





**Center for
Educational Research**

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Introductory Overview

The specific concern of the Center for Educational Research is the study of development and learning from the perspective of institutionalized education. Educational settings, such as schools, provide a specific structure of opportunities and constraints for learning and development. This structure offers a variety of developmental opportunities, but, at the same time, excludes others. How do the learning gains of students in different schools or school types differ? How do teachers' pedagogical knowledge, content knowledge, and pedagogical content knowledge differ, and to what extent do these differences influence student learning gains? How do aspects of schooling affect the intra- and interindividual differentiation of personality traits and guide career-forming processes? How strongly do students themselves actively influence their own academic development—for example, by selecting or switching learning environments? What role does family background play in student development, the selection of learning environments, and the optimization of academic outcomes? These and other questions are explored by a multidisciplinary team including educational scientists, psychologists, mathematicians, and sociologists.

Conceptual Orientation: Knowledge Acquisition and Psychosocial Development in the Context of Institutional Learning Settings

Learning in institutional settings is a complex and multidetermined process. It is fundamentally difficult to determine whether a school career and a student's learning outcomes can be described as successful. It is even more difficult to identify the causes of success or failure. Although popular with the public, press, and policy makers, simple explanatory models relying on a single factor to explain successful or unsuccessful learning processes are usually insufficient, if not entirely misleading. Given the complexity of learning in institutional contexts, our Center's research program is guided by multiple perspectives. The interactive nature of individual student characteristics and institutionalized learning settings must be taken into account. In all of our research, learners are perceived as the coproducers of their own development. Special attention is paid to how cognitive activation and self-regulation can be stimulated and supported by instructional environments. Moreover, we assume that individual students proactively select and shape their developmental environments.

A comprehensive analysis of institutional opportunities and constraints requires researchers to consider several contextual levels, including countries, schools, classrooms, and the family. Accordingly, our research is

embedded in a multilevel perspective, both conceptually and methodologically, and addresses these different contextual levels. It is important to analyze the effects of various facets of these learning contexts simultaneously. For this reason, our research models incorporate conceptually different facets, such as the curriculum, the quality of instruction, and the composition of the learning group.

Because both educational systems and society as a whole change over time, it is crucial that researchers remain attuned to the historical time in which learning takes place. We therefore embed our research in historical analyses and conduct studies to document the effects of changes in institutional settings. The domain specificity of knowledge acquisition is determined by the way in which educational institutions structure content areas into different academic subjects. Our research focuses on domains of knowledge, such as reading, mathematics, English as a foreign language, and sciences. These domains represent basic cultural tools that are critical for individual development in modern societies.

Although the acquisition of knowledge in core domains is the central variable in learning settings, it is not the only aspect of interest. We also investigate students' motivation, personality, personal goals, and values as both outcomes of institutional learning and predictors of academic success and choices.

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We use various methodological approaches to identify powerful learning environments, with experiments and intervention studies complementing large-scale longitudinal studies.

Summary Outline

Work at the Center for Educational Research is organized into four Research Areas, which also provide the structure for this Annual Report. It should, however, be noted that there is considerable overlap between the Research Areas in terms of researchers, topics, and methods.

Research Area I focuses on the relationship between the opportunity structures of schools and the optimization of individual development in terms of cognitive competencies, motivational and social resources, value commitment, and successful transitions to university education, vocational training, and the labor market.

Research Area II examines how institutional, individual, and familial factors relate to transitions in the educational system. A main focus of the activities in this Research Area is the Center's participation in the Trends in International Mathematics and Science Study (TIMSS), with the development of an additional module to examine the transition from elementary to secondary school. Another emphasis is on the transition from school to university.

The research questions being addressed within **Research Area III** draw on a key finding of PISA 2000, 2003, and 2006. In Germany, at least 25% of the upcoming generation can be identified as potentially at risk in terms of reading literacy. Research Area III uses longitudinal, cross-sectional, and experimental studies to examine how students' reading literacy and language skills develop, and how they can be effectively assessed and promoted.

Research Area IV investigates teacher competence as an important antecedent of educational quality. Drawing on earlier research that identified factors of successful learning environments, the research focus has now shifted to the role that teachers play in creating such high-quality instructional settings. Based on a theoretical model of teacher competence, we investigate how teachers' knowledge, beliefs, and psychological functioning determine their instructional practices. Moreover, we examine how these aspects of teacher competence are shaped and changed within formal learning settings, such as the practical phase of teacher education.

Research Area I Opportunity Structures of School and Individual Development in Adolescence and Young Adulthood

The successful development of human beings across the lifespan is dependent both on individual characteristics and on external socializers, such as significant others and social institutions. The social institution of school plays a major role during childhood and adolescence, particularly in the domain of academic learning and, more generally, cognitive development. Furthermore, schools influence the development of motivation, emotions, attitudes, and other personal characteristics. Major research topics addressed in Research Area I include the opportunity structures open to students from different backgrounds, academic achievement trajectories across secondary education, the educational standards attained in German upper secondary schools, the comparability of the school-leaving qualifications awarded across Germany, and determinants and consequences of different academic biographies.

The Empirical Database

Given its theoretical focus on institutional influences on human development, the research conducted within Research Area I entails longitudinal multilevel studies that collect data at the country, state, school, class, and individual levels, cover more than one knowledge domain, and allow both intraindividual change across domains and interindividual differences in patterns of intraindividual change to be investigated. The Research Area's flagship studies were designed to investigate how learning contexts in school and college environments affect human development while meeting the requirements of multilevel longitudinal designs. This applies to *Learning Processes, Educational Careers, and Psychosocial Development in Adolescence and Young Adulthood* (BIJU; see Figure 1), *Transformation of the Secondary School System and Academic Careers* (TOSCA; see Figure 2), and the new study *Tradition and Innovation: Development at Hauptschule and Realschule in Baden-Wuerttemberg and at Mittelschule in Saxony* (TRAIN; see Figure 3).

The analyses conducted in Research Area I also draw on PISA and TIMSS data as well as on additional data sets collected at our Center. Because the longitudinal modeling of hierarchically structured data is methodologically difficult, data analysis requires specific and complex methods, and our Center is involved in optimizing research designs and analytical strategies (see Lüdtke, Marsh et al., 2008).

Schools as Differential Learning Environments: An Overview of Recent Research

Research in Area I has yielded a multitude of theoretically and practically significant findings in recent years. We first give a brief overview of several key results before describing some selected research endeavors in more depth.

Differential Learning Environments and Academic Achievement

One continued focus of research has been on student performance and learning gains in differential learning environments. Germany is characterized by its differentiated secondary system, with the vocational track *Hauptschule*, intermediate track *Realschule*, and academic track *Gymnasium*, although there is much flux in the structure of the school system in many German states at the moment, with several states reducing the number of school types to two.

A main hypothesis of our Research Center is that the different school types represent differential developmental environments, potentially resulting in differential student learning gains at different school types (fan-spread effect). There are three main explanatory approaches to this fan-spread effect (see Baumert, Stanat, & Watermann, 2006). The first explanation attributes differential developmental trajectories in German secondary schools to differences in students' performance and learning speed that existed before they entered secondary school. Thus, differing developmental trajectories are an expression

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The BIJU Study—Aims and Data Collection

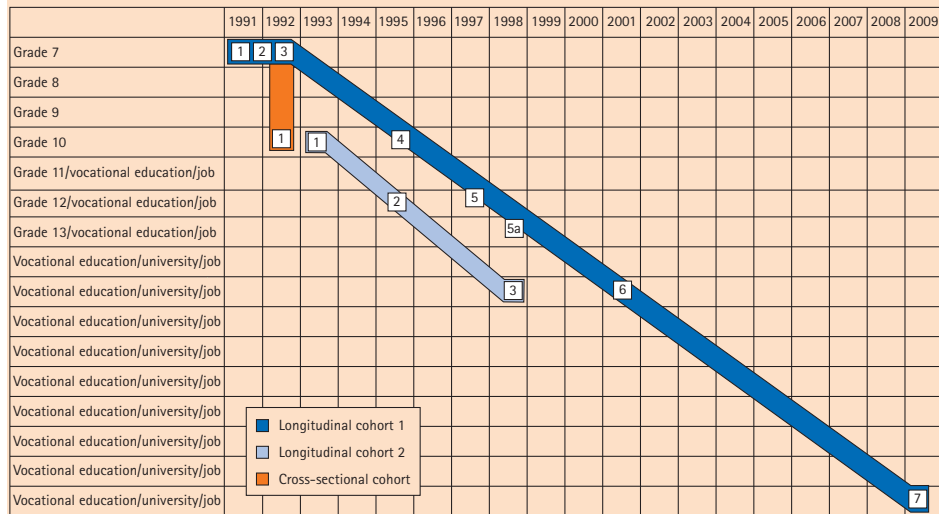
BIJU has four guiding components:

- (1) providing institutional and individual baseline data on the integration of the East and West German educational systems since 1991;
- (2) analyzing domain-specific learning as a function of personal resources and institutional opportunity structures;
- (3) analyzing long-term trajectories of psychosocial development in adolescence and young adulthood;
- (4) analyzing ways of coping with the transition from school to vocational training or university.

Data collection began with a survey of the main cohort (longitudinal cohort 1) in the 1991/92 school year (see Figure 1). Data was gathered from 7th graders at three measurement points. The first point of measurement coincided with the transformation of the unitary school system of the former East Germany to the tracked system adopted from West Germany. The fourth wave of data collection was conducted in spring 1995, when the main cohort students were in the final grade of lower secondary school. The fifth wave took place in spring 1997, when participants were either in vocational education or in the academic track of upper secondary level. The sixth wave of data collection, conducted in 2001, focused on how students had mastered the transition from school to university or from vocational education to the labor market. A seventh wave of data collection will take place in 2009/10. The sample of school classes comprises some 8,000 students from 212 secondary schools of all types in the states of Berlin, Mecklenburg-West Pomerania, North Rhine-Westphalia, and Saxony-Anhalt. A second longitudinal cohort and a cross-sectional add-on study complement the BIJU data set.

Figure 1. Study design of the BIJU project.

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of differential learning rates and a function of entrance selectivity to the three school types. The second approach focuses on the differential effects of school types and school systems relying on differing timetables, curricula, teacher training, and teaching cultures; these effects are "institutional" in nature (Baumert et al., 2006). The third explanation refers to composition effects arising from differences in the achievement, social and cultural background, and educational biographies of student populations. According to this approach, differences in learning trajectories are not, or are only partially, dependent on attending a certain school type. Rather, they are a consequence of the characteristics of the specific learning group. It is quite possible that all of these influences take effect at the same time.

How consistent are empirical findings on the differential effects of school types on student achievement gains? In his recently completed dissertation project, Michael Becker systematically analyzed the available studies of school type effects in Germany. His findings showed that the empirical evidence is not conclusive. Many studies, including investigations conducted in our Research Center (e.g., Becker, Lüdtke, Trautwein, & Baumert, 2006; Neumann et al., 2007), have found evidence for school type effects; others have not. For mathematics, the evidence seems to be in favor of school type effects; for reading comprehension, in contrast, trajectories seem to be more uniform across school types. Becker identified several methodological issues that make it generally more difficult to detect differential school type effects, even when they exist. Moreover, he examined the extent to which any differences in the learning gains of students in different school types are causally attributable to attending a certain school type. Becker used the potential outcome approach introduced by Donald Rubin to define causal effects. According to this approach, causal conclusions can be drawn only when it is possible to control the assignment mechanism to the different school types (ignorable treatment assignment). In his own study, Becker used propensity score matching, an approach in which the control of the assignment

mechanism is separated from the outcome analysis. His findings indicate substantial differences in student learning across school types, at least when students have been in that environment for some time. Future studies need to examine whether the findings from Germany, with its special form of ability grouping, generalize to other systems with different forms of student grouping (e.g., differentiation by curriculum).

Differential Learning Environments: Impacting Student Self-Concept

The effects of differential learning environments are not restricted to the domain of academic achievement but also apply to student motivation, emotion, and behavior. In a series of studies, we have continued our research program examining frame-of-reference effects on self-related cognitions. Herbert Marsh coined the term *Big-Fish-Little-Pond Effect* (BFLPE) to describe the finding that students in high-achieving groups develop lower self-concepts than equally proficient students in low-achieving environments. In recent years, we have documented frame-of-reference effects on the physical self-concept of elementary school students (Trautwein, Gerlach, & Lüdtke, 2008): When actual physical ability was controlled, students whose classmates showed high physical ability reported lower physical self-concepts. Moreover, low physical self-concept was associated with less leisure-time physical activity. An interesting additional finding was that the negative frame-of-reference effect on physical self-concept was still observable after the transition to secondary school, despite the change of reference group (Gerlach, Trautwein, & Lüdtke, 2007).

Evidently, the frame-of-reference effects predicted by the BFLPE are not restricted to academic self-concepts. But quite how broad is the scope of the BFLPE? Marsh, Trautwein, Lüdtke, and Köller (2008) used PISA data to address this question. Critical factors seem to be the nature of the social comparison process—comparison with generalized others (class- or school-average) or with individuals (target classmate)—and the nature of self-belief constructs that invoke normative (social

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Data Collection in TOSCA

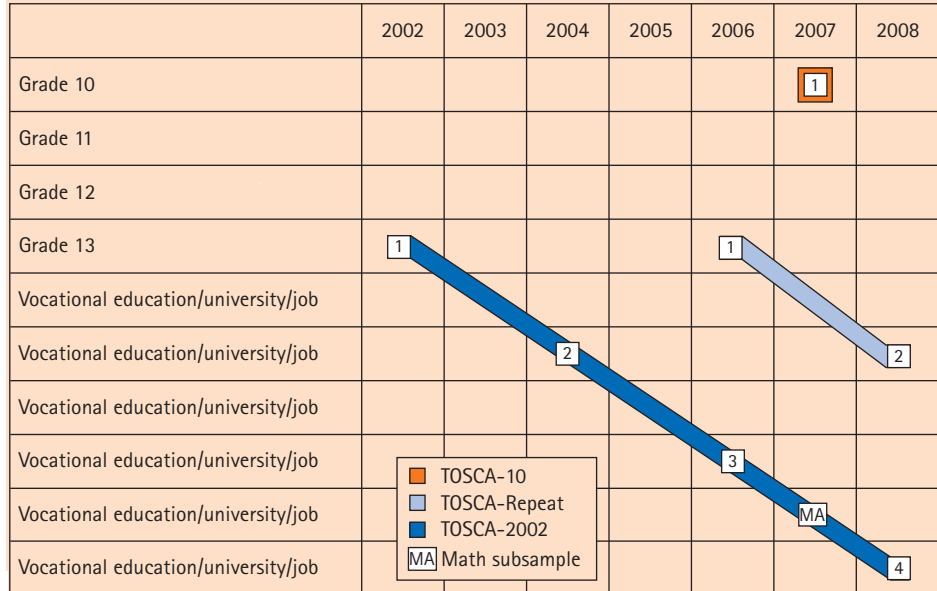
At Time 1 of the TOSCA 2002 cohort, a representative sample of 4,730 students in their last year of upper secondary education (aged about 17 to 19 years) was sampled between March and May 2002. All students were attending either traditional *Gymnasium* schools or one of the five (now six) forms of vocational *Gymnasium* schools that have been established in Baden-Wuerttemberg. More than 60% of these students consented to be recontacted for follow-up studies. The second wave of data collection took place from February to May 2004 with 2,315 students. The third wave took place from February to May 2006 with 1,912 students. In early 2007, a subsample of participants was administered a set of mathematics and cognitive ability tests. Finally, another wave of data collection took place in 2008, with more than 1,500 participants.

A second TOSCA cohort ("TOSCA-Repeat") was recruited in 2006, comprising almost 5,000 students in their last year of upper secondary education at more than 150 schools in Baden-Wuerttemberg. TOSCA-Repeat was designed to assess the effects of the structural reform of upper secondary education (the last 3 years of schooling before the *Abitur*). The school system in Baden-Wuerttemberg has experienced major changes since 2002. The most important change at upper secondary level has been the introduction of core competence subjects and the abolition of the traditional advanced courses (*Leistungskurse*). About 3,000 TOSCA-Repeat participants were recontacted and administered a questionnaire in 2008.

A third cohort ("TOSCA-10") comprises *Realschule* and *Gymnasium* students who were in grade 10—that is, approaching the end of lower secondary education—in 2007. Again, achievement tests and questionnaires were administered. One focus of our analyses is on which student characteristics are particularly powerful predictors of whether or not a student enters the preuniversity track (*gymnasiale Oberstufe*).

Figure 2. Study design of the TOSCA project.

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comparison) or absolute frames of reference. In a large cross-national study (26 countries; 3,851 schools; 103,558 students), school-average ability negatively affected academic self-concept, but had little effect on four other self-belief constructs that did not invoke social comparison processes (e. g., self-efficacy and effort persistence).

*Differential Learning Environments:
The Case of Homework Assignments*

We have also addressed differential learning opportunities within the Homework as Learning Opportunities (HALO) project. This project, which has strong links to Research Area IV, uses several data sets to explore the effects of teachers' homework assignments and students' homework completion. Building on our earlier work (Trautwein & Köller, 2003; Trautwein, Lüdtke, Schnyder, & Niggli, 2006), we have systematically expanded our research program in the past two years. For instance, one of our recent articles (Pieper, Trautwein, & Lüdtke, in press-b) challenged the widespread assumption that more time spent on homework is generally associated with higher achievement. This cross-cultural study analyzed the relationship between homework time and mathematics achievement, drawing on data from 231,759 students in 9,791 schools and 40 countries who participated in PISA 2003. Multilevel analyses found a positive association between school-average homework time and mathematics achievement in almost all countries, but the size of the association decreased considerably when socioeconomic background and school track were controlled. At the student level, no clear-cut relationship was established between homework time and achievement across the 40 countries. The results highlight the need to use multilevel analyses and to control for confounding variables in homework research. Although homework per se does not lead to better learning outcomes, it seems likely that the quality of homework assignments plays a significant role. Indeed, several of our studies have shown that homework quality as rated by students or external observers is related to important outcomes, such as homework

effort and school grades (Schnyder, Niggli, & Trautwein, 2008; Trautwein & Lüdtke, in press; Trautwein, Schnyder, Niggli, Neumann, & Lüdtke, 2009). Further studies are currently in the data analysis stage.

Differential Learning Environments and Students' Social Dominance Hierarchy

Another area of research that we have expanded over the past two years is work on how the classroom structures students' social hierarchies, status, and friendships. Adolescents spend about half of their waking hours with peers, primarily at school. The peer group of the classroom, like any other group, involves different roles and norms. In one of the studies conducted for her dissertation project, Kathrin Jonkmann focused on students who are actively involved in establishing peer norms, whose opinions matter to classmates, who hold high prestige and authority, and who are highly visible and often the center of attention—in short, social dominants. These are the students that teachers have in mind when they think about the few who shape the classroom climate; they may well be the classmates that other children tell their parents about over dinner. Whether the influence of these socially dominant students is beneficial or harmful might depend on their personal characteristics and attributes. Who are these socially dominant teenagers? Is their status in the classroom solely attributable to positive qualities—or do problem behaviors, such as disruptive and deviant behaviors, also play a role? Furthermore, how does the classroom influence who becomes socially dominant? Drawing on data from 5,468 participants of the BIJU study, Jonkmann, Trautwein and Lüdtke (2009) identified four types of highly influential grade 7 teenagers who differ tremendously in the means they use to gain social influence, and showed that classrooms can differ widely with respect to the rules determining who becomes dominant. Jonkmann and colleagues asked each student to name up to four classmates who were influential and therefore often the center of attention. Overall, we found that social dominance related to a number of positive

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The TRAIN Study—Aims and Data Collection

The TRAIN (Tradition and Innovation) Study investigates students' developmental trajectories and learning gains in the differently structured educational systems of two German states, Baden-Wuerttemberg and Saxony. The focus of our analyses is on the lower and intermediate tracks (*Hauptschule* and *Realschule*), which are separate in Baden-Wuerttemberg, but implemented in a combined *Mittelschule* in Saxony.

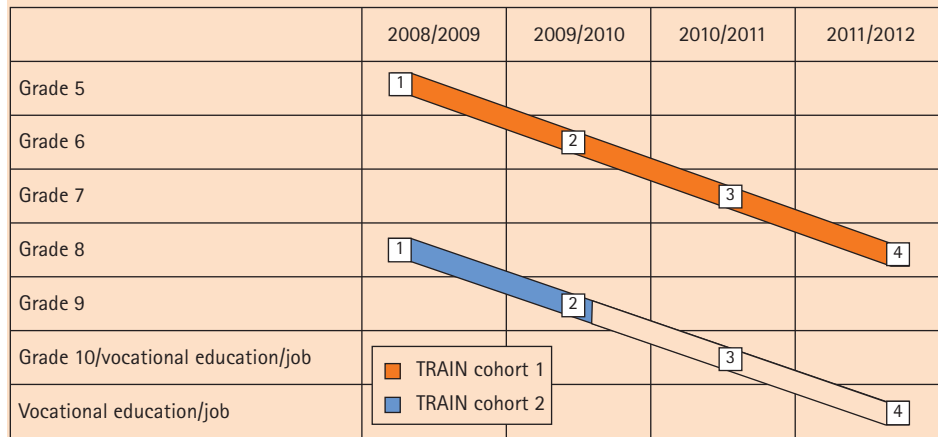
TRAIN addresses important research questions that prior studies were not able to examine in sufficient detail. Most important, TRAIN will investigate the consequences of different forms of ability grouping and the impact of class composition. Moreover, intervention modules (e.g., remedial reading support) will be implemented with the aim of identifying effective means of improving the motivation and achievement of at-risk students. In addition, we will analyze the educational careers of students with specific learning difficulties or behavioral or psychological problems and their influence on the learning and development of their classmates.

Data collection began in November of the 2008/09 school year. Participants were some 6,000 grade 5 and grade 8 students in 60 *Hauptschulen* and 24 *Realschulen* in Baden-Wuerttemberg and 22 *Mittelschulen* in Saxony (see Figure 3). Data were also obtained from the students' teachers and parents. The students were administered a comprehensive battery of tests and questionnaires over a 2-day period. The achievement tests covered the domains of mathematics, English as a foreign language, and German. Basic cognitive ability, concentration, and career knowledge were also assessed. The questionnaires focused on student motivation, interests, family background, self-concept, psychological problems, learning difficulties, uptake of additional and remedial instruction, and covered various aspects of the form tutor's work. In Saxony, social network data were additionally obtained. Teacher ratings of each student's behavioral problems, participation, and motivation were also obtained in both states.

Data are to be collected annually over a 4-year period (for the grade 5 cohort). We intend to continue monitoring the students of the grade 8 cohort after they have left school.

Figure 3. Study design of the TRAIN project.

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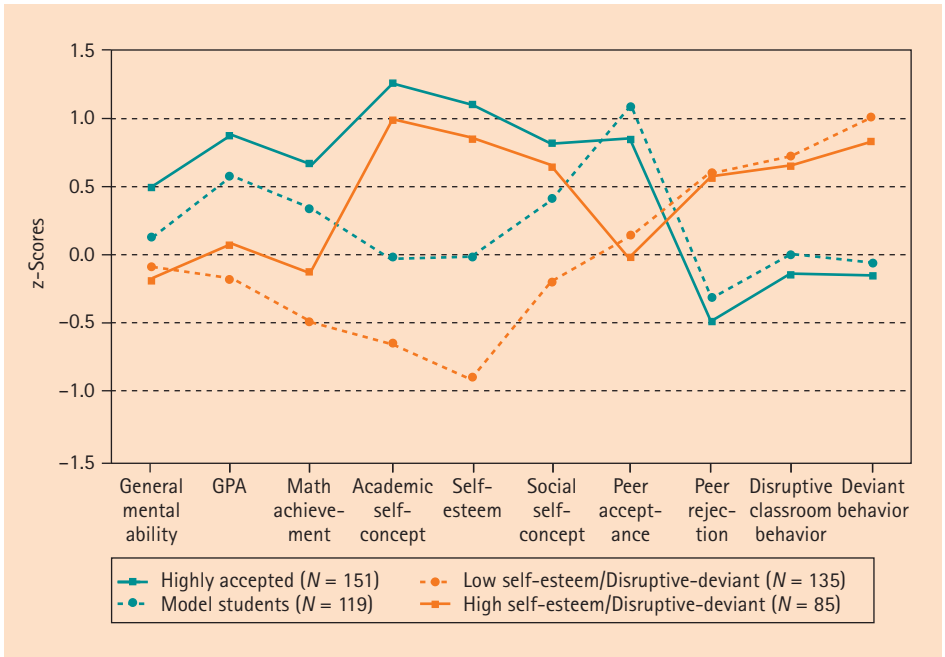


Figure 4. Latent profiles of socially dominant students.

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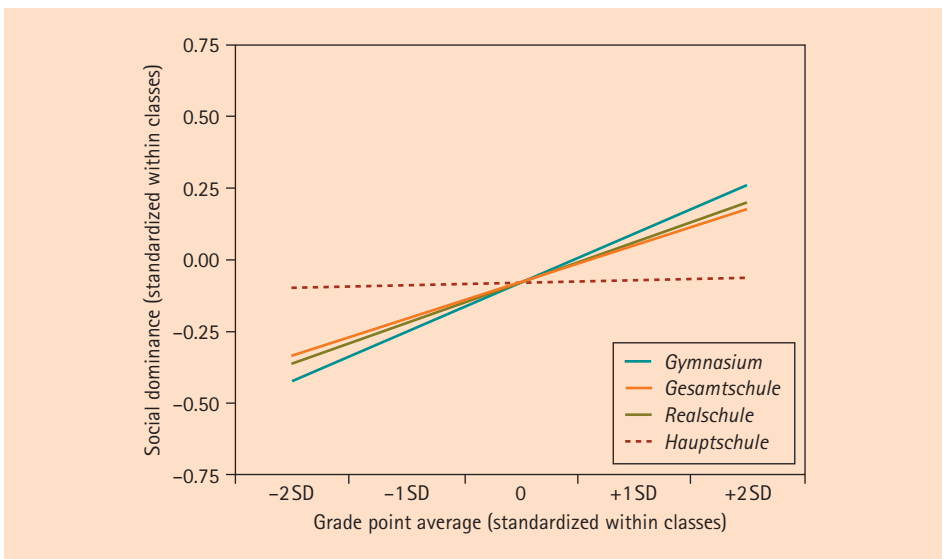


Figure 5. Association between GPA and social dominance in different classroom contexts.

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characteristics, such as being liked by many classmates, better grades, higher cognitive abilities, and higher academic self-esteem, as well as to more negative characteristics, such as being disliked by peers and disruptive or deviant behaviors. We successfully disentangled these seemingly contradictory findings by using latent profile analysis to look more closely at the two most dominant students in each classroom (Figure 4). Four ways of

gaining peers' attention were discernable: The model students in the first group were very good academic achievers with a very positive self-image. The students in the second group were exceedingly popular among their peers. The third and fourth groups were both characterized by very high levels of disruptive and deviant behaviors. Interestingly, one of these groups showed high self-esteem, whereas the other showed low self-esteem and academic

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engagement. This latter group may be at particular risk for a career of delinquency and further maladjustment.

Jonkmann and colleagues also found that the social context is important in determining who is dominant: Multilevel analyses revealed that, in classrooms with low average achievement (*Hauptschule*), a student's grade point average (GPA) was inconsequential for his or her social status. In more achievement-oriented environments, especially the *Gymnasium*, however, higher GPA was associated with greater influence (Figure 5). Hence, similarly to programs addressing aggressive behavior, interventions for teenagers who seriously neglect their school work may be doomed to failure if they do not include the peers who reward academic disengagement and disruptive and deviant behaviors with social prestige.

Differential Learning Environments: Methodological Aspects of Assessing Contextual Effects

A key assumption of most educational research is that cognitive, motivational, emotional, and behavioral student outcomes are substantially shaped by features of the social context, such as learning climate, instructional quality, and the social composition of the class or school. In the last two decades, multilevel modeling has become the standard approach for assessing contextual effects in the social sciences. A major strength of multilevel modeling (MLM) lies in the possibility of simultaneously exploring relationships among variables located at different levels. In the typical application of MLM in educational research, outcome variables are related to several predictor variables at the individual level (e.g., students) and the group level (e.g., schools, classes). Despite the progress that has been made in the estimation of multilevel models in recent decades, there are still a number of open questions regarding the assessment of contextual effects in educational research. Our Research Center's work in this area has focused on two issues. First, group characteristics are frequently assessed by aggregating individual student data across groups. We have evaluated different

approaches to assessing the psychometric properties of such aggregated data. Second, we have developed statistical methods that can correct for unreliability when multilevel models are used to estimate contextual effects.

Psychometric Properties of Group Characteristics

One simple and efficient research strategy for assessing contextual characteristics that is often used in educational research is to ask students to rate several specific aspects of their learning environment. At the *individual level* these student ratings represent the individual student's perception of the learning environment. Scores aggregated to the *classroom or school level* reflect perceptions of the shared learning environment, corrected for individual idiosyncrasies.

Once researchers have identified the classroom or school level as the theoretically appropriate level of their analysis, they need to investigate the psychometric properties of the aggregated student ratings. In other words, they need to show that the student responses can be used to adequately measure the respective construct at the class or school level. There are two complementary approaches to assessing the psychometric properties of aggregated student ratings of the learning environment (Lüdtke, Trautwein, Kunter, & Baumert, 2006): the reliability of the aggregated student ratings and the within-group agreement of the students in a group (e.g., class).

In the multilevel literature, the intraclass correlations ICC(1) and ICC(2) are used to determine whether aggregated individual-level ratings are reliable indicators of group-level constructs. These indexes are based on a one-way analysis of variance with random effects, where the individual-level rating at level 1 is the dependent variable and the grouping variable (e.g., class, school) is the independent variable. Whereas the ICC(1) indicates the reliability of an individual student's rating, the ICC(2) provides an estimate of the reliability of the group-mean rating. When aggregating data from the individual to the group level, it is only possible to distinguish relationships

on the group level if the aggregated data are sufficiently reliable.

In contrast to the reliability of student ratings, there has as yet been very little research on the *agreement* of student ratings of group-level constructs in educational research. James, Demaree, and Wolf proposed a method for assessing agreement among a group of raters who have all rated the same stimulus (e. g., students rating their teacher's behavior). The basic idea is that, when there is strong agreement between the students in a class, the variance between the students' ratings should be as small as possible—in the case of perfect agreement, it should be zero. The crucial question is when the variance between the raters in a group can be considered "small." Lüdtke and Robitzsch (in press-a) critically evaluated a data-driven approach that utilizes random-group resampling (RGR) procedures to determine the variance that would be expected to follow from raters making their ratings at random. They showed mathematically and by means of simulation studies that the probability of obtaining statistically significant within-group agreement when applying the RGR procedure strongly depends on characteristics of the total sample of groups, such as the ICC(1) and the group sizes. Consequently, they strongly recommend that the RGR procedure not be

used to determine the level of within-group agreement.

A Multilevel Latent Covariate Model

One problematic aspect of assessing contextual effects using multilevel modeling is that the observed group average obtained by aggregating individual observations may not be a very reliable measure of the unobserved group average if the number of individuals sampled from each group is small. For example, if only 10 students are sampled from each school to obtain an estimate of school climate, the school-average student ratings from each school will not be a very reliable measure of the true school climate. The relationship between the expected bias and the ICC(1) as well as the group size is depicted in Figure 6 for different values (.5 and .8) of the contextual effect. In both panels, the bias becomes smaller with larger group sizes n . In other words, when the group mean is more reliable due to a higher n , the contextual effect can be more precisely approximated by the manifest group-mean predictor. The bias also decreases as the ICC(1)—the reliability of an individual student rating—increases. Together with Herbert Marsh (University of Oxford), Tihomir Asparouhov, and Bengt Muthén, we have developed a latent variable approach that takes the unreliability of the

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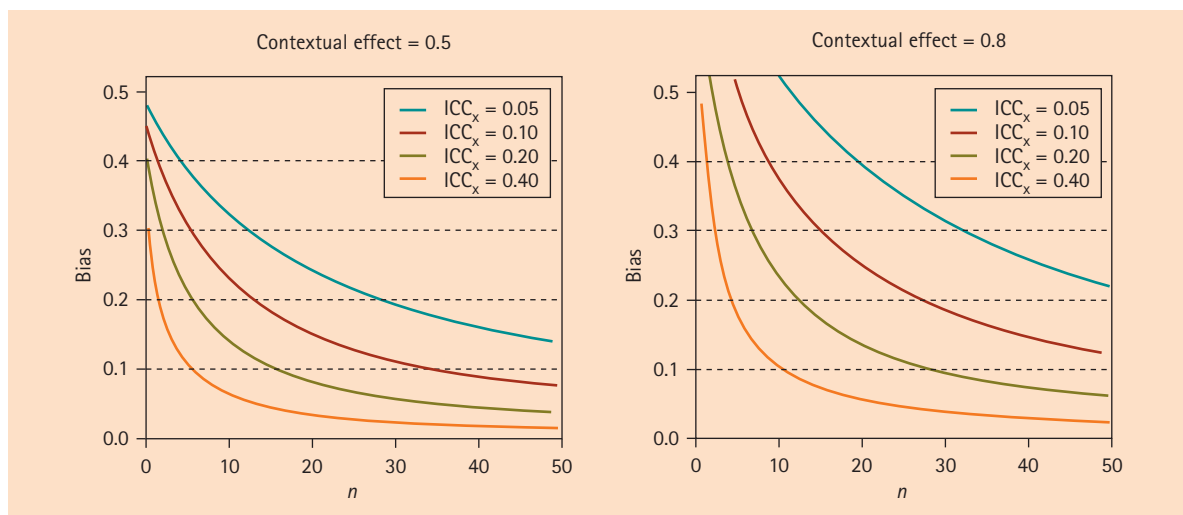


Figure 6. Relationship between bias, group size (n), and intraclass correlation (ICC) for different contextual effects.

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The IPEA Project

Standardized achievement testing has been a key component of educational monitoring systems in the United States and Great Britain for decades; similar developments are now observable in many other countries. Yet studies show that systems of governance based exclusively on performance-oriented measures can have serious adverse effects, ranging from teachers intervening in the selection of the students who participate in evaluations to teaching to the test.

The negative effects of performance-based monitoring in English-speaking countries are well documented. However, the empirical findings available to date are not able to inform the development of more effective systems. The International Project for the Study of Educational Accountability Systems (IPEA) has been set up to analyze the consequences of standardized achievement testing in more depth. The project's primary concern is to examine the effects of monitoring systems in schools. To this end, it aims to examine the effects of administering certain tests on instructional practice, to track changes in test scores over successive years, to identify the factors underlying these processes, to promote the enhancement of test designs, and to investigate the relationship between school evaluation and standardized achievement testing.

An international research group was initiated by Daniel Koretz at Harvard Graduate School of Education, Cambridge; the IPEA network now spans several countries. The partner organizations include several German research institutes (Institute for Educational Progress, Berlin; Institute for School Quality, Berlin; Leibniz Institute for Science Education, Kiel; German Institute for International Educational Research, Frankfurt a. M.)—that is, the institutions involved in conducting national tests, monitoring educational standards, and running large-scale international studies. The international partners come from the Netherlands (CITO, Arnhem), Israel (National Authority for Educational Measurement and Evaluation, Tel Aviv), Hungary (University of Szeged), and the US (Harvard University; RAND Corporation).

In order to track the effects of implementing and extending system and school monitoring, the IPEA project partners will examine—in national and international comparison—how systems change when specific factors (e. g., high- vs. low-stakes testing, methods of test administration, availability of past papers) vary or are changed. This may involve comparisons of trends between state-specific and supraregional or international tests, as in U.S. research. In the German context, we can draw on data from state-specific, nationwide, and international tests (e. g., TIMSS, PISA, PIRLS). In addition, we are currently developing test instruments to gauge change in the handling of standardized testing. To this end, student and teacher questionnaires aligned with U.S. and OECD research are currently being constructed.

The new international IPEA project has a number of precursors in the Center. We have, for example, previously investigated the extent to which literacy tests, such as those implemented in PISA, are sensitive to targeted training measures. In an experimental study, Brunner, Artelt, Krauss, and Baumert (2007) found that student performance on the PISA tests could, in principle, be enhanced by a comprehensive and multifaceted coaching program, but that such extensive programs are scarce in practice—of course, this may change in the future. Moreover, the findings of an experimental study by Baumert and Demmrich (2001) suggest that the PISA 2000 results in Germany were not significantly affected by lack of student motivation. Again, however, there is no guarantee that future data will point in the same direction.

group mean into account when estimating the contextual effect (Lüdtke, Marsh, Robitzsch, Trautwein, Asparouhov, & Muthén, 2008). Because the group average is treated as a latent variable, we call this approach the *multilevel latent covariate model*. The "traditional" multilevel modeling approach, in contrast, treats the observed group means as manifest and does not infer from them to an unobserved latent construct that controls for unreliability. Our simulation studies have shown that the traditional approach indeed tends to yield a more biased estimate of the group effect than the latent approach. In certain data constellations (low ICC [1] and low number of level-2 units), however, the estimate yielded by the latent approach exhibits greater variability than that yielded by the traditional approach. This is a critical point, as it means that the estimate obtained by the

latent approach in specific applications may—given its greater variability—be further from the true value than the estimate obtained by the traditional approach. Further, Lüdtke et al. (2008) argue that it is important to consider the extent to which the assumptions of the latent approach (e.g., unobserved group average) are consistent with the nature of the group construct investigated. Despite these issues, the latent approach implemented in Mplus offers a promising tool for dealing with the problem of unreliable group means in multilevel models, and is thus of great relevance for investigating school context effects in empirical educational research. Currently, we are working on an extension of the multilevel latent covariate model to cases in which group constructs are assessed by multiple indicators (e.g., students rate their teacher's instruction on several items).

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**Research Area II
 Transitions in the Educational System**

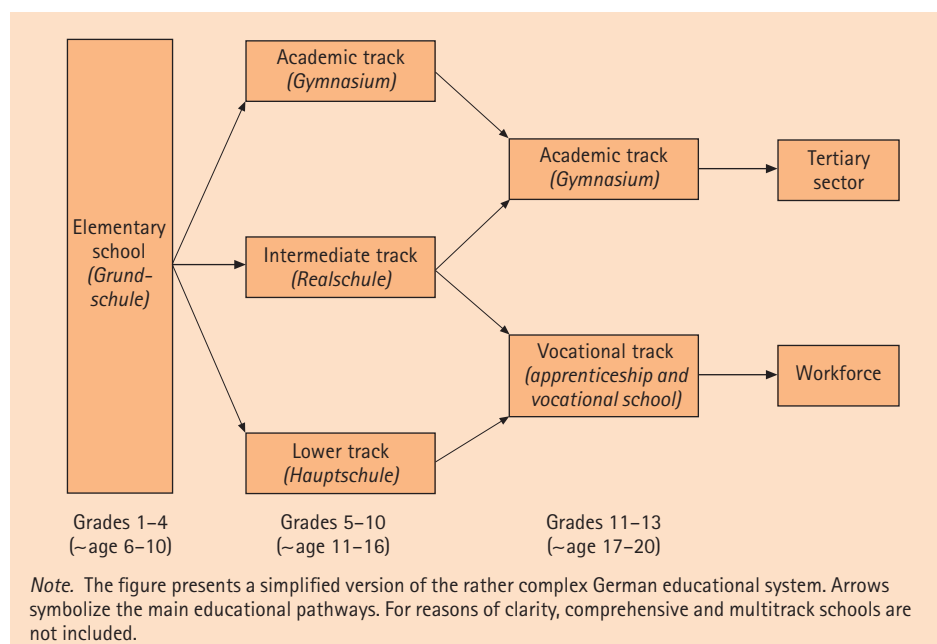
The biographies of young people are characterized by a host of transitions. Beyond the biological changes and psychological transitions from childhood to adolescence and adulthood that each individual needs to negotiate, young people have to make several transitions within the educational system, each governed by specific institutional, legal, and societal regulations. These transitions require complex decisions that, particularly in tracked systems, have far-reaching effects on students' educational and vocational biographies. The analysis of transitions has a long tradition within the Center for Educational Research. Research Area II integrates all of the Center's projects and subprojects that deal explicitly with the analysis of transitions at various stages of educational careers, placing a particular focus on family background.

The specific importance of educational transitions in the German school system results from the structure of the educational system. Students in Germany are selected to different secondary tracks at the end of grade 4 or 6, when they are about 10 or 12 years of age (Figure 7). There is considerable variation across the German states in terms of the number and quality of these tracks. Although between-school tracking is the major form of achievement differentiation, within- and between-school differentiation are used concurrently in some states. In addition, some major reforms have been implemented in many German states in the last few years,

with a clear shift toward a two-track system. Nevertheless, the "tripartite" system of *Hauptschule*, *Realschule*, and *Gymnasium* remains the best known in Germany, and most of our data sets were collected when there were still three or more secondary tracks in most German states.

Figure 7 shows a simplified version of the German school system. *Hauptschule* is the academically least demanding track; *Realschule*, the intermediate track; and *Gymnasium*, the college-bound track. *Hauptschule* students, who graduate after grade 9 or 10, typically enter the dual system, which combines part-time education at vocational school with an

Figure 7. The German educational system.
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apprenticeship. *Realschule* students graduate after grade 10; most of them also enter the dual system, usually aspiring to more skilled occupations. *Gymnasium* students graduate after grade 12 or 13; the final *Gymnasium* examination (*Abitur*) is a requirement for university entrance (Maaz, Neumann, & Trautwein, 2009; Maaz, Trautwein, Lüdtke, & Baumert, 2008). Although the educational pathways illustrated are the most common, it is also possible for students to transfer to a higher or lower track at various points in their school careers.

The philosophy guiding the tracked secondary system is to provide all students with an education commensurate with their aptitudes and needs that allows them to reach their fullest potential. To what extent this strategy succeeds has been examined widely, for example, in Research Area I. The findings of this research indicate that the school types of the tracked secondary system represent differential learning and developmental environments and that students in the different school types learn different amounts. The secondary school type attended can thus critically influence the learning trajectories observed in the following years. Moreover, Maaz, Trautwein et al. (2008) have shown that student achievement and transition decisions covary with social disparities in the tracked secondary system, which can result in social disparities increasing over the secondary school years. Although various opportunities have been put in place to correct previous decisions in the educational biography, there has been little research into student uptake of these opportunities. There is, however, much evidence to show that the qualifications obtained at school are related to later occupational success. Relative to other countries, the association between the educational and the occupational systems is particularly strong in Germany across the entire occupational spectrum. Indeed, the prestige of the first job and the financial return on educational investment is very strongly dependent on the educational qualifications acquired.

In all German states, academic achievement is the main determinant of the secondary

school type attended. Parents can also influence the transition decision, however, and various systematic (e.g., regional structures) and unsystematic factors (e.g., "measurement errors") may play a role. Whether and how students are able to transfer from one track to another during lower secondary education also depends on various factors.

In view of the significance of the transition to the tracked secondary system, Research Area II addresses theoretical and practical questions, such as the following:

- How close is the association between family background and the transition decision? What are the mechanisms underlying this association?
- How permeable is the school system? Which students take advantage of this permeability?
- What role do teachers play at decisive points of transition? How do they approach the difficult diagnostic task of recommending a secondary track?
- Are there undesired reference group effects at points of transition, similar to those known to exist for grading, for example?
- Do students from immigrant families face specific challenges at the transition to secondary education?

Systematic Disparities at Transition Points

In recent years, work in Research Area II has focused on investigating two systematic disparities at points of educational transition: social disparities and reference group effects.

Social Disparities at Transition Points

The PISA data have allowed in-depth investigations of social disparities in the educational participation of 15-year-olds. Evidence has been found for serious social inequalities, particularly in *Gymnasium* attendance. Students from professional families are around three times as likely as students from working class families to attend a *Gymnasium* rather than a *Realschule*, even given comparable aptitude and achievement. These findings have reignited the scientific and public discussion on social disparities in the educational system and have informed our analyses of social inequalities.

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In collaboration with: Franz Baeriswyl, University of Fribourg, Switzerland

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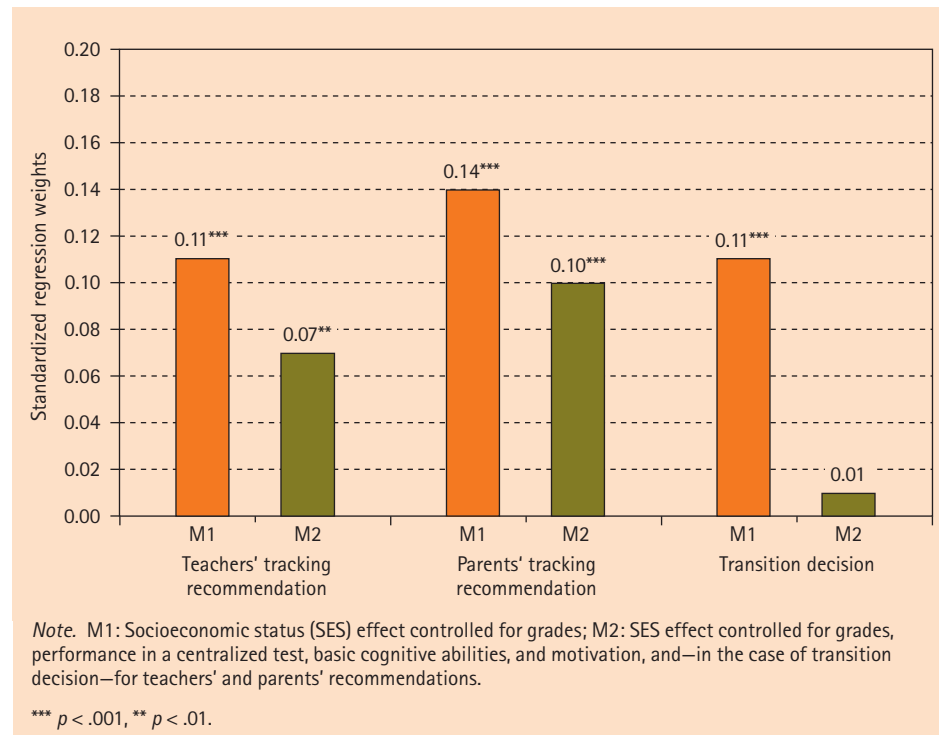
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In an international cooperation project with the University of Fribourg (Switzerland), Baeriswyl, Wandeler, Trautwein, and Oswald (2006) investigated transition behavior from elementary to lower secondary education in German-speaking schools in the canton of Fribourg. In the Fribourg model, assessment of student aptitude and achievement is standardized through centralized achievement tests, teachers take students' motivation and learning behavior into account in their tracking recommendation, parents are closely involved in the transition decision, and pathways to upper secondary education are open to all students. We investigated the effects of this model on the transition to secondary education, drawing on data from a complete population of grade 7 students. We were particularly interested in whether the model succeeded in reducing or eliminating undesired family background effects. In addition, we examined the degree of agreement between teachers' recommendations, parents' preferences, and students' test scores. Results show that the Fribourg model succeeds in suppressing the effects of family background

at the transition from primary to secondary education. Socioeconomic background did impact the transition decision via teachers' and parents' tracking recommendations, but its absolute effects—when grades were controlled—were relatively weak (Figure 8). The evaluation sheet that teachers and parents use, in addition to grades, as a basis for their tracking recommendation seems resistant to effects of family background. How can the effects observed be systematized in theoretical models? To some extent, the allocation of students to different secondary school types reflects differences in achievement that are already present at school entry or that emerge over the elementary school years. These differences in achievement are not independent of the students' social, ethnic, and cultural background, however. In fact, the assignment of students to different secondary tracks on the basis of their achievement is always associated with social, ethnic, and cultural disparities. Based on the work of R. Boudon, sociocultural differences in educational participation that are attributable to differences in student ability and per-

Figure 8. Impact of social background (ISEI) on teachers' and parents' tracking recommendations and on the transition decision (standardized regression weights).

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formance are called *primary* disparities. These disparities are consistent with the principles of meritocracy—although, from a normative perspective, they may well be criticized as too large. Additionally, however, parents from different social and ethnic backgrounds may differ systematically in the secondary track they choose for their children. These differential choices produce new disparities in educational participation at the transition to secondary schooling. These *secondary* disparities violate the principles of meritocracy, in that they are independent of ability and attainment. In taking into account the primary and secondary effects of social background, we follow Boudon's microsociological approach, according to which educational decisions result from the interplay of students' academic performance, the selection mechanisms of the educational system, and decision-making processes within the family. Social disparities in educational decisions result primarily from differences in educational aspirations and in students' academic achievement; these disparities lead to educational inequalities. Track choice can be seen as the result of a combination of primary and secondary effects of social background. Primary effects in terms of student achievement levels determine the probable success of an educational investment; secondary effects lead to additional background-related differences in cost-benefit calculations. As a theoretical framework for our research, we therefore take an extended value-expectancy approach that allows sociological rational choice theories to be tested against more psychological value-expectancy models.

Primary and Secondary Effects From a Comparative International Perspective

In view of the well-documented social disparities in educational participation that result from the interaction of primary and secondary background effects at points of transition, Maaz, Watermann, and Baumert (2007) investigated the social selectivity of access to college-bound schools from a comparative international perspective. Secondary disparities were analyzed in four tracked secondary systems—in Austria, Germany, Switzerland,

and the Flemish part of Belgium. Analyses revealed differences in the proportion of students attending college-bound schools, with the highest proportions in the Flemish part of Belgium and in Austria. In both of these systems, it is possible to correct transition decisions made at the end of primary education by transferring to a college-bound school later in the educational career. The data showed that, in Austria, where the first transition—like in Germany—is made after grade 4, selection to *Gymnasium* is less closely associated with achievement than in Germany or Switzerland. When the second point of transition was taken into account, however, the effect of reading achievement was more pronounced, and findings were comparable with those obtained for Germany. Primary and secondary social disparities were evident in all four systems. Whereas findings on the effects of social background variables were comparable across the systems, findings on the effects of family structure and process characteristics differed. These results indicate that analyses of social disparities relying exclusively on family structure variables paint an incomplete picture of the effects of family background variables. Although family structure characteristics are, in large part, mediated by family process characteristics, the latter also have effects on educational participation in secondary education that are independent of social background.

Reference Group Effects at Educational Transitions

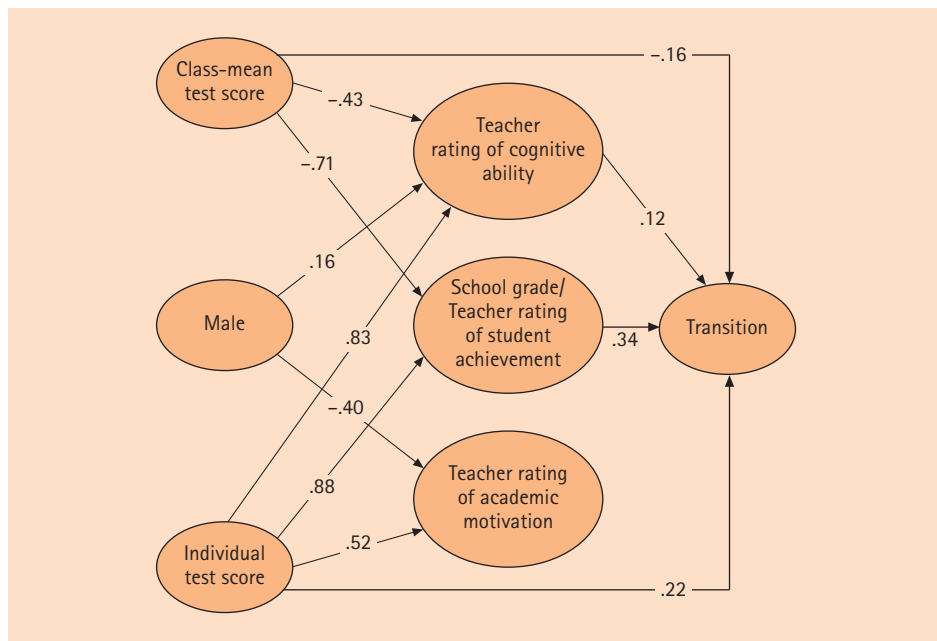
The second focus of our research on disparities at points of educational transition in recent years has been on reference group effects. Reference group effects are a well-known phenomenon in psychology. Studies conducted in Research Area I have found reference group effects on academic self-concept. In particular, much evidence has been found for the big-fish-little-pond effect, which hypothesizes that the self-concept of students is negatively correlated with class-mean achievement. Can similar reference group effects be observed in teachers' assessments of student aptitude and achievement, and consequently in transition decisions? To date, there has

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Figure 9. Model predicting the transition decision: Key findings from multilevel analyses.

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been little empirical research on the potential impact of reference group effects on the transition process. Trautwein and Baeriswyl (2007) therefore investigated whether teachers' tracking recommendations and students' transition decisions are systematically related to class-mean achievement. We expected that—when individual achievement was controlled—teachers' recommendations and students' decisions would be lower in higher achieving classes than in lower achieving classes. This hypothesis was tested in a study with 741 students from practically all German-speaking classes in the Swiss canton of Freiburg. The students were administered a standardized achievement test at the end of elementary schooling. In addition, teacher ratings of student achievement, academic motivation, and cognitive ability were obtained. As expected, multilevel analyses controlling for individual achievement level showed a negative regression coefficient of class-mean achievement on teacher ratings of student achievement and cognitive ability as well as on teacher recommendations and the actual transition decision (Figure 9).

Another study examined the tracking recommendations made by elementary teachers

in Berlin (Maaz, Neumann et al., 2008). In Berlin, teachers' ratings of students' general academic ability take on particular significance when a student's grade point average does not clearly indicate a specific tracking recommendation. Findings showed that the legal regulations governing student allocation to the tracks of the secondary system were observed in almost all cases in which students' grades fell within the specified ranges. However, in approximately 37% of cases in which their grades fell between these ranges, and the recommendation given was at the teacher's discretion, it could not be inferred directly from the student's grade point average. In most of these cases, teachers recommended the less demanding track. In further analyses of elementary teachers' ratings of students' general academic ability, we investigated whether—beyond the predictive effect of individual achievement variables and social background indicators—teacher ratings were systematically related to class-mean achievement. The empirical analyses drew on data from a sample of 976 students approaching the end of elementary schooling in Berlin. Multilevel analyses showed that, as expected, achievement indicators and socioeconomic status were positively associ-

ated with ratings of general academic ability. When individual achievement was controlled, moreover, there was a negative regression coefficient of class-mean achievement level on the teacher rating of general academic ability. This key finding of the study can be interpreted as a reference group effect. Although teacher ratings of students' general academic ability may have predictive validity for secondary school achievement over and above grades, their power to neutralize reference group effects at the transition to secondary education therefore seems limited.

Opening of Educational Pathways and Permeability of the Secondary System

Given the long-reaching effects of entering a specific educational channel and the systematic disparities observed at points of transition, it is crucial that educational pathways in tracked school systems be flexible and permeable. The opening of educational pathways and provision of alternative routes to qualifications are thus seen as key steps in the modernization of the tracked secondary system; corresponding reforms have been implemented, at least formally, in all German states. As yet, however, there has been no systematic investigation of the extent to which students take advantage of the permeability of the system, what characterizes these students, or the barriers to permeability. One of our recent projects aims to close this research gap.

Opening of Educational Pathways Against the Background of Institutional Regulations

As part of the cooperative project with the University of Fribourg, outlined above, Trautwein, Baeriswyl, Lüdtke, and Wandeler (2008) used data from the Swiss canton of Freiburg to examine the opening of new routes to educational qualifications. To this end, 525 students from German-speaking schools were tracked from the end of elementary schooling to the transition to upper secondary education at *Gymnasium* or its alternatives. Almost half the students who attended *Gymnasium* at upper secondary level came from a general secondary school (and not a *Progymnasium*), indicating a considerable level of permeabil-

ity in the system. Moreover, results showed that even students whose performance at the end of elementary schooling was relatively weak can succeed in making the jump to *Gymnasium* at upper secondary level. However, findings also showed that attending a *Progymnasium* has a channeling effect on the educational biography. *Progymnasium* graduates were about twice as likely as otherwise comparable students to attend *Gymnasium* at upper secondary level. Likewise, students from more advantaged social backgrounds were more likely to enter upper secondary education. The two lines in Figure 10 symbolize the probability, predicted by logistic regression, of attending *Gymnasium* at upper secondary level depending on the type of lower secondary school attended and social background (ISEI score), controlling for mathematics and German achievement at the end of elementary schooling. As is shown, the probability of attending *Gymnasium* at upper secondary level increased as a function of both attending a *Progymnasium* and social status.

Measures have also been undertaken to increase the permeability of the German school system, ensuring that lower secondary level qualifications can be acquired indepen-

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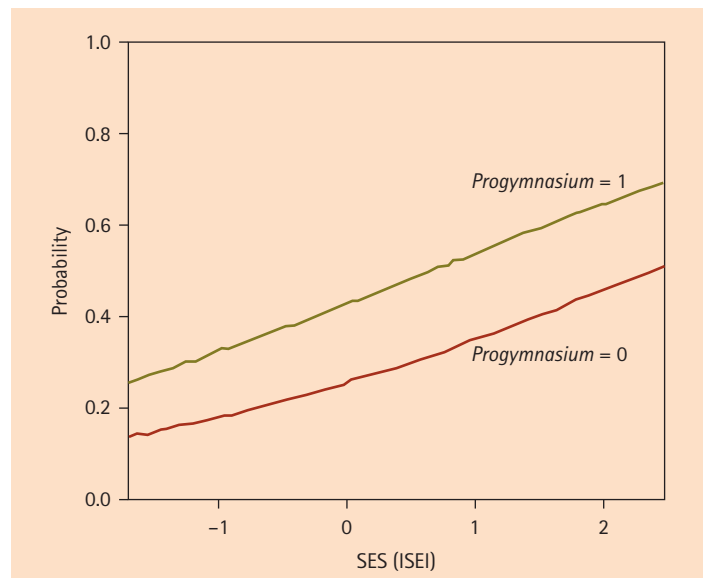


Figure 10. Probability of attending *Gymnasium* at upper secondary level: Predictions from logistic regression models.

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dently of the school type attended. To date, there has been little scientific study of the effects of this process. Given that students are much more likely to take advantage of the option to obtain an alternative leaving qualification than to switch to another school type, however, it may well have a more important role to play in the correction of previous educational decisions. However, the institutional conditions (in terms of entrance and exit criteria) regulating the qualifications obtained by *Hauptschule* students, in particular, differ markedly from one federal state to the next. Based on the theory of rational action, Schuchart and Maaz (2007) used PISA 2000 data to analyze the influence of social background characteristics, gender, and immigration status on parental aspirations for *Hauptschule* students given the state-specific "opportunity structures." Their findings show that parents' educational aspirations vary significantly as a function of social and ethnic background, whereby the social background effects, in particular, were subject to institutional influence. In states with more flexible entry and exit criteria, parents from lower social strata were much more interested in their children attaining a higher level of qualification than in states with more restrictive criteria.

In another study on the opening of educational pathways, Maaz, Gresch, Köller, and Trautwein (2007) focused on forms of access to upper secondary education. The opening of alternative routes to higher education has had important consequences for educational careers. Given good achievement levels at the end of grade 10, comprehensive school students have the option of transferring to the academic track and obtaining the *Abitur* qualification. But new institutional regulations in many federal states now also allow high-achieving students who have completed their lower secondary education elsewhere to graduate to the academic track. Against the background of this modernization process, the study focuses on two states (Baden-Wuerttemberg and Hamburg) whose educational systems differ markedly in some respects. In Hamburg, 15% of students who qualify for higher educa-

tion attended comprehensive schools. The *Abitur* qualification can also be acquired at *Aufbaugymnasium* schools catering specifically for *Hauptschule* and *Realschule* graduates (6%) or at *Gymnasium* schools specializing in economics (10%) or technology (2%). Students in Baden-Wuerttemberg can now qualify for higher education at a traditional *Gymnasium* or at one of six types of vocational *Gymnasium* schools. This opening of the educational system is intended to offer capable students from diverse family backgrounds the opportunity to qualify for higher education, even if they did not attend a *Gymnasium* at lower secondary level. Overall, our findings revealed considerable variability in educational careers in Hamburg and Baden-Wuerttemberg. Moreover, a substantial proportion of *Abitur* holders did not take the traditional *Gymnasium*-based route. In Baden-Wuerttemberg, 70% of all students attending a vocational *Gymnasium* had not attended *Gymnasium* at lower secondary level (Hamburg: 55%). Our analyses of educational trajectories show that the opening of routes to higher education in both Hamburg and Baden-Wuerttemberg is manifest primarily in the establishment of alternative college-bound paths at upper secondary level. Most students in these school types did not attend a *Gymnasium* at lower secondary level.

Comparison of *Abitur* students in Hamburg and Baden-Wuerttemberg revealed that the similarities in family background and cognitive ability outweighed the differences. The mean cognitive ability scores of students from Hamburg and Baden-Wuerttemberg were similar; their mean socioeconomic status was practically identical. Slight differences were found in certain aspects, especially immigration status. The percentage of students from immigrant families among the *Abitur* holders was higher in Hamburg than in Baden-Wuerttemberg; in fact, students from immigrant families were only slightly underrepresented among *Abitur* holders in Hamburg.

Larger differences emerged within states than between states. Findings confirmed that comprehensive schools, *Aufbaugymnasium* schools (Hamburg), and vocational *Gymna-*

sium schools (Hamburg and Baden-Wuerttemberg) indeed provide students who would previously probably have been excluded from this kind of educational career with access to higher education.

Education Across the Lifespan

The qualifications gained at school are crucial determinants of transitions to occupational training and, later, the labor market. The distribution of qualifications awarded to school leavers gives a first impression of the general qualification structure. There are, however, various possibilities for students to return to education or upgrade their school-leaving qualifications later in life. Maaz (in press) drew on data from the West German Life Course Study initiated by Karl Ulrich Mayer to examine acquisition of general educational qualifications in the 1972 cohort. The findings showed that the proportion of respondents with no school-leaving qualifications de-

creased to 1.7% by the age of 26 years. Substantial numbers of respondents in the lower educational categories evidently went back to school later in life. Corrections of previous educational decisions were also observed in higher educational categories, however. For example, the proportion of *Abitur* holders increased from 35% at 21 years to 42% at 26 years (Figure 11). Furthermore, inspection of changes in the qualification structure of different social groups shows change for all groups up to the age of 26. However, the data also show that the available opportunities to acquire or upgrade educational qualifications do not suffice to even out the marked inequalities in educational participation that have been highlighted, for example, by the PISA data. For instance, 80% of respondents from professional families had obtained the *Abitur* qualification by the age of 26 years, compared to just 21% of those from working class families.

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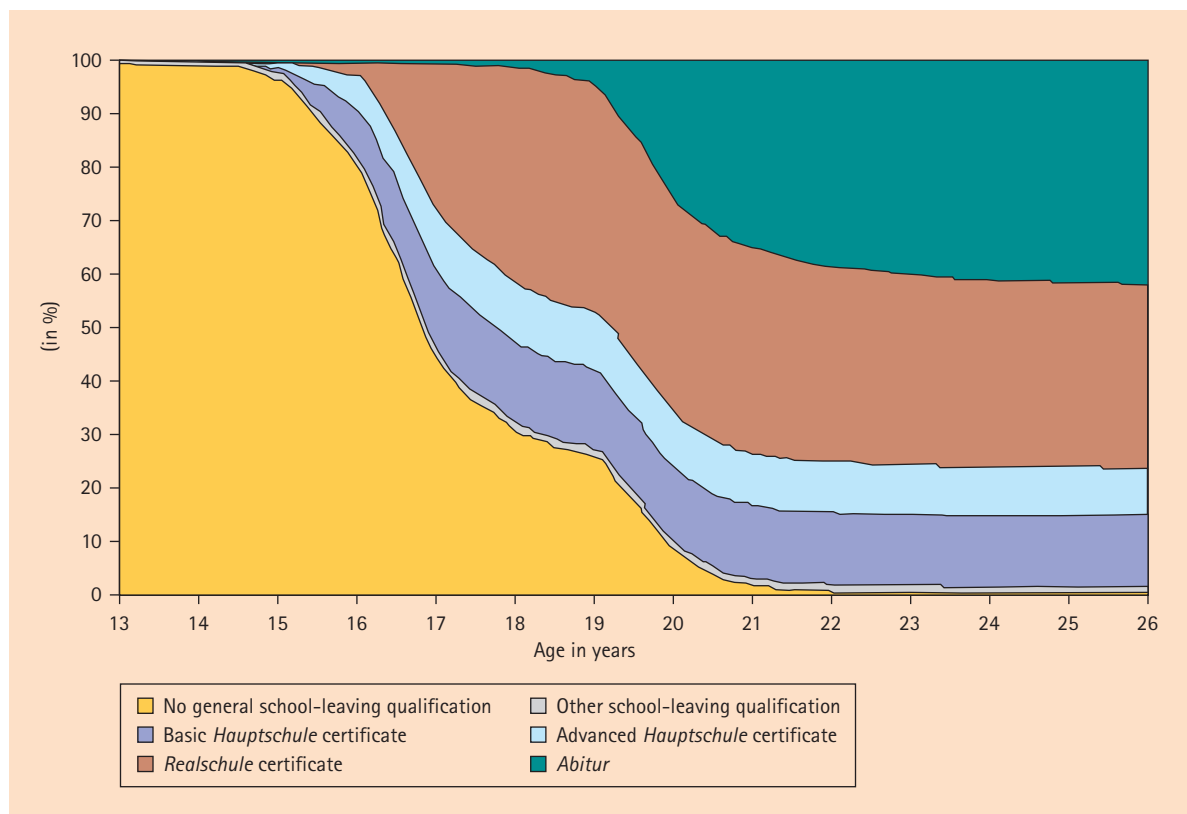


Figure 11. Distribution of school-leaving qualifications in the 1971 West German cohort at age 13 to 26 years.

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The Transition Project

The studies described above have enhanced our understanding of the effects of social background characteristics at different points of transition in educational systems. Many questions remain unanswered, however, especially regarding the transition to secondary education. These questions relate to the effects of social background variables and decision-making processes within the family, on the one hand, and the impact of institutional regulations and regional factors on educational aspirations, teacher recommendations, and transition behavior, on the other. Moreover, very little is yet known about the decision-making mechanisms of students from immigrant families. A new project has therefore been initiated to address these questions: The Transition study, a cooperative project of the Max Planck Institute for Human Development, Berlin, the Department of Education at the University of Göttingen, the Institute for School Development Research (IFS) at the University of Dortmund, and the Institute for Educational Progress (IQB) at the Humboldt University, Berlin, examines issues of meritocracy and regional, social, and ethnic-cultural disparities in the transition to secondary education.

Theoretical Background

Comparison of data obtained for schools or small areas, such as administrative districts or residential areas, already provides first insights into the effects of social disparities at the transition to secondary education. For example, the proportion of students attending an academic-track *Gymnasium* can range from 10% to 80% depending on the district. Likewise, the probability that a student from a certain background will be enrolled in an intermediate-track *Realschule* or an academic-track *Gymnasium* varies considerably from school to school and from region to region, irrespective of the permeability of the secondary sector.

How do these kinds of differences develop? Is it possible to reduce them, and, if so, how? Any attempts to answer these questions highlight just how little we know about the

transition from elementary to secondary school. We can only speculate that performance differences and secondary social and ethnic disparities in educational participation emerge from the interaction of the cultural background and social status of the parental home, the students' actual performance, teachers' recommendations, institutional regulations, and, not least, the cultural, social, and economic environment. Very little is known about the decision-making process itself, however.

Insights into this process are needed if we are to understand the logic and social dynamics of the German school system as a whole. For example, we know that the low *Gymnasium* attendance of certain student groups at lower secondary level can be compensated by establishing alternative college-bound paths at upper secondary level. Opening up the secondary system in this way also leads to a reduction of social disparities. However, it remains unclear whether it can compensate for secondary disparities arising at the transition from elementary to secondary school, about which little is known. Knowledge of the other educational pathways is even more limited.

The Transition Study—Aims and Design

Germany's participation in the TIMSS 2007 study of grade 4 students has provided an ideal opportunity to considerably extend scientific knowledge of how parental intentions, cultural, social, and economic backgrounds, teachers' recommendations, and institutional regulations interact at the transition from elementary to secondary school. The main objective of the Transition study is to analyze parental decisions on the transition from elementary to secondary school against the background of the following factors:

- students' achievement and attitudes at elementary school;
- the parental decision-making process as a function of the social, ethnic, and cultural background;
- the secondary track recommended by the elementary school teacher;
- the process of parent-teacher consultation;

- institutional regulations;
- the regional structure of the secondary system and the regional provision of secondary schools;
- the cultural environment of the school's catchment area; and
- the regional economic and labor market structure.

The objectives of the study are, to us, specially developed scales to identify critical variables influencing both the parental decision process and elementary school teachers' tracking recommendations, and then to model the interactions of these indicators, rather than relying on single indicators. The studies' four main lines of research are as follows:

- (1) modeling the decision process in the parental home;
- (2) examining the situation of immigrant families separately;
- (3) reconstructing elementary teachers' recommendation behavior and determining their diagnostic competence; and
- (4) analyzing the importance of different institutional regulations.

A further objective of the study is to analyze how students and their parents cope with the process of transition. As such, two further waves of data collection were undertaken after the transition to secondary school (6 months later to coincide with the grade 5 mid-term report card and one year later to coincide with the final grade 5 report card). The Transition study is embedded within the design of TIMSS 2007. Its sample (5,819 students in 253 classes) comprises most of the classes participating in TIMSS, excluding the federal states of Berlin, Brandenburg, and Mecklenburg-Western Pomerania, where students do not transfer from elementary to secondary schooling until after grade 6. The sample was extended to include an additional 26 classes with a higher rate of students from immigrant families. Parents, students, and teachers were interviewed. Moreover, institutional and regional context factors were assessed.

Data collection and preparation are complete, and analyses are currently in progress. First publications of key results are planned in 2009.

Reliability and Validity of Social Background Information

Indicators of social background have always been among the standard instruments of empirical educational research. Indeed, these indicators are used in all studies conducted in our four Research Areas, often representing key variables. However, it is important not to forget that assessing and coding social background characteristics can entail measurement problems.

Assessment of background variables presents the first challenge. In educational assessments, social background variables are obtained using either student or parent questionnaires. Data on parents' education and occupation obtained from students constitute proxy responses. A second major challenge is posed by the complex coding processes necessitated by occupational data, in particular. Before information on parental occupations can be used in empirical analyses, responses first have to be categorized by the research team or specialist coders on the basis of a coding scheme. Measures of "prestige" or socioeconomic status are then derived from these categorizations. To date, little is known about the reliability of the coding process. A collaborative project has therefore been initiated with the University of Maryland and the University of Göttingen to examine potential problems and bias in the assessment of social background variables. Using data provided by a random sample of 300 *Gymnasium* students on parental occupations, Maaz, Trautwein, Gresch, Lüdtke, and Watermann (in press) examined the intercoder reliability of occupational classifications according to ISCO-88 principles as well as the ISEI values generated on the basis of these classifications. The student data were double coded: by a team of professional coders, on the one hand, and by our own research team, on the other. Results revealed marked discrepancies in the coding of the students' open-ended responses on occupational activities, with complete agreement in the 4-figure ISCO code allocated by the two coding institutes in just over half of the cases. The validity of the ISEI values generated on the basis of these classifications can, in contrast, be described

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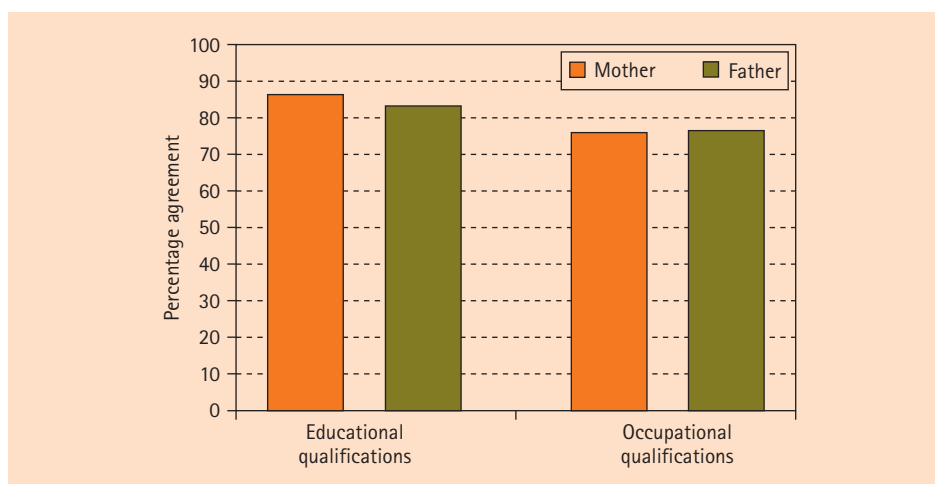
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Figure 12. Percentage agreement of parent and student ratings of parental educational level.

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as very good, with very high interrater correlations. The predictive power of family background did not vary depending on the coder. In other words, there do not seem to be any systematic differences between the ISEI codes allocated by different (well-trained) coders, but this does not rule out the possibility that the relationship with other variables might be higher overall if the assessment of social background were “error free.”

Analyses of PISA data showed that there is, in general, a good level of agreement between parents' and students' responses on key features of the social background (Maaz, Kreuter, & Watermann, 2006). The analyses revealed that responses on general educational qualifications are less prone to error than responses on vocational qualifications (see Figure 12), and that students were better able to report their parents' profession than their vocational qualifications.

In further studies, Kreuter, Maaz, and Watermann (2006) examined the consequences of various types of measurement error for correlational analyses. Providing data on parents' educational and vocational characteristics demands cognitive effort and a certain degree of abstraction from students. The associated measurement error and its correlation with the dependent variable can lead to systematic distortion of results. For example, inspection of the bivariate regression coefficients of mathematics test scores on various measures of the father's vocational training shows that regression coefficients are lower when

student data on parents' vocational qualifications are used than when parent data are used. This simple bivariate regression highlights the effects of measurement errors and of potential bias. The resulting underestimation is low, but statistically significant. It can be assumed that the underestimation of the effect of parents' vocational qualifications can be offset in multivariate models when several indicators are combined to measure social background.

Research Area III Reading Literacy and Language Skills

Introduction and Project Overview

In Research Area III, we examine students' language skills and reading literacy. Using longitudinal, cross-sectional, and experimental approaches, we investigate how these skills develop and how they can be effectively assessed and promoted.

Written language, whether in print or on the computer screen, is probably the most important medium for communicating information in school and daily life. Accordingly, reading literacy is a core competency for education, training, and working life. Yet large-scale assessment studies like PISA have revealed considerable interindividual differences in reading proficiency in all phases of reading development. Most alarmingly, many students in German secondary schools are unable to comprehend texts on a deeper level; their understanding is limited to simple information retrieval. This applies particularly to students from immigrant families or families with low socioeconomic status. One major focus of our research is, therefore, on the determinants of reading development and its promotion in disadvantaged students.

The foundations for reading proficiency are laid at elementary school. However, even after transition to secondary school, students' reading literacy is one of the most important factors in their educational progress, affecting the course of the whole school career. Accordingly, our research projects are closely connected to the studies on transitions in the educational system conducted in Research Area II.

In the past two years, two main projects in Research Area III have addressed key aspects of the development of reading proficiency—from the acquisition of basic reading skills in elementary school to the effective assessment and promotion of reading proficiency in secondary school:

(1) The development of reading proficiency from grade 3 to 6 and its individual and social predictors have been examined in a longitudinal study, the *Berliner Leselängsschnittstudie* (Berlin Longitudinal Reading Study). In complementary projects, we have developed questionnaire measures to assess teacher

knowledge of reading literacy and student reading strategies.

(2) Little is known about how students process texts that incorporate instructional pictures or how teachers can use these texts effectively in their teaching. A new project on text-picture integration (BiTe), conducted in cooperation with the University of Landau and funded by the German Research Foundation (DFG), was initiated in 2007 to examine how students develop the ability to integrate text- and picture-based information with their teachers' guidance.

An additional project (CLAss: Cognitive Language Assessment) has investigated how general and language-based subskills influence student performance on reading assessments.

Berlin Longitudinal Reading Study

Overview

Despite the vital importance of reading for educational, professional, and day-to-day life, recent assessment studies have repeatedly identified serious deficiencies in student

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Berlin Longitudinal Reading Study—Data Collection

- 772 students
- 33 participating whole classes
- Elementary schools in Berlin
- Study period: end of grade 3 (basic reading skills usually acquired) to end of grade 6 (transition to secondary school)
- Student, teacher, and parent questionnaires; student reading assessments

Key Reference

McElvany, N., Kortenbruck, M., & Becker, M. (2008). Lesekompetenz und Lesemotivation: Entwicklung und Mediation des Zusammenhangs durch Leseverhalten. *Zeitschrift für Pädagogische Psychologie*, 22, 207–219.

reading literacy in Germany. Moreover, reading motivation seems to decrease with age. Apart from being a valued resource in its own right, intrinsic reading motivation is positively related to reading performance. In the Berlin Longitudinal Reading Study (LESEN 3–6), we therefore investigate the development of reading comprehension and reading motivation from grade 3 to 6, analyzing their complex mutual influences from both a cross-sectional and a longitudinal perspective. If higher motivation indeed coincides with higher competence, it is important to examine the mechanisms underlying this correlation: Why is it that children who are intrinsically motivated also read better? One potential mediator is reading behavior.

Reading Motivation, Reading Behavior, and Reading Comprehension: Development and Mutual Influences

Our findings confirm the expected developmental trajectories, with reading comprehension increasing, but reading motivation decreasing, from grade 3 to 6. Path analyses show mutual cross-sectional and longitudi-

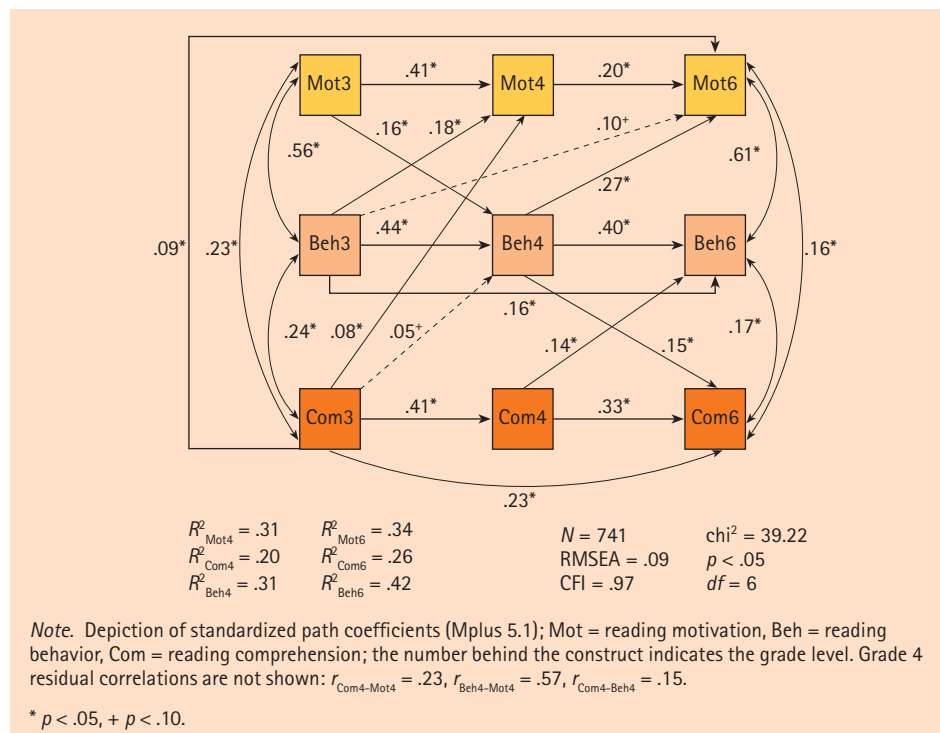
nal influences of reading motivation, reading behavior, and reading comprehension, as well as an indirect effect of early reading motivation on later reading comprehension mediated by reading behavior (see Figure 13). Overall, the power of reading motivation and reading behavior to predict reading comprehension is relatively small; conversely, both constructs are influenced by reading comprehension (McElvany, Kortenbruck, & Becker, 2008).

The Role of Family Background

Another research issue being addressed within the Berlin Longitudinal Reading Study is how the family background influences reading comprehension and individual reading-related characteristics (see Figure 14). Although reading skills are usually acquired in school, reading literacy as a key cultural tool is determined not only by instructional and individual characteristics but also by the environment. As the most important component of the out-of-school environment, family background can lead to further performance differences between students. Many studies point to the relevance

Figure 13. Longitudinal autoregressive cross-lag panel model of reading motivation, reading behavior, and reading comprehension from grades 3 to 6.

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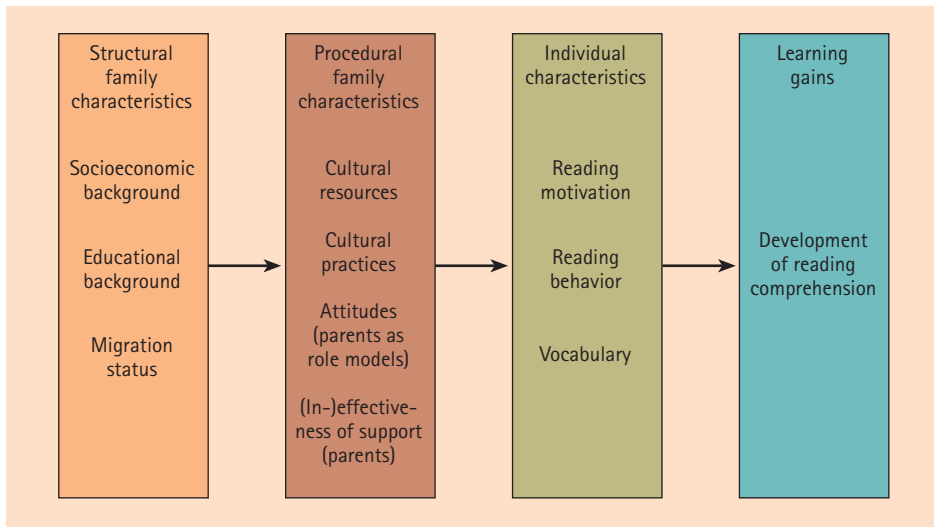


Figure 14. Simplified model of family influences and individual characteristics (inter-correlations are not shown).

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of preschool reading socialization within the family, but comparatively few empirical studies have gone beyond cross-sectional correlations with family socioeconomic status when examining the effects of family characteristics *during* school. The Berlin Longitudinal Reading Study sheds first light on the multifactorial structure of reading socialization in the family. Its results reveal complex and differentiated influences of structural and process family variables on reading comprehension, reading motivation, and reading behavior. The longitudinal data confirm the relevance of the families' social, educational, and language background for reading comprehension. These influences are mediated by cultural resources (number of books in the home) and by individual vocabulary skills. Family structural characteristics have also been found to influence family process variables (McElvany, Becker, & Lütke, in press).

Additional Research Foci

We have also addressed a number of research questions relating to teachers, parents, and systematic reading training in the context of the Berlin Longitudinal Reading Study. A Diploma thesis by Camilla Rjosk examining teachers' ability to diagnose students' basic reading skills was awarded the Marie-Schlei award of the Free University Berlin. The analyses showed that teachers substantially overestimate their students' basic reading

skills, which may prevent them from providing adequate support in this area. McElvany and Schneider (2009) reviewed approaches designed to support reading and related skills in the school, home, and elsewhere in different target populations. A quasi-experimental intervention study integrated within the Berlin Longitudinal Reading Study examined the potential of a systematic intervention based on a parent-child reading program to support reading literacy and strategy use (Berlin Parent-Child Reading Program; McElvany, 2008; McElvany & Artelt, 2009). We are currently cooperating with researchers from the universities of Amsterdam and Tilburg on a meta-analysis of studies on the effectiveness of family literacy programs. Given the critical importance of teacher competencies (see Research Area IV), we have recently developed a questionnaire to assess teacher competencies in the area of reading, based on the COACTIV framework. The questionnaire covers teacher knowledge, motivation, beliefs, self-regulation, and diagnostic competencies ("Conditions for the Development of Reading Literacy at School," CODE R). Pilot studies were conducted in 2007 with elementary school teachers and in 2008 with lower secondary teachers (McElvany, in press-a). Additional research addressed the problem of barriers to proficiency in school-related language among second language learners (Eckhardt, 2008).

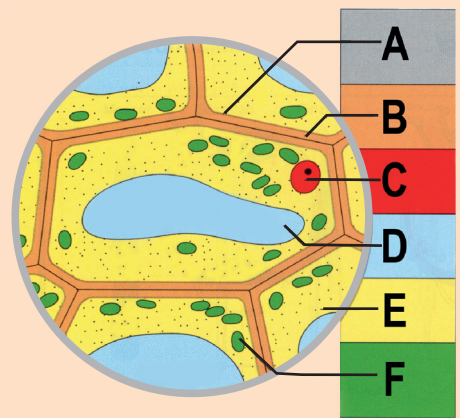
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Figure 15. Example of a task involving text-picture integration.

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Each cell is bounded by a rigid cell wall (B). The inside of the cell is filled with a viscous fluid, the cytoplasm (E). This transports materials through the cell and is bounded by a fine skin, the cell membrane (A). The chloroplasts (F), the cell nucleus (C), and a cavity filled with cell sap, the vacuole (D), float in the cytoplasm. The chloroplasts produce food sugars for the plant. The cell nucleus controls the activities of the cell and contains the genetic material. The vacuole stores sugar or waste products.



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Developing and Assessing Proficiency Models of Text-Picture Integration (BiTe)

Background

Teaching materials used in many subjects at lower secondary level involve texts containing instructional pictures (see example in Figure 15). Instructional pictures may be realistic (e.g., photographs) or highly abstract (e.g., complex charts or diagrams). To build appropriate knowledge structures, learners need to extract information from both sources (text and picture), correlate the text and picture information by means of surface and deep structure level mapping, and engage in integrative processing. The demands of integrating text and picture information differ, from extracting detail information to establishing complex relations.

Analogous to skill development in other domains, the development of students' ability to integrate textual and graphical information is likely to be considerably influenced by the instruction that their teachers provide. Accordingly, models describing the structure and development of this competence at the student level should be complemented by corresponding models of teacher competence, particularly diagnostic skills.

Project Overview

The Developing and Assessing Proficiency Models of Text-Picture Integration (BiTe) project has been initiated in cooperation with researchers at the University of Koblenz-Landau to develop and evaluate proficiency models and instruments assess-

ing the integration of texts and images at the student and teacher levels. At the student level, we analyze structural features characterizing text-picture integration skills and examine the influence of school type and age on proficiency levels. At the teacher level, we examine the abilities of teachers of different subjects to promote successful text-picture integration and the extent to which these abilities depend on their training and teaching experience. One of the key features of teacher competence is the ability to diagnose student strengths and needs. In order to teach their subject successfully, teachers must be able to judge whether their students understand the text-picture materials featured in school books and worksheets and to identify potential comprehension difficulties. Only then can they teach their subject in the manner most appropriate to the students' current level of performance. Such diagnosis is particularly demanding in the area of text-picture integration, as it involves judgment of the text, the picture, and the demands of developing a full understanding of their content.

For the purposes of discriminative construct validation, these proficiency models of text-picture integration will be compared, at both student and teacher level, with models of reading proficiency.

Both newly developed instruments were evaluated in February 2008 in a pilot sample of 48 grade 5 to 8 classes and with 116 German-language, biology, and geography teachers in three different school types.

The main study will take place in February 2009 and a second project phase is planned for 2010–2011. The project is funded by the German Research Foundation (DFG) as part of its Priority Programme on proficiency models assessing individual learning outcomes and evaluating educational processes.

Language Assessment and Cognitive Predictors of Reading Ability

It has recently been alleged that the tests used in large-scale educational assessments do not assess domain-specific competencies—defined as the contextualized knowledge and skills that enable students to master various situations within a specific knowledge domain (Baumert, Brunner, Lüdtke, & Trautwein, 2007)—but rather general intelligence. In response to these allegations, we have shown that measurement models that account for the domain-specificity of the competence structure are empirically superior to general unidimensional models. In order to understand how such a misconception could have arisen in the first place, we need to look at specific knowledge domains (Baumert, Lüdtke, Trautwein, & Brunner, in press). In the domain of reading, for example, it is difficult to distinguish at first glance between general reasoning ability and specific reading proficiency. Most tools designed to measure reading pro-

ficiency focus on high-level comprehension and text understanding at a very general level. While inferencing and reasoning abilities are necessary prerequisites for success on such tasks, they are clearly not sufficient. Instead, they are believed to enable the language- and text-specific cognitive processes that underlie comprehension. The CLAss (Cognitive Language Assessment) project was initiated in summer 2008 to clarify the relationship between reading proficiency tests and the cognitive processes specific to reading. In one study, we compared the cognitive demands of different reading test-taking strategies. Previous research has shown that students are able to guess the right answer to reading multiple-choice items, even if they have not read the corresponding text. We hypothesized that the cognitive processes driving this guessing strategy differ from those driving normal responding after text reception. Approximately 350 students from 15 intermediate- and academic-track schools in Berlin participated in the study. All students were administered a reading comprehension test in two of three conditions. In the first condition, students read a short text and then answered multiple-choice items in the usual way. In the second “no text” condition, students were not shown the texts, but asked to guess the right answer.

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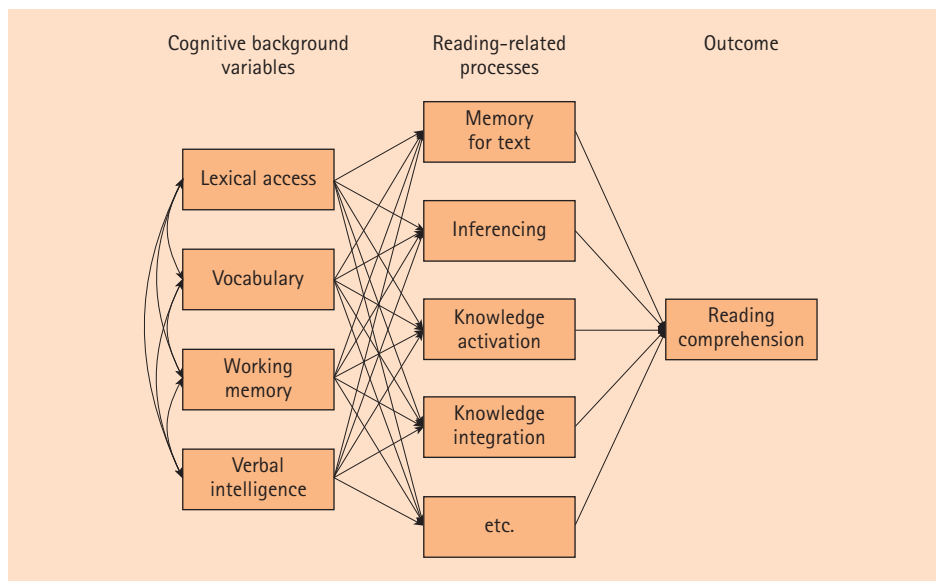


Figure 16. Mediation model.

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Figure 17. The first words of a text as read in the moving-window paradigm.

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In the third "no text/no question" condition, students were not even given the question for the four response options. In a separate session, before the reading comprehension tests, students were tested on several general cognitive ability measures (verbal intelligence, working memory, etc.) and on language-related subskills (text inferencing, memory for text, etc.).

Our preliminary analyses confirm that the students were indeed able to guess the right answer to reading multiple-choice items. However, the relationship between students' test scores in the three conditions and their cognitive and language-related abilities differed considerably. Overall, students' test scores in the "normal" condition were strongly predicted by cognitive variables. In contrast, test scores in the "no text" and "no text/no question" conditions were only weakly related to cognitive functioning. To disentangle the effects of general intelligence and language-related skills in the three conditions, we fitted a mediation model to the data as shown in Figure 16.

In this model, cognitive background variables are assumed to drive language processing, which, in turn, influences the reading process and reading comprehension. We found that language-related variables predicted reading comprehension test scores only if students had read the corresponding text. In contrast, processing in the "no text" condition was driven primarily by general cognitive abilities and was only weakly related to language processing skills.

In a follow-up study, we addressed an associated question: If reading comprehension tests indeed reflect the differential effectiveness of language-related skills, then scores on these tests should, in turn, predict actual reading behavior. To test this assumption for reading speed, we asked 125 students to read the reading comprehension test texts on the computer using the "moving window" method. In this paradigm, the letters of a text are replaced by the symbol "~." When the reader presses the space bar, the first word of the text is revealed. At the next press of the space bar, the first word is concealed again and the second word revealed, and so forth (Figure 17). After reading the text in this manner, the students answered the corresponding questions. We were thus able to measure how much time each reader spent on each word of a text and, at the same time, to assess reading comprehension.

Preliminary multilevel analyses indicate that there are no overall differences in text processing speed between good and poor comprehenders. Rather, most processing differences are attributable to interactions between text characteristics and reader characteristics. For example, the poor readers sped up as they read a text, reading the end faster than the beginning. It seems that they tried to reduce cognitive load by skipping difficult passages and by shallower processing. In contrast, good readers kept their reading speed steady, even as the processing load accumulated. They were generally more sensitive to the linguistic structure of the text.

Outlook

The projects reported here focus on the fundamental principles guiding the development of reading literacy and its central determinants. In direct continuation of these studies, we are currently preparing two new projects in which this knowledge is applied to promote students' language and literacy skills more directly. The first project involves the development of a new instrument to assess student reading strategies that differentiates between habitual and text-specific strategy use. The second project centers on the evaluation of an intervention program designed to foster the reading skills of lower track secondary students.

Reading strategies are assumed to have high relevance for reading and learning from texts. However, empirical results to date are mixed. One reason for these inconclusive results may be the lack of instruments to measure both text-specific and habitual reading strategy use, drawing on a comprehensive theoretical framework of cognitive and metacognitive strategies. To close this gap, we are currently

evaluating a newly developed instrument to assess reading strategies, the Berlin Reading Strategy Inventory. The inventory includes six subscales assessing cognitive (elaboration, memorizing, organization) and metacognitive (planning, monitoring, regulating) strategies during reading and exists in two versions (text specific/general). We hope that this instrument will yield more conclusive results on the role of reading strategies in self-regulated learning. Second, large-scale studies, such as PISA, have shown that the reading skills of students in lower track secondary schools are particularly impoverished. The TRAIN project located in Research Area I has been initiated to investigate whether it is possible to remediate these deficiencies. An intervention has been designed to improve the reading competencies of lower track students by enhancing their general reading motivation and providing intensive training on a wide variety of reading tasks. It is hoped that participating students will learn to read more efficiently and extensively at school as well as in everyday nonschool settings.

The Center for Educational Research in February 2009



From left to right, in front: Jürgen Baumert, Uta Klusmann, Swantje Pieper, Nele McElvany, Mareike Kunter, Nicole Husemann;
behind: Thamar Voss, Kathrin Jonkmann, Michael Becker, Dirk Richter, Marko Neumann, Cornelia Gresch, Gabriel Nagy, Axinja Hachfeld, Jürgen Elsner, Kai Maaz, Sascha Schröder.

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Research Area IV

Professional Competence of Teachers and Cognitive Activation in the Classroom

Research Area IV focuses on the teacher as a crucial lever for improving the functioning and outcomes of the educational system. Building on our earlier research on powerful learning environments, our research program has shifted from describing features of high-quality classroom instruction to determining the knowledge and skills that teachers need to create such successful learning environments. Drawing on a theoretical model of teacher competence, we have developed tools and procedures to tap interindividual differences in the knowledge, beliefs, and psychological functioning of teachers and found that these aspects of teacher competence are systematically linked to differences in instructional quality. We have recently begun to investigate how teachers acquire these professional competencies—for example, by examining the learning opportunities provided by preservice teacher education. We complement this research on the antecedents and consequents of teachers' competence with studies that investigate specific aspects of instructional quality in more depth. Drawing on our understanding of classrooms as powerful learning environments, we focus on identifying factors that foster active knowledge construction.

Methodologically, we combine correlational and (quasi-)experimental studies, many of them including both teacher and student data, to gain insights into the instructional process. The flagship of Research Area IV is the COACTIV study, which was embedded in the longitudinal part of the PISA 2003 assessment and investigates how aspects of mathematics teachers' competence relate to their classroom instruction. New projects, such as the COACTIV-R study, complement the COACTIV research program by investigating the beginning of teachers' professional development.

Theoretical Framework: Insightful Learning in Powerful Learning Environments

Work in Research Area IV is guided by a theoretical framework that conceptualizes teachers, lessons, and students as the three cornerstones of teaching and learning processes in classroom instruction. The framework draws on aspects of teacher expertise, the process-mediation-product model, and the (social-)constructivist approach. Our theoretical framework is outlined in Figure 18.

Our theoretical framework is based on the idea that conceptual understanding is a central aim of mathematics instruction. It is now widely accepted that new concepts and insights are not acquired through passive

knowledge transmission of the teachers' knowledge to the learner's mind, but rather that they are the result of the learner's active process of constructing increasingly complex and elaborated cognitive structures. Powerful classroom environments are those that stimulate students to apply themselves cognitively and that are structured in such a way that active and independent knowledge construction is possible.

Our research focuses on three general features of instruction that are crucial for insightful learning processes in secondary school mathematics: cognitively activating elements, classroom management, and individual learning support (see below for detailed descriptions). It is important to note that the uptake of the learning opportunity depends both on the students themselves (in terms of their individual strengths and weaknesses) and on situational affordances and constraints. Successful instruction thus hinges on the degree to which instructional strategies are suited to the needs of both the situation and the students. Instructors need to provide challenging tasks, monitor student learning, and adapt their teaching as appropriate to support active and independent knowledge construction for many learners. For teachers in classroom situations, this is a demanding task—it is no easy matter to create challenging and suitable learning

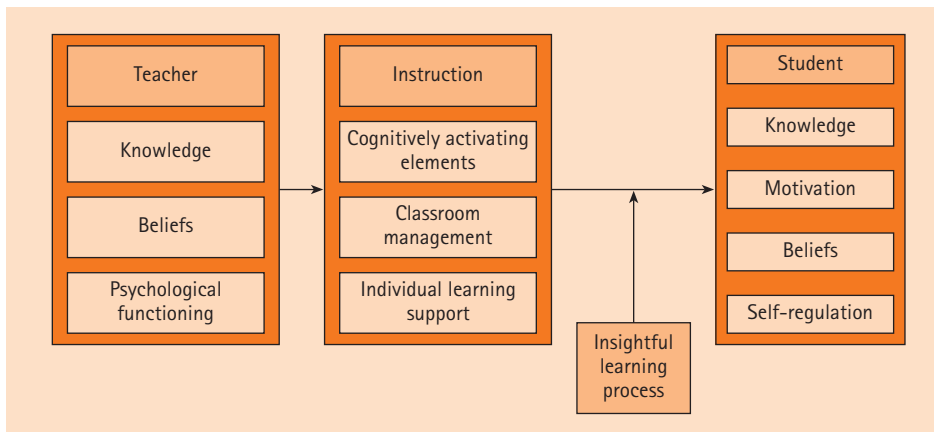


Figure 18. Teacher competence, mathematics instruction, and student learning: The theoretical framework guiding research in Research Area IV.

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conditions for groups of students who may differ greatly in terms of motivation or prior knowledge. Such deliberate, but, at the same time, flexible and adaptive classroom practice is dependent on a solid knowledge base supported by adaptive beliefs and psychological functioning. The professional competence of teachers and its empirical assessment is, therefore, a major aspect of our work. Until recently, professional competence was rarely measured by quantitative means. We have, therefore, developed a model of professional teacher competence and instruments for its empirical assessment (Kunter, Klusmann et al., 2007). The model combines aspects of knowledge, beliefs, motivations, and psychological functioning. It is based on the assumption that teachers acquire their professional competence during their initial training as well as in classroom practice. Hence, we see teachers not only as providers of education but also as professional learners. Like their students, teachers acquire their skills through the active construction of knowledge and the uptake of the learning opportunities available to them. Our research program encompasses several objectives, which we are addressing step by step. In a first step, we developed and validated empirically sound measures to tap the theoretically postulated aspects of teacher competence. Second, as a crucial part of the validation process, we have investigated the link between teachers' competence and the quality of their instruction, examining the relative importance of the different dimensions of teachers' domain-specific knowledge.

Building on these results, we have, in a third step, extended our theoretical approach from a focus on teachers' subject-related knowledge and skills to a broader model of teacher competence that encompasses noncognitive aspects, such as motivation and self-regulation as well as subject-unspecific aspects of professional knowledge. Fourth, in our current work, we investigate the malleability of teacher competence and how it can be improved in formal teacher education.

Professional Competence of Teachers

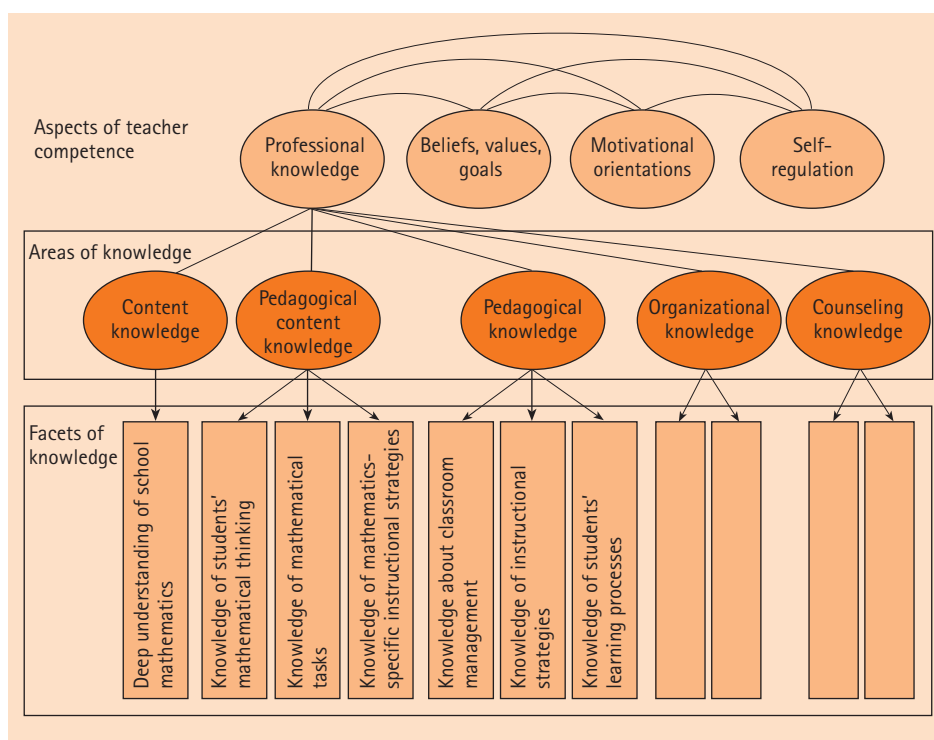
Fostering the professional competence of teachers is considered one of the keys to improving instructional quality and the educational system at large. However, despite a widely shared understanding that teachers are crucial agents in the instructional process, there has been little investigation of which teacher characteristics are particularly relevant for creating high-quality learning situations. Likewise, research on how professional competence is acquired during institutionalized teacher training is scarce. In Research Area IV, we work at closing this empirical gap. Drawing on a generic model of professional competence, we have identified aspects that may be particularly relevant for successful mathematics teaching. We have put this theoretical model to empirical test and found evidence for its predictions. In our ongoing research, we are concerned with which aspects of competence can predict instructional quality and how teachers' competence changes and develops.

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Figure 19. A model of teacher competence as specified for mathematics teachers.

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A Model of Teacher Competence

Our theoretical model of teachers' professional competence draws on a general model of professional competence and specifies aspects relevant for the teaching profession (see Figure 20; Baumert & Kunter, 2006). The "competence" concept extends on previous approaches to teacher professionalism in a number of important respects. In its narrow meaning, "competence" is limited to cognitive aspects. In its broader meaning, it covers both the ability and the willingness to act. It thus describes a broader spectrum of individual characteristics than, for example, the knowledge-based concept of teacher expertise, also taking account of motivational, metacognitive, and self-regulatory aspects. Moreover, competencies are generally assumed to be learnable and teachable, which has direct implications for quality assurance in teaching, as it places a much stronger emphasis on aspects of preservice and in-service training than on selection to the profession. It is, though, that the process of professional competence acquisition can continue throughout the occupational career, from university training to retirement.

Our model of professional teacher competence rests on the assumption that teachers, as the agents primarily responsible for orchestrating instruction, have to be equipped with certain knowledge and skills. It is teachers who determine the goals pursued in the classroom, the organization and content of instruction, and the support provided for individual students. The professional competence to meet these demands derives from an interaction of professional knowledge, values and beliefs, motivational orientations, and metacognitive self-regulatory skills. Each of these domains comprises other more specific facets—as illustrated in Figure 19 and summarized briefly below.

Professional Knowledge

Knowledge of learning content and of instructional strategies can be considered core components of teachers' professional competence. Work by Shulman and Bromme, the COACTIV model distinguishes five domains of teachers' professional knowledge:

- content knowledge,
- pedagogical content knowledge,
- pedagogical knowledge,

- knowledge about school organization and the school system, and
- knowledge about counseling.

Content knowledge is conceptualized as a deep mathematical understanding of the content to be taught. This professional knowledge includes a masterly command of the content of the school mathematics curriculum, but neither this school-level knowledge nor everyday mathematical knowledge equip teachers for the challenges of preparing and delivering instruction. Content knowledge is, therefore, distinguished from *pedagogical content knowledge*, which Shulman defines as the knowledge necessary to make mathematics accessible to students. Three facets of pedagogical content knowledge are considered crucial: knowledge of strategies for representing and explaining learning content in a specific subject, knowledge of the didactic potential of tasks and sequences of tasks for learning processes, and knowledge of subject-specific student cognitions. Another dimension of knowledge that is directly relevant to instructional practice is *pedagogical knowledge*: the generic cross-curricular knowledge needed to create and optimize teaching and learning situations, including a basic understanding of developmental and educational psychology and knowledge of lesson planning, instructional methods, and classroom management strategies. Our theoretical conception of professional competence in COACTIV focuses on aspects that are directly relevant to the practice of teaching. Of course, an exhaustive description of teachers' professional competence would include further dimensions of knowledge that are relevant for their work outside the classroom, such as knowledge about school organization and the school system and a command of adaptive and effective communication, particularly with laypeople.

Beliefs and Values

We define teachers' beliefs as implicit or explicit conceptions that influence their perception of the environment and their behavior. We distinguish professional values and ethics; epistemological beliefs about the structure, development, and validation of knowledge;

and beliefs about learning content, lesson planning, and instructional practice. Specifically for mathematics instruction, two opposing belief sets can be described both theoretically and empirically. On the one hand, teachers may take a "transmission view" that draws traditional learning theories and tends to see students as passive receivers of information. On the other hand, teachers may take a constructivist view that endorses the principles of active and constructive learning as outlined above (Dubberke, Kunter, McElvany, Brunner, & Baumert, 2008). Clearly, the latter is thought to be more conducive to high-quality instruction than the former.

Motivational Orientations and Self-Regulation Skills

The teaching profession is characterized by a relative lack of external constraints on—or control of—teachers' behavior. The typical career path offers few direct incentives or rewards to enhance occupational commitment. At the same time, the profession makes high demands on teachers' attention, energy, and frustration tolerance. Adaptive motivational orientations and self-regulation skills are thus vital for teachers to succeed in their jobs on the long term. Aspects of motivation (e. g., intrinsic motivational orientations in terms of enthusiasm, interests, control beliefs, and self-efficacy beliefs) seem important for the development and maintenance of occupational commitment (Kunter et al., 2008). At the same time, self-regulation skills (i. e., the ability to distance oneself from one's work and to cope adaptively with stress) are needed to maintain occupational commitment on the long term and to preclude unfavorable motivational and emotional outcomes (Klusmann, Kunter, Trautwein, Lüdtke, & Baumert, 2008b).

Assessing Teacher Competence

Although notions of teacher competence are convincing from the theoretical perspective, empirical evidence to support them is as yet sporadic. One prime aim of our research was to develop valid and reliable measures capable of tapping inter- and intraindividual differences in all aspects of teacher competence.

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The COACTIV Study—Aims and Data Collection

The aim of the COACTIV study is to investigate mathematics teachers' competence and how this competence relates to instructional processes. By assessing the knowledge, beliefs, motivation, and self-regulatory skills of mathematics teachers, and then linking these aspects to features of their classroom instruction and to the development of their students' mathematical literacy, we aim to provide unique insights into the prerequisites for students' mathematical learning. The COACTIV study was embedded in the longitudinal component of the PISA 2003 study. Both the students sampled for PISA and their mathematics teachers were assessed twice—once at the end of grade 9 and once at the end of grade 10. We are thus able to combine student achievement and questionnaire data with their teachers' data and to observe changes over a school year. Information on mathematics instruction was obtained from three sources: teacher reports, student reports (standardized questionnaires), and analyses of the teaching material used in the given period. To this end, teachers were asked to submit the tasks they had assigned their PISA classes (homework assignments, exams, and tasks used in introductory lessons). These tasks were coded by trained raters using a newly developed classification scheme to gauge the cognitive potential of the tasks. To assess teachers' competence, we developed an array of new instruments focusing on content knowledge and pedagogical content knowledge.

Our teacher sample consists of 351 teachers and their mathematics classes in the first wave, and 240 teachers and their classes in the second wave (the reduction in sample size is due to students from vocational schools no longer being included in the assessment at the second wave). A total of 178 teachers participated in both waves of the assessment and taught the PISA classes over the whole school year.

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The assessment of teachers' knowledge represented a particular theoretical and methodological challenge, as no standard instruments were previously available. The theory-based construction of the tests was a multidisciplinary and a multistep project. Researchers in (mathematics) education, psychology, and secondary mathematics teachers collaborated in writing, piloting, and analyzing items. The successful construction of a set of valid and reliable measures tapping aspects of teacher competence was one of the most important milestones of the COACTIV study. These new measures (see Figure 20 for sample items) now allow us to learn more about the relations between the different aspects of teacher competence, to compare different groups of teachers, and, most importantly, to investigate which of the competence aspects are particularly relevant for educational outcomes.

Linking Teacher Competence and Instruction

A particular strength of the COACTIV design is that it allows us to link aspects of teacher

competence to features of classroom instruction and to student performance. We can thus determine the extent to which differences in teachers' professional competence are indeed reflected in their instructional practice and in student learning gains. Our findings show that all aspects of teacher competence identified on the basis of our theoretical considerations show systematic relationships to instructional quality, which, in turn, influences student learning outcomes. Along with results on teachers' beliefs, motivation, and judgment accuracy, our findings on teachers' subject-specific knowledge and self-regulatory skills are particularly interesting.

Knowing Your Math Is Not Enough

There is consensus in the teacher education literature that a strong knowledge of the subject taught is a core component of teacher competence. Opinions on what exactly is meant by subject matter knowledge are divided, however, particularly for mathematics. While some educational theorists and policy makers contend that teachers seldom have an adequate understanding of their

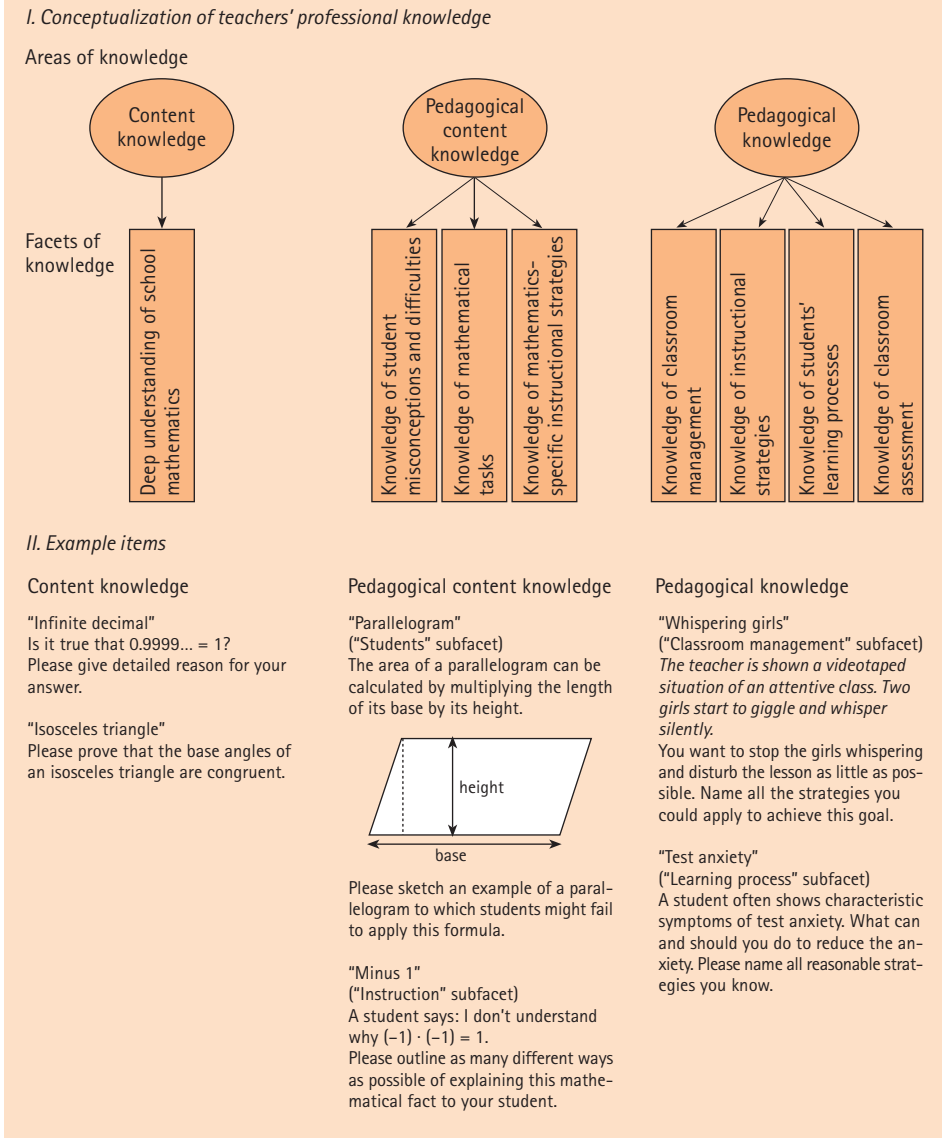


Figure 20. Assessing teacher knowledge: Sample items from the COACTIV study.

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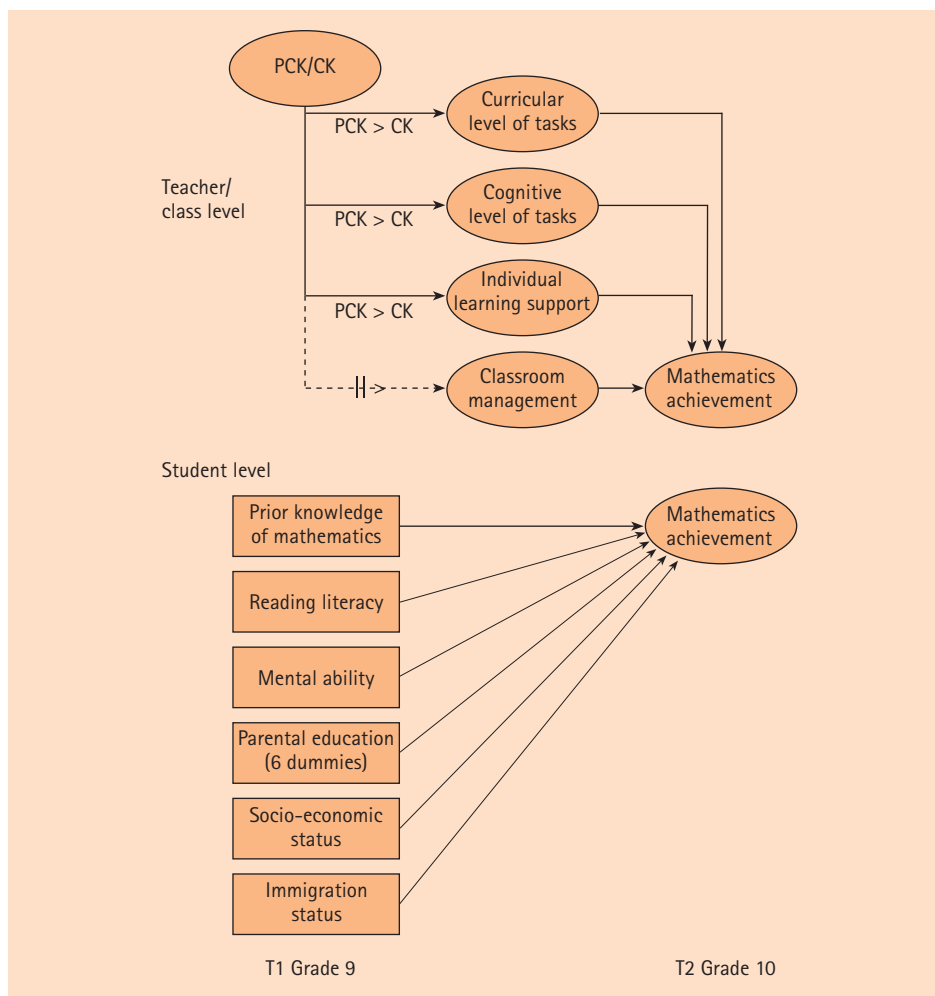
subject and thus need more subject matter instruction during teacher training, others argue that teachers' subject matter expertise is relatively good, but that their pedagogical knowledge, both domain-specific and general, needs to be improved. Upon closer inspection, the empirical evidence for both standpoints is surprisingly weak. In COACTIV, we addressed this issue by constructing two separate scales to measure teachers' understanding of their subject—that is, their content knowledge (CK)—and their knowledge of how to make that content ac-

cessible to students—that is, their pedagogical content knowledge (PCK; see Figure 20). We found that the two knowledge aspects can be distinguished empirically, although they are positively related. These findings raise the urgent question of whether PCK or CK is decisive in the classroom or whether the two components of professional knowledge are interchangeable. Our theoretical assumption is that PCK is inconceivable without a substantial level of CK, but that CK alone is not a sufficient basis for teachers to deliver cognitively activating

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Figure 21. Hierarchical linear model testing the significance of teachers' pedagogical content knowledge for instructional quality and student learning.

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instruction that, at the same time, provides adaptive support for individual students' learning.

In a study combining our teacher data with the student data from the PISA 2003/2004 assessment, we found that CK and PCK both make unique contributions to explaining differences in quality of instruction and student outcomes. Drawing on the longitudinal PISA 2003/2004 data, we were able to control the assignment of students to teachers, thus creating a quasi-experimental situation in which differences in student achievement could be directly attributed to differences in teacher knowledge. Figure 21 presents results from multilevel structural equation models, which showed that a substantial positive effect of PCK on students' learning gains was mediated

by the provision of cognitively activating and adaptive instruction.

This effect applied only to PCK, however: CK was not found to have any direct effect on students' learning or instructional quality. In other words, knowing your math does not necessarily make you a good teacher. It would, however, be unwise to interpret these findings as implying that CK is unimportant for teachers. It is inconceivable that PCK can be acquired and applied without a solid basis of CK. In fact, our findings have shown the correlations between CK and PCK to increase as a function of the mathematical expertise of the teacher group (Krauss, Brunner et al., 2008). In our ongoing research, we are, therefore, especially interested in capitalizing on quasi-experimental situations that allow us to

disentangle the causal relationships between the two knowledge components (e.g., Krauss, Baumert, & Blum, 2008, and in the new COACTIV-R study presented below).

Beyond Knowledge: The Importance of Noncognitive Aspects of Teachers' Professional Competence

Within the COACTIV framework, we argue that teachers' professional competence extends to the emotional and motivational skills they need to cope effectively with the many demands of their profession. We focus on the intraindividual interplay of two self-regulatory behaviors that are highly relevant in the occupational domain: engagement and resilience. Based on Conservation of Resources Theory by Hobfoll and the work by Schaarschmidt, we assume that the *optimal balance* between work *engagement*, which can be seen as the investment of resources, and *resilience*, which can be seen as the conservation of resources, is the most adaptive self-regulatory style in the work context. We hypothesize that individual patterns of self-regulation predict two key outcomes that have rarely been studied together: high levels of occupational well-being and better instructional performance, which, in turn, leads to favorable student outcomes. Recent research by Schaarschmidt has suggested four interpersonal patterns of engagement and resilience (see Figure 22). The "healthy-ambitious" (H) type, with high scores on both engagement (sample item: "I spare no effort at work") and resilience (sample item: "I can switch off easily after work"), is seen as the best adapted pattern. The "unambitious" type (U) is characterized by low engagement, but high resilience. The other two types are thought to be at particular risk for low occupational well-being. The "excessively ambitious" type (A), scoring high on engagement and low on resilience, is characterized by excessive engagement, striving for perfection, and an inability to recover emotionally from work. The "resigned" type (R) is characterized by low engagement and low stress resistance. Applying different cluster analytic methods to the COACTIV teacher sample, we consistently identified the four theoretically predicted

patterns with their prototypical profiles of engagement and resilience (Klusmann, Kunter, & Trautwein, in press; Klusmann et al., 2008b). Latent profile analysis identified 29.2% of our teachers as belonging to the healthy-ambitious type, 25.4% to the unambitious type, 16.4% to the excessively ambitious type, and 29.0% to the resigned type (Klusmann et al., 2008b). Did individuals of the four self-regulatory types differ in terms of the level of occupational well-being they reported? As expected, we found substantial differences in the emotional exhaustion ("I often feel exhausted at school") reported by the four types. Teachers belonging to the healthy-ambitious type reported the lowest emotional exhaustion, followed by the unambitious type. The excessively ambitious type and the resigned type scored highest on emotional exhaustion. Similar results were found for job satisfaction (sample item: "Given the choice, I would definitely become a teacher again"). As expected, the healthy-ambitious type scored highest on job satisfaction, followed by the unambitious type. Teachers of the excessively ambitious and resigned types scored lowest. The results remained stable when age, gender, and school track were controlled. Furthermore, we found that the self-regulatory patterns predicted teachers' occupational well-being one year later. Teachers of the two "at-risk" types (excessively ambitious and resigned) showed more emotional exhaustion after one year than teachers of the two other types. We also found a negative spillover effect for the excessively ambitious type, who reported significantly less overall life satisfaction one year later than the healthy-ambitious type. We expected to find that teachers' self-regulatory patterns were differentially related to their instructional performance in terms of

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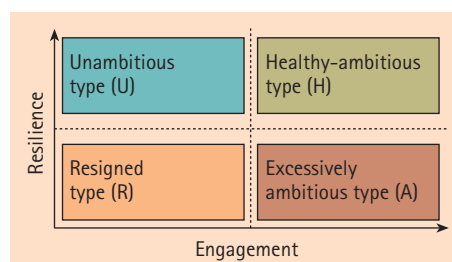
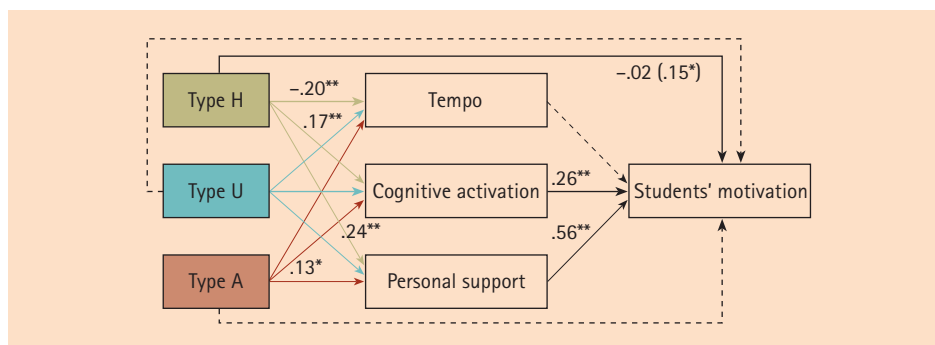


Figure 22. Interpersonal patterns of engagement and resilience.

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Figure 23. Predicting instructional quality and student outcomes by teachers' self-regulatory styles.

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classroom management, interaction tempo, cognitive activation, and personal support as rated by their students. A set of linear regression models was conducted to test (a) the effect of self-regulatory type on instructional performance and (b) whether instructional performance mediates the effect of self-regulatory type on student motivation (see Figure 23). From the students' perspective, there were considerable differences in the instructional performance of the four teacher types. Teachers of the healthy-ambitious type received more favorable ratings on interaction tempo than teachers of the resigned type, indicating that their instructional pace was evaluated as being more appropriate to student needs. Teachers of the healthy-ambitious type also outscored teachers of the resigned type on the level of cognitive activation provided in mathematics lessons and the personal support provided for students. The excessively ambitious type likewise outscored the resigned type on cognitive activation. However, none of the self-regulatory types predicted classroom management as reported by students. Interestingly, we found an effect of the healthy-ambitious type on students' motivation in mathematics that was mediated by cognitive activation and personal support. Teachers' self-regulatory patterns are thus manifest in their classroom behavior.

Why Do Teachers Differ With Respect to Their Competence? Investigating Teacher Learning

Our results to date show that teachers differ considerably in all aspects of competence investigated, especially in the extent and structure of their knowledge. However, our findings

also show that these differences cannot be attributed solely to years of teaching experience. Rather, it seems that the foundations for these differences are laid early in teacher education. COACTIV provided first support for this hypothesis with findings showing that differences between teachers are closely related to the type of training they received, with teachers who trained to teach at *Gymnasium* schools outperforming their peers. Teacher training in Germany consists of two phases. During the first phase, university-based, teacher candidates acquire theoretical knowledge. It is only in the second phase, teaching placement (*Referendariat*), that they gain practical knowledge by observing lessons and teaching themselves. During this two-year phase, teacher candidates are both teachers and students, teaching their own classes, but being supervised by a mentor, and attending preparatory seminars. These structured learning opportunities offer great potential for development. The new COACTIV-R study (R meaning *Referendariat*) has been initiated to examine the processes and outcomes of the *Referendariat* in more depth.

What Level of Competence Do Teacher Candidates Exhibit at the End of Their University Training?

In Germany, teacher candidates aspiring to teach at secondary level must choose between teacher education programs qualifying them to teach either in the academic track (*Gymnasium*; 5-year training program) or in the other secondary tracks (e.g., *Realschule*; 4-year training program). We do not expect teacher candidates approaching the end of

their university training to have achieved knowledge levels comparable to those found for the experienced teachers sampled in COACTIV. However, we expect to find systematic differences in competence levels at the end of the first phase of training, with candidates training to teach at *Gymnasium* schools exhibiting higher levels of subject knowledge and lower levels of pedagogical content knowledge and general pedagogical knowledge than their peers training for the other tracks.

How Do Teacher Competencies Change During the Teaching Placement?

During the *Referendariat*, teacher candidates are placed in the school track for which they trained. They gain their first real practical experience and receive supervision and meaningful feedback: formal evaluation (including examinations) as part of their training, on the one hand, and the direct responses of their students and mentors, on the other. It can be assumed that all aspects of professional competence change as a consequence of these experiences, but that nature of this change may differ. For instance, we expect to find roughly linear growth in general pedagogical knowledge and pedagogical content knowledge in all participants. At the same time, we expect to observe a so-called "practice shock" in teachers' beliefs, self-efficacy, and motivation. Teacher candidates seem to enter the profession highly motivated and with rather idealistic progressive beliefs that plummet when they experience the demands of full-time teaching for the first time. Motivation

and well-being are also likely to fluctuate considerably. COACTIV-R will thus investigate long-term changes and short-term fluctuation in teacher candidates' knowledge, beliefs, and motivational and emotional characteristics.

Which Factors Cause Change; What Role Do Structured Learning Opportunities Play?

Teacher candidates are afforded different learning opportunities during the *Referendariat*. However, the extent to which these opportunities actually foster learning hinges on two factors: First, on the quality of the learning opportunities themselves (i. e., whether their structure fosters insightful learning processes) and second, on the candidates' individual uptake of those learning opportunities (e. g., reflection, actual learning behavior, effort, help-seeking, etc.), which may be influenced by their individual characteristics (basic cognitive abilities, prior knowledge, attitudes to learning, motives, goals, interests, etc.). COACTIV-R will examine the relative importance of different learning opportunities and individual characteristics for the learning process of teacher candidates during the *Referendariat*. To ensure that a broad range of different learning opportunities is covered, the study will compare teacher candidates from training systems with markedly different structures.

Design of the Study

COACTIV-R is a longitudinal study with two main measurement points and two cohorts: teacher candidates in the first and second year of the *Referendariat*. The target popula-

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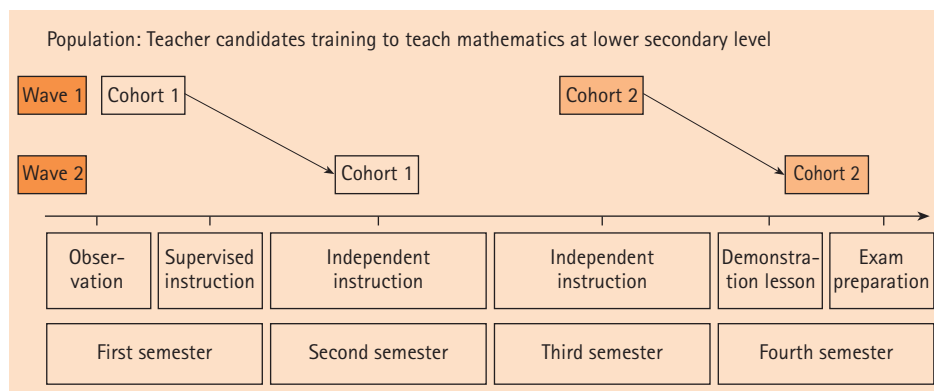


Figure 24. Design of COACTIV-R, a study investigating the development of teacher candidates' professional competence.

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tion for the study was teacher candidates training to teach mathematics at lower secondary level in all school tracks. The first wave of data collection took place between fall 2007 and spring 2008 in four federal states: Bavaria, Baden-Wuerttemberg, North Rhine-Westphalia, and Schleswig-Holstein. The reason for choosing these four states was that they differ systematically in the structure of the *Referendariat*. Data have been obtained from 856 teacher candidates. The second wave of data collection ran from fall 2008 to spring 2009. Figure 25 shows how the measurement points are embedded in the structure of the *Referendariat*. Beyond the two main measurement points, more detailed research questions, such as nonlinear growth trajectories of motivation and beliefs and the role of supervision for the learning process, will be investigated with subsamples from North Rhine-Westphalia.

**The Basis for Teachers' Success:
Investigating the Quality of Instruction**

Our model of teacher competence derives from the idea that effective teaching—that is, planning, structuring, and guiding lessons in such a way that they become powerful learning environments for students—is the key task to be mastered by all teachers. As an ongoing line of research in Research Area IV, we complement our recent work on teacher competence with studies examining dimensions of instructional quality in more detail. Classroom instruction can be described in various ways. As a first approach, it is often useful to describe the organizational structure of the learning environment, for instance, the general lesson scripts or the use of particular learning settings, such as whole class discussion, group work, or partner work. However, instructional research has shown that these surface features alone do not decide whether students will engage in insightful learning processes, and thus do not necessarily predict learning outcomes. In order to describe strengths and weaknesses of instruction, researchers need to examine the interaction between teacher and students in the instructional process in more detail. Within our theoretical framework, we

distinguish three aspects of the instructional interaction between teacher and students that are crucial for initiating and sustaining insightful learning processes. These general dimensions of instructional quality may be specified to describe instructional processes in various subjects; in our work, the focus has been on mathematics (see Figure 18). The first, subject-unspecific, dimension is *efficient classroom management*. How well is the class organized and how efficiently is time used? To initiate insightful learning processes, instruction should be structured in such a way that learning time is maximized and frictions between students and teachers are minimized. Second, given that opportunities for insightful learning in the mathematics classroom are determined primarily by the types of problems selected and the way they are implemented, we consider the frequency of *cognitively activating elements* of instruction. Cognitively activating tasks in the mathematics classroom might, for example, draw on students' prior knowledge by challenging their beliefs. Cognitive activation may also take place in class discussion if the teacher does not simply declare students' answers to be "right" or "wrong," but encourages students to evaluate the validity of their solutions for themselves. Third, we consider the *individual learning support* provided by the teacher. Studies based on motivational theories show that providing challenge is not enough to get students to engage in insightful learning processes, but that their learning activities need to be supported and scaffolded. Continuous diagnosis of difficulties and calibrated support that respects student autonomy is not only important for student motivation but is an essential component of a powerful instructional environment in terms of cognitive outcomes. Several studies conducted in Research Area IV have investigated these three dimensions of instructional quality from different perspectives. All of these studies seek to represent the complexity of classroom instruction in an authentic way, consider multiple outcomes—that is, students' domain-specific learning as well as their motivational development—and see learning as a co-constructive process in which instructional processes are actively

shaped by learners and teachers in interaction. Employing different methodological approaches, they address overarching questions, such as the following:

- To what degree are the three dimensions of instructional quality observable in classroom instruction and are there systematic differences, for instance, across school types?
- What is the specific impact of each quality dimension on students' learning and motivation?
- How can instructional quality be improved?

As shown by the research examples below, the three dimensions of instructional quality paint a comprehensive picture of the antecedents and consequences of high-quality instruction.

In-Depth Analyses of Mathematics Instruction Using Large-Scale Assessments

The Center for Educational Research has a long tradition of involvement in large-scale educational assessments, both national and international (see Research Areas I and II). One prime principle of our research is to use these data not only to report mean levels and changes in achievement but also to inform in-depth analysis of the instructional processes that may underlie the differences. Our current research program builds on earlier work carried out in the context of studies, such as BIJU, TIMSS, and PISA, which provided first insights into the features of classroom instruction essential for student learning. In these large-scale studies, instructional quality is typically assessed via student questionnaires (and sometimes teacher questionnaires). Supported by methodological analyses confirming the reliability and validity of this measurement approach, we have constructed a comprehensive battery of instruments to assess instructional quality in a valid and ecological way. In addition, as in our secondary analyses of the 1996 TIMSS Videotape Classroom Study, we have linked classroom observation data with student data. This has enabled us to describe, for example, how cognitively activating elements of instruction (e.g., in the tasks set or in teacher-student discourse) affect

student outcomes, including motivational development. Within the framework of the COACTIV study, we have taken another novel approach to measuring instructional quality by classifying the homework and exam tasks assigned by teachers in terms of their didactic potential. A standardized coding system has enabled us to describe the cognitive challenge of mathematics instruction in objective and detailed terms.

In sum, our in-depth analyses of large-scale data have shown that mathematics instruction in German secondary schools is not optimally suited to trigger insightful learning processes (Jordan et al., 2008; Kunter, Baumert, & Köller, 2007). In line with prior findings (e.g., based on TIMSS data), studies drawing on the PISA 2003 and COACTIV data show that German mathematics lessons typically focus on drilling routines rather than on developing conceptual knowledge. Our recent task analyses have shown that typical homework or exam tasks require only factual or computational knowledge, and that tasks requiring students to actively engage in mathematical problem solving and to link concepts or strategies are relatively rare. This low level of cognitive activation characterizes German mathematics instruction in general, but it is specifically pronounced in the non-academic tracks. At the same time, students in the nonacademic tracks report more individual learning support than their peers in the academic track. The school type-specific patterns of instruction, clearly apparent in German mathematics classrooms, are one explanation for the differential learning gains observed in the different tracks. However, even within tracks, there are substantial differences in instructional quality. The question now is what causes these differences. Our recent work has thus focused on teacher characteristics that may explain the observed differences in instructional quality.

Instructional Quality and Student Motivation: An Intraindividual Approach

The feelings and emotions that students experience on a day-to-day basis play an important role in their learning. In her dissertation project, Yi-Miau Tsai investigated

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how student motivation emerges and changes in the day-to-day classroom context. Drawing on self-determination theory, she hypothesized that autonomy-supportive instruction would enhance interest and competence perception in the classroom. Tsai investigated three specific aspects of autonomy-related instructional behavior: autonomy-supportive climate, controlling behavior, and cognitive autonomy support.

In addition, the project revisited the theoretical notion that motivational experience tends not to be solely situation-driven, but to derive from both the situation (e.g., teachers' instructional practice) and individual characteristics and resources. Tsai took a short-term intraindividual approach to examine how both the learning situation and individual motivational resources shape students' motivational experience. Specifically, the objectives of the project were (1) to describe the extent of intraindividual variability of students' motivation and emotion in daily lessons, (2) to predict the rise and fall of students' motivation and its correspondence to need-supportive climate in the classroom, (3) to investigate individual differences in the extent to which students are sensitive and reactive to environmen-

tal supports and constraints, and (4) to investigate the domain specificity of these relationships by collecting data on three school subjects.

A group of 261 grade 7 students and their teachers from two *Gymnasium* schools in Berlin participated in a lesson-specific assessment spanning three consecutive weeks. After each German, mathematics, and second foreign language lesson, a short questionnaire was administered to assess the students' experience and perception of the teacher's instructional behavior during the lesson. The students were also recruited for a follow-up assessment in grade 8.

Results from this project suggest that students' interest experience and felt competence in the classroom are not fixed entities (see Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008; Tsai, Kunter, Lüdtke, & Trautwein, 2008), and that both motivational resources and classroom instruction contribute to students' classroom experience. The findings make it clear that educators make a real difference to students' competence beliefs, values, and affect in learning situations. Furthermore, they provide insights into how it may be possible to generate motivating contexts in educational settings.

Supporting Students' Autonomy in Science Lessons: An Experimental Study

Cognitive activation and individual learning support are features that are also discussed in the context of new methods of problem-based or constructivist teaching, as advocated in recent reforms of science education. A common feature of these reform-based approaches is that they conceptualize teachers as providers of guidance and scaffolding more than as sources of authority, and students as actively engaged in the learning process rather than as passive recipients of knowledge. Although these reform-based approaches have gained a significant foothold, they have been found difficult to implement successfully, and their effectiveness in increasing student learning and motivation has yet to be proven. The small-scale experimental study "Supporting Autonomy in Science Activities (SASA)" has addressed these issues, investigating the effectiveness of a reform-based lesson script for students' learning and motivational development. The instructional experiment places a specific focus on autonomy support. Drawing on self-determination theory, it further categorizes autonomy-supportive classroom environments in terms of the procedural autonomy support (e.g., students are allowed to choose and handle their own experimental materials) and cognitive autonomy support they offer (e.g., students may find multiple solutions to problems, receive informative feedback, and are supported in the reevalua-

tion of misconceptions). A focus on these two categories of autonomy support may help to clarify the nature of the guidance that students need in reform-based learning contexts, and the ways in which their autonomy might best be supported. For example, students might benefit from support in reevaluating their misconceptions during a lesson (cognitive autonomy), but their learning might, in fact, be hindered by too much freedom to choose materials (procedural autonomy). To test this hypothesis, we conducted a study with a 2×2 pre-posttest experimental design, with conditions combining two levels of procedural autonomy (hands-off vs. hands-on activities) and cognitive autonomy (controlling vs. supportive). The treatment conditions were embedded in two lesson units in which students measured and graphed uniform and nonuniform motion. The lessons took place in the laboratory classroom at the Center of Educational Research (see Figure 25) and were delivered by two trained science teachers who followed semistandardized teaching scripts that varied according to the experimental condition. Students were allocated to the conditions through stratified random assignment. The experimental phase was successfully implemented and data analyses are currently in progress. In addition to standardized measures of achievement and motivation, observational data are being analyzed to learn more about critical differences in student-teacher interactions.

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Figure 25. Observation of a lesson in the SASA project.

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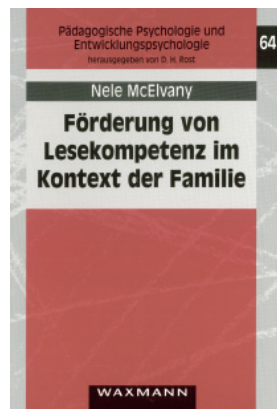
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