DEPARTMENT OF BIOLOGY EDUCATION

The Department of Biology Education at the IPN seeks to provide findings on teaching and learning biology in institutional as well as in informal settings. Thus we aim to foster biology as well as science understanding and trigger motivation to engage in biology. Recent work has focused on biology learning, with attention directed at the central biological concept *evolution*, and at the science concept *energy* investigating specific biological as well as interdisciplinary features of students' respective understanding in different age groups. In this context the question how to visualize biological concepts to make them tangible for learners as well as the evaluation of instructional strategies to teach these concepts are central. Besides addressing conceptual understanding we conducted studies to get insight into students' argumentation competencies in science and particularly in biology in comparison to argumentation in the humanities. Another focal point of our work is the identification of epistemological beliefs and their significance for science learning. Further work addresses questions referring to the structure and assessment of biology student teachers' and laboratory assistants' professional knowledge. Here we focus on the development of tests to assess professional knowledge of these groups. Thus we created the basis for our current studies to investigate the development of professional knowledge during university studies and vocational education, respectively. Also we engage in questions how the professional knowledge of student teachers in biology develops in the interplay with other aspects of teachers' professional competence like for example motivational orientations. Other foci of research are the biology–related science competitions that are hosted by the IPN. The department's research activities are mainly carried out in joint collaboration with either the other IPN departments or with national and international colleagues. Besides the empirical research conducted in the department we engage in transfer activities, for example in the life:lab of the Kieler Forschungswerkstatt where we focus on molecular biology and genetics.

Neubrand, C., Borzikowsky, C., & Harms, U. (in press). Adaptive prompts for learning Evolution with worked examples – Highlighting the students between the "novices" and the "experts" in a classroom. *International Journal of Environmental & Science Education (IJESE).*

Paulick, I., Großschedl, J., Harms, U., & Möller, J. (2016). Pre-service teachers' professional knowledge and its relation to academic self-concept. *Journal of Teacher Education (JTE), 67*(3), 173–182.

DEPARTMENT OF CHEMISTRY EDUCATION

The Department of Chemistry Education at the IPN combines empirical research with the development of educational practice. Foci have been set on student learning, both in school and beyond, and on teacher professionalization. All levels from kindergarten up to tertiary education have been investigated during the research period reported here.

Influences of learning environments on basic science knowledge and interests are investigated on the kindergarten level. At the same time we analyze professional competencies of preschool teachers and the relation to children's learning. On a secondary level the department has specifically developed and analyzed learning environments aiming to foster an understanding of structure–property relations, connected to aspects of energy exchange and chemical reactions. The design and analyses of context-based learning tasks and processes relates outcomes to instructional features. A current longitudinal analysis examines the development of understanding in relation to interest and motives for further engagement for the duration of school chemistry education. The results are and will be used to develop teacher training programs as well as scaffolds for transition phases. Related to school learning, the department develops and investigates competitive and non-competitive enrichment programs aiming to strengthen students' understanding of science and science career options. The accompanying research has characterized specific features of potential talents in science and evaluated exemplary enrichment approaches. These projects, as well as the department's long-standing tradition of managing the International Chemistry and Science Olympiads provide the foundation for further investigations into development processes during enrichment activities. The new Leibniz ScienceCampus Kiel Science Outreach Campus (KiSOC) will consolidate research and development for outreach activities.

Broman, K., Bernholt, S., & Parchmann, I. (2015). Analysing task design and students' responses to context-based problems through different analytical frameworks. *Research in Science & Technological Education, 33*(2), 143–161.

Steffensky, M., Gold, B., Holodynski, M., & Möller, K. (2015). Professional vision of classroom management and learning support in science classrooms – Does professional vision differ across general and content-specific classroom interactions? *International Journal of Science and Mathematics Education, 13*, 351–368.

DEPARTMENT OF EDUCATIONAL MEASUREMENT

The Department of Educational Measurement was established as an independent department of the IPN in 2015 and includes a team of educational researchers, psychometricians, and psychologists. In its research the department addresses statistical and methodological challenges in educational research and large-scale assessment studies. The primary focus is on three research topics: First, data structures in educational research often have a multilevel structure (e.g., students nested within schools). Multilevel modeling techniques that deal with these data structures are further improved and evaluated using simulation studies. A special focus is on the evaluation of the potential of alternative estimation approaches such as Bayesian approaches in problematic data constellations (e.g., small sample sizes). Second, competencies and other educational constructs are often assessed using complex measurement designs. Psychometric latent variable models are evaluated that take into account the complexities of these designs (e.g., item context effects) when assessing differences between groups or modeling longitudinal change. Third, missing data represent a pervasive problem in educational research. For example, it is often the case that students do no respond to all items in a questionnaire or even refuse to participate in a study. Different approaches (multiple imputation, structural equation modeling) for dealing with missing data are compared and recommendations for research practice provided on the basis of comprehensive simulation studies. In addition, statistical software is developed that allows for an easy implementation of the different strategies for handling missing data. The department is complemented by the independent junior research group "Personality development in educational contexts" (Dr. Jenny Wagner) jointly established with the Department of Educational Research, which uses innovative longitudinal designs and methods to better understand and describe developmental processes across the lifespan in different educational contexts. In addition, the department contributes to the IPN graduate school offering workshops for doctoral candidates that are also accessible for more advanced colleagues.

Lüdtke, O., Robitzsch, A., & Grund, S. (in press). Multiple imputation of missing data in multilevel designs: A comparison of different strategies. *Psychological Methods.*

Zitzmann, S., Lüdtke, O., Robitzsch, A., & Marsh, H. W. (2016). A Bayesian approach to estimating latent contextual models. *Structural Equation Modeling, 23*, 661–679.

DEPARTMENT OF EDUCATIONAL RESEARCH

The Department of Educational Research focusses on empirical research on teaching and learning from an institutional and psychological perspective. Most activities can be classified according to three core research foci. The first research focus is on cognitive, psychosocial, and health characteristics of (prospective) teachers which also affect teachers' professional behavior and student outcomes. The department's second research focus is on individual academic development and its individual and contextual prerequisites. Hence, we use longitudinal designs to investigate how student characteristics like family and social background, cognitive abilities, or motivation affect individual development in different academic contexts such as school track, student composition, or vocational trainings particularly during transitions (cf. e.g., Chapter 2). The third focus has a strong infrastructural character combining scientific service with research in educational assessment (cf. Chapter 4). Research-based services refer on the one hand to the IPN's involvement in the international large-scale assessments Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), and International Computer and Information Literacy Study (ICILS), and on the other hand to test development in the context of the German National Educational Panel Study (NEPS). Research in educational assessment focusses on questions concerning the validity of tests and their interpretation. In a psychometric vein, the projects particularly focus on the comparability of mathematics and science tests from different national and international large-scale assessments. In addition, experimental studies are conducted to better understand information processing while students are working on multiple-choice (MC) items, some of them employing eye-tracking methodology.

Guill, K., Lüdtke, O., & Köller, O. (2017). Academic tracking is related to gains in students' intelligence over four years: Evidence from a propensity score matching study. *Learning and Instruction, 47*, 43–52.

Lindner, M. A., Eitel, A., Strobel, B., & Köller, O. (2017). Identifying processes underlying the multimedia effect in testing: An eye-movement analysis. *Learning and Instruction, 47*, 91–102.

DEPARTMENT OF MATHEMATICS EDUCATION

The Department of Mathematics Education researches the prerequisites, conditions, processes, and results of mathematics education as well as its interrelations with the learning in other science- and engineering-related domains. It examines educational processes in relation to mathematics across the lifespan from preschool to university education. Main research foci are the development of student competence in mathematics and the professional competence of mathematics teachers.

Current research projects on mathematical competence development address the transition from kindergarten to elementary school as well as from secondary school to university. In an ongoing longitudinal study with 130 elementary school classes we investigate the role of individual learning prerequisites at the time of school enrollment, mathematics curriculum topics, and environmental conditions like mathematics textbooks for children's development in mathematics during elementary education. Research on the transition from school to university focused the development of valid and reliable tests measuring mathematical competence of freshmen. The devised tests allow the investigation of first-year students' development in mathematics.

The department's research on teachers' professional competence addresses two aspects. First, we validated a model of preservice teachers' subject-specific knowledge. Data of 500 preservice teachers supported a three-dimensional model distinguishing scientific content knowledge as it is taught at universities, school-related content knowledge, which covers a link between scientific and school mathematics, and pedagogical content knowledge. Second, we developed approaches to measure subject-specific competence of in-service teachers using an extended structure model of reflective and action-related competences. In order to closely implement the teaching demands, we used item formats based on video-vignettes. Resulting instruments target mathematics teachers on secondary, elementary, and kindergarten level and are used to further research on the nature and development of teacher competence.

Neumann, I., Rösken-Winter, B., Lehmann, M., Duchhardt, C., Heinze, A., & Nickolaus, R. (2015). Measuring mathematical competences of engineering students at the beginning of their studies. *Peabody Journal of Education, 94*(4), 465–476.

Knievel, I., Lindmeier, A. M., & Heinze, A. (2015). Beyond knowledge: Measuring primary teachers' subject-specific competences in and for teaching mathematics with items based on video vignettes. *International Journal of Science and Mathematics Education, 13*(2), 309–329.

DEPARTMENT OF PHYSICS EDUCATION

In 2015–2016, research in the Department of Physics Education has focused primarily on the development of student competence in physics, professional knowledge and competence of teachers, and the role of extracurricular offerings in supporting student learning and engagement in physics.

Through several internal, cross-institutional, and international projects, the department has investigated how students develop well-structured knowledge for the core physics ideas of matter and energy. This work has revealed the importance of focusing on a small set of aspects of these core ideas over time, and the department is continuing to investigate the influence of coherent curriculum on helping students develop well-structured knowledge of core physics concepts.

Physics competence includes both understanding of core science concepts and ability to engage in science practices. To explore how to support student competence in science practices, the department has investigated how physics instruction can best support students' ability to design and conduct controlled scientific experiments.

To investigate teacher professional knowledge and competence, the department has focused on testing and extending a developmental model of teacher professional competence that specifies the relationship between key dimensions of teacher knowledge, beliefs, and experiences in school. Our findings contribute to a broader understanding of how to support preservice and induction phase science teachers.

To study the role of extracurricular activities on physics learning and engagement, the department has worked with external partners such as the International Physics Olympiad and the student laboratory Kieler Forschungswerkstatt to investigate factors affecting girls' persistence in physics competitions and to study how interacting with technologies like thermal imaging cameras can support students' interest and learning in physics.

In the coming years, the department will extend its work in the respective research lines and continue its collaborations with partners in Germany and throughout the world to advance our understanding of how physics learning can be supported in both formal and informal settings.

Hadenfeldt, J. C., Neumann, K., Bernholt, S., Liu, X., & Parchmann, I. (2016). Students' progression in understanding the matter concept. *Journal of Research in Science Teaching, 53*, 683–708.

Schwichow, M., Croker, S., Zimmermann, C., Höffler, T., & Härtig, H. (2016). Teaching the control-of-variables strategy: A meta-analysis. *Developmental Review, 39*, 37–63.