balloon and then hold it against someone's hair. The hair went up because of the static. Teacher: Very good. Today we will conduct a new experiment on the topic of water and air pressure. Please gather around the front with your chairs. (transcript of the video test)
Dimension:	Diagnosis
Criteria:	Assessing previous knowledge
Indicator:	Clarifying previous knowledge in recapitulating
Example for recognition:	"He wants now to continue with the experiments and recapitulates previous content. I think, he starts in a strange way, in that they work on a whole new series of experiments and he recaps a passed experiment." (transcript of a participant's response to the video test, selected as an anchor example in the rating manual)
Example for providing an adaptive alternative:	"I would have asked them what one could do with this material. When I only present an experiment, half of the pupils in my experience don't pay attention. It would be more exciting. And also for me as a teacher, I would then see, whether the previous experiments have already resulted in learning, that they are able to transfer their experience and imagining, what experiment they could do." (transcript of a participant's response to the video test, selected as an anchor example in the rating manual).

Therefore, students' competencies are assessed with a scientific literacy test, which enables further analysis of Adaptive Teaching Competency to compare specific learning differences within classrooms. The post-test assesses whether the intervention has had a positive effect on students' increase of learning.

To develop items for the scientific literacy test, problems from the two international school achievement studies TIMSS and PISA were used. This ensures that the problems used in the tests are of high methodological quality, calibrated on large samples. The items were selected from the fields of geography, biology, physics, chemistry and environmental studies. They covered a broad spectrum of difficulty to avoid any ceiling effect. The test for the 13–14 year old students included 26 items, 22 from TIMS second population (Beaton et al., 1996) and four are example tasks from PISA 2000 and 2003 (OECD/PISA, 2000, 2003). The test for the 10–11 years old students included 16 tasks taken from TIMS study 1 and four from TIMS study 2 (Martin et al., 1997). The students from both, experimental and control group estimated the readiness to

apply high effort in the test situation as 'quite high'. Cronbach- α reliabilities for the secondary school students' test were 0.75 on the pre-test and 0.76 on the post-test; for the primary school students' test they were 0.60 and 0.59 respectively.

3. Findings

In this quasi-experimental study, the effects of the intervention on the experimental group are compared with the control group. Pre- and post-test were identical in both groups. First, the effects on the teachers' development are reported; secondly, experimental and control group are compared with respect to students' achievement gains; thirdly, additional results are briefly discussed examining the link between higher Adaptive Teaching Competency and higher student achievement gain.

3.1. Development of Adaptive Teaching Competency through the intervention

Hypothesis 1

Teachers of the experimental group develop their Adaptive Teaching Competency better than those of the control group.

To give consideration to the complexity of the construct Adaptive Teaching Competency, the effect of the intervention was measured on the Adaptive Planning Competency on the one hand, using the vignette, and the Adaptive Implementation Competency on the other hand using the video test. The research seeks to ascertain whether the intervention, consisting of a seminar on Adaptive Teaching Competency and the nine sessions of content-focused coaching, would have an impact on Adaptive Planning Competency and on Adaptive Implementation Competency.

3.1.1. Intervention effects on Adaptive Planning Competency

Adaptive Planning Competency increases for teachers of both groups (experimental and control) due to the rating system, as new points achieved in the post-test were added to the result of the pre-test. Both groups therefore show a statistically significant increase in scores for the dimensions 'diagnosis of student learning' and 'teaching methods', the increase in the dimension of the 'relevance of subject knowledge' is only significant for the experimental group. Overall, the total scores for Adaptive Planning Competency show an overall gain for the experimental group of 14.0 and 7.8 points for the control group. To examine the effect of the intervention on teachers' Adaptive Planning Competency the difference of the overall gains between experimental group and control group was then tested. Repeated Measures Analyses of Variance were employed. Results indicate significant differences, $F(1,47) = 4.36$, $p = 0.04$, between teachers, which were exposed to content-focused coaching and control group teachers regarding their Adaptive Planning Competency as measured by the vignette (Table 4, Fig. 3).

The increase in the scores of the teachers in the experimental group is significantly higher than the increase in the scores

Table 4
Means and standard deviations of pre- and post-test scores on Adaptive Planning Competency by treatment groups.

	Diagnosis			Methods of teaching			Subject knowledge			Total score Adaptive Planning Competency		
	Pre-test M (SD)	Post-test M (SD)	Gain	Pre-test M (SD)	Post-test M (SD)	Gain	Pre-test M (SD)	Post-test M (SD)	Gain	Pre-test M (SD)	Post-test M (SD)	Gain
Experimental group	20.3 (17.3)	33.3 (21.2)	13.0	30.2 (12.3)	45.3 (19.5)	15.1	17.2 (32.6)	31.3 (33.0)	13.9	22.6 (14.7)	36.6 (18.3)	14^a
Control group	20.6 (17.2)	27.5 (16.6)	6.9	33.3 (11.8)	44.12 (13.1)	10.8	11.8 (21.9)	17.7 (24.6)	5.9	21.9 (12.8)	29.7 (13.5)	7.8^a
Overall	20.4 (17.1)	31.3 (19.7)	10.9	31.3 (12.1)	44.9 (17.4)	13.6	15.3 (29.2)	26.5 (30.8)	11.2	22.3 (13.9)	34.2 (17.0)	11.9

The numerical values represent percent scores. They indicate what percentage of the maximum score was obtained on average.

^a Difference in gain between experimental group and control group is significant repeated measures analysis of variance $F = 4.36$, $df = 47$, $p = 0.04$; $\eta^2 = 0.09$.

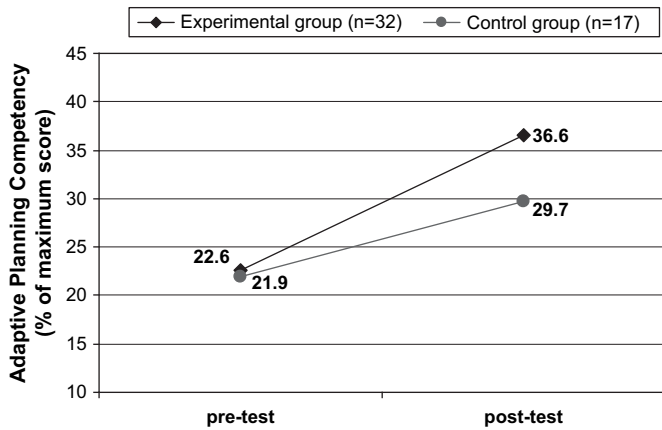


Fig. 3. Overall effect of the intervention on the Adaptive Planning Competency.

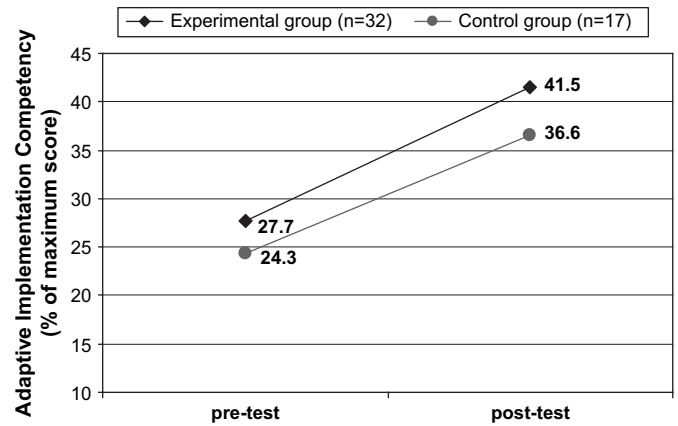


Fig. 5. Overall effect of the intervention on the Adaptive Implementation Competency.

amongst the teachers in the control group. This effect explains 8.5% of the variance. Results also reveal that the dimension of ‘diagnosis of students’ learning’ provides the most important contribution towards the intervention effect on Adaptive Planning Competency.

Fig. 4 shows that the effect which is depicted above explains 8.5% of the variance and that all effects for each single dimension point into the expected direction: Relevance of subject knowledge ($F = 1.70, df = 47, p = 0.20$), diagnosis of student learning ($F = 2.12, df = 47, p = 0.15$) and teaching methods ($F = 0.69, df = 47, p = 0.41$). Examined individually none of the effects is statistically significant. The dimension diagnosis of student learning seems to contribute the most towards the overall effect. The effect of the intervention explains 4.3% of the variance in diagnostic planning competency. For the dimension relevance of subject knowledge and teaching methods it only explains 3.5% and 1.5%, respectively.

3.1.2. Effects of the intervention on Adaptive Implementation Competency

The intervention effect for teachers’ Adaptive Implementation Competency (as measured by the video test, consisting of the dimensions teaching methods, diagnosis of student learning, and classroom management) is not significant, $F(1,47) = 0.202, p = 0.66$ (Fig. 5). Both groups of teachers (experimental and control) develop their Adaptive Implementation Competency to a similar extent. Even though for the individual dimensions no significant effects are shown, all results point into the expected direction. The effect on

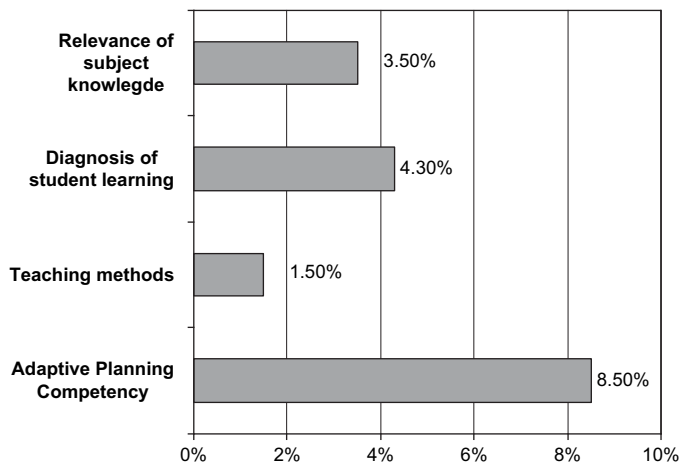


Fig. 4. Accountability of variance for Adaptive Planning Competency and the individual dimensions (according to Cohen, 1988: 1% small; 6% medium and 14% large effect).

teaching methods accounts for 1.7% of the variance. Regarding the grade taught, years of teaching experience, and teachers’ gender no significant differences ($F = 0.814; df = 1, 47; p = 0.371$) were found for the development of the Adaptive Implementation Competency.

The hypothesis is being confirmed regarding the Adaptive Planning Competency, but rejected regarding the Adaptive Implementation Competency. Thus the teachers of the experimental group develop their Adaptive Planning Competency more than those of the control group.

3.2. Intervention effects on students’ achievement gains

Hypothesis 2

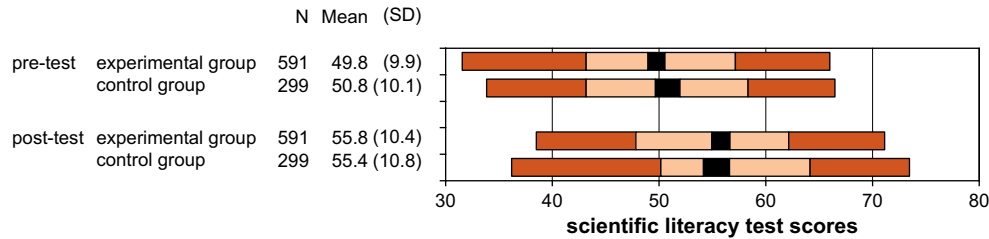
Following the intervention, the students of the experimental group show a larger achievement gain in the scientific literacy test than those of the control group.

The pre-test scores of the experimental and control groups ($t = -1.49; df = 888; p = 0.14$; Fig. 6) show no significant differences on the scientific literacy test for primary and secondary school students. However, the achievement gains for all students (experimental and control groups together) are significant ($F = 305.75; df = 1, 890; p = 0.000$). The increase in scores remains significant even when the two groups are assessed individually. Especially important for our hypothesis is the confirmation of a significant effect of the intervention: The gains of science achievement of experimental group students’ are significantly larger than those of the students of the control group ($F(1,890) = 5.95, p = 0.015$).

These results make clear that both groups of students enhance their science knowledge over the nine months of the study duration. However, students of the experimental group had a greater achievement gain than students of the control group.

The intervention effect remains if student achievement is aggregated on the classroom level, $F(1,47) = 4.193, p = 0.046$ (Fig. 7). This effect explains 8.2% of the variance.

Fig. 7 depicts the significant increase of science competency between the pre- and post-test for students of both groups and the significantly greater achievement gain of the experimental group compared with the control group. It is important to notice that it was not possible to compare systematically several factors which might also be relevant for achievement gains (e.g. topics selected by the teachers from the broad curriculum). The results for grade level differences show that it is the secondary school students of the experimental group who significantly improve their achievement compared with the control group ($F(1,432) = 4.06, p = 0.045$). The



The black segment shows the confidence interval (95%). Fifty percent of student achievement scores around the mean are pictured in the fair segment. The whole bar portrays the span of 90% of achievement scores.

Fig. 6. Achievement of the students in the scientific literacy test (student level).

effect of the intervention for the primary school students is not significant ($F = 2.48, df = 1, 458, p = 0.12$).

The hypothesis is accepted: the students of the experimental group show larger achievement gains in the science test than the students of the control group. The research reveals that the intervention with the teachers, consisting of content-focused coaching and the seminar 'Adaptive Teaching Competency', led to better learning outcomes for their students.

3.3. Adaptive Teaching Competency and learning outcome

The aforementioned findings refer to the effects of the intervention on teachers' Adaptive Teaching Competency and on their students' achievement gains. In addition, the research project also seeks to establish, whether high Adaptive Teaching Competency is linked to students' learning outcomes. We seek to determine whether students benefit in terms of their learning outcome, when they are taught by teachers with a high Adaptive Teaching Competency. The hypothesis for this examination of the data is as follows:.

Hypothesis 3

Students in classes, who are taught by teachers with high Adaptive Teaching Competency, have higher achievement gains than students in classes, who are taught by teachers with low Adaptive Teaching Competency.

To test this theoretical assumption empirically all the participating teachers were each assigned to one of two groups based on the results of a hierarchical cluster analysis and their students' learning gains were compared. One third of all teachers could be assigned to the group with high Adaptive Teaching Competency. These teachers obtain higher scores on all dimensions of Adaptive

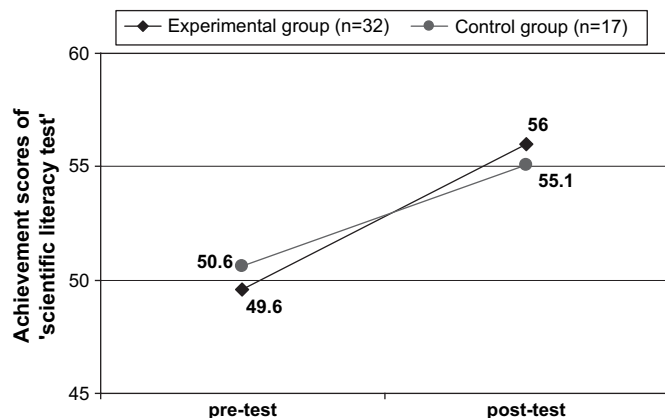


Fig. 7. Effect of the intervention on the scientific literacy test (classroom level; experimental group $n = 32$; control group: $n = 17$).

Planning and Adaptive Implementation Competency than the teachers of the group with low Adaptive Teaching Competency.

In order to compare the effects of high versus low Adaptive Teaching Competency on students' learning outcomes, all participating teachers were given the same learning topics and learning goals and asked to cover these with their class in eight lessons. Learning outcome was measured with a control of the previous knowledge and the students' knowledge after eight lessons had been taught on a given subject. We assume that this learning outcome reflects most closely the effects of the teaching quality, as all teachers were given the same learning objectives and then each planned and taught a defined number of lessons with their class. In addition, the achievement gains of students in the scientific literacy test were also compared.

To test the hypothesis, repeated measures analyses of variance were conducted. Students who were taught by teachers with high Adaptive Teaching Competency obtained a significantly higher achievement gain after the eight lessons on the given topic than students who were taught by teachers with low Adaptive Teaching Competency (low ATC $M = 14.37$, high ATC $M = 17.38$; $F = 4.94, df = 45, p = 0.03$). For the scientific literacy test, the difference was not significant (low ATC $M = 5.35$, high ATC $M = 6.61$; $F = 1.94, df = 1, 47, p = 0.171$) (Fig. 8). We conclude that high Adaptive

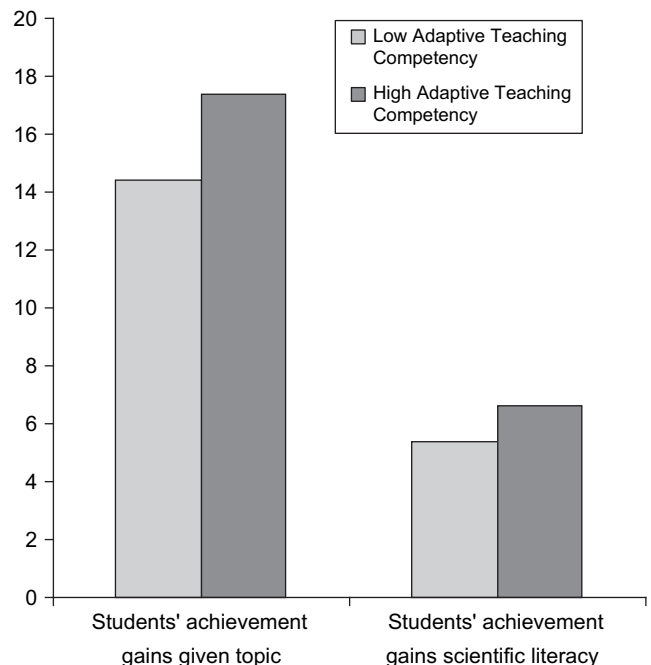


Fig. 8. Adaptive Teaching Competency and students' achievement gains.

Teaching Competency has positive effects on the students' learning outcomes (Beck et al., 2008).

4. Discussion

The results demonstrate that Adaptive Teaching Competency can be fostered through content-focused coaching and has positive effects on students' learning outcomes.

The research examined the potential of fostering Adaptive Teaching Competency through an intervention in a quasi-experimental design. The intervention, consisting of a seminar and content-focused coaching, did not result in a general increase of Adaptive Teaching Competency, but had effects in one of the two aspects of Adaptive Teaching Competency: Adaptive Planning Competency was significantly increased through the intervention, whereas Adaptive Implementation Competency, as measured in the video test, did not significantly change. A follow-up study would be important, as the existing data does not allow for assessing the long-term effects of content-focused coaching.

We interpret the difference of effects on planning versus teaching as an indication, that Adaptive Planning Competency needs less time to be fostered. An effect on implementation would require a longer duration of the coaching. In addition, the knowledge gained through the seminar on Adaptive Teaching Competency is more readily accessible in the mode of written planning as captured through the vignette than in the mode of observing and suggesting alternative actions as required by the video test. Also content-focused coaching emphasises lesson planning which is discussed in the pre-lesson coaching sessions. It seems plausible that the effect of the intervention with nine coaching sessions within six months might first be noticeable in teachers' Adaptive Planning Competency. In order to change teachers' behaviour, a longer coaching phase might be necessary. Many theories on teachers' action assume that teachers' knowledge is not stored in the memory as in an encyclopaedia, but rather is linked to a specific situation and is implicitly triggered by a certain action, built up on the basis of teaching experiences (Groeben, Wahl, Schlee, & Scheele, 1988; Heider, 1958; Neuweg, 1999). The coaches' reports reveal that diagnosis and differentiation for students' diverse learning needs have received less attention than the discussion of teaching methods. In order to have greater effect, coaches' training might need to place greater emphasis on diagnosis and diverse needs.

Content-focused coaching, the intervention tested in this research, requires considerable resources: each teacher of the experimental group received nine sessions of content-focused coaching, whereby the coach visited the teacher and engaged in co-construction of the lesson. While the intervention can be regarded as effective in terms of the desired outcomes such as competencies of teachers and students' achievement gains, the question remains, as to whether the intervention is cost effective.

The effects of the intervention are not only visible in the increased Adaptive Planning Competency, but also in the higher learning outcome of students in the scientific literacy test. Students of the experimental group, taught by teachers receiving content-focused coaching, had a higher learning outcome over a school year than the students in the control group. We can also conclude that the sole fostering of Adaptive Planning Competency, as achieved through the intervention, has a positive effect on students' learning. High quality planning forms a crucial pre-condition for high quality teaching. This finding is in line with Shavelson and Stern (1981). Their research showed that lesson plans were hardly changed during implementation even when major problems occurred. This resistance to changing plans would be less problematic for student learning if the teacher is planning a highly adaptive lesson on the basis of their Adaptive Teaching Competency. Amongst the teachers

with high Adaptive Teaching Competency, the combination of planning and implementation is most effective.

The distinction between planning and implementation has proven to be a useful one for this study. It has been important to find instruments to capture each mode as appropriately as possible. However, the study is limited in that Adaptive Teaching Competency has not been examined in the real context of teachers' teaching in the classroom. Measurement was indirect, capturing beliefs and knowledge, but not the action in the real context. In order to evaluate the relevance of the Adaptive Teaching Competency as measured through the vignette and the video test it would be necessary to compare the test results with observations of real teaching situations and of lesson planning. The development of these specific tests is useful to capture teachers' knowledge in complex, yet simulated, situations. The video test has methodological potential, which has yet to be fully realised.

The study proves that high Adaptive Teaching Competency of the teacher is linked with higher learning outcome of the students. Content-focused coaching (West & Staub, 2003) is effective for fostering Adaptive Planning Competency and is also linked with higher student learning outcome. Adaptive Implementation Competency is more difficult to increase with the methods deployed in teacher education as changing teachers' action has been found to be difficult. This intervention study develops an approach which could provide an important way to the improvement of teacher education to achieve long term gains, in particular, as effectiveness of teacher education is not only measured by capturing teachers' knowledge but is also linked to student learning outcome.

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