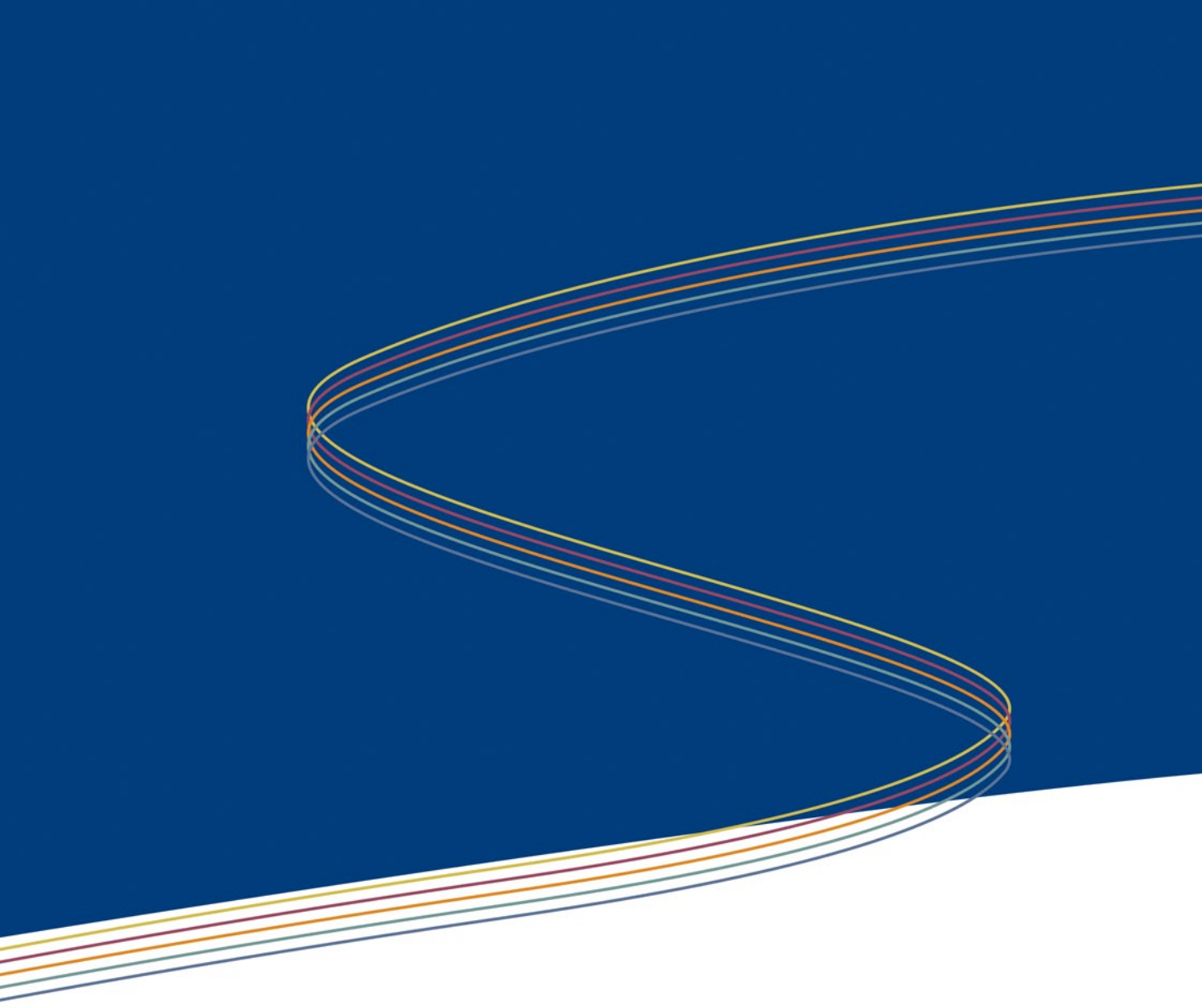

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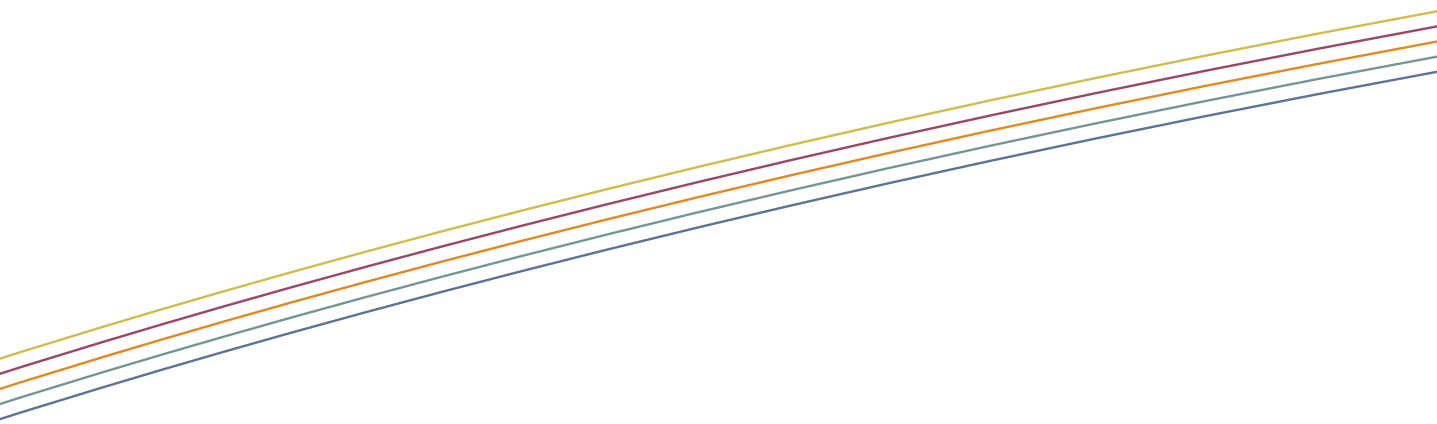

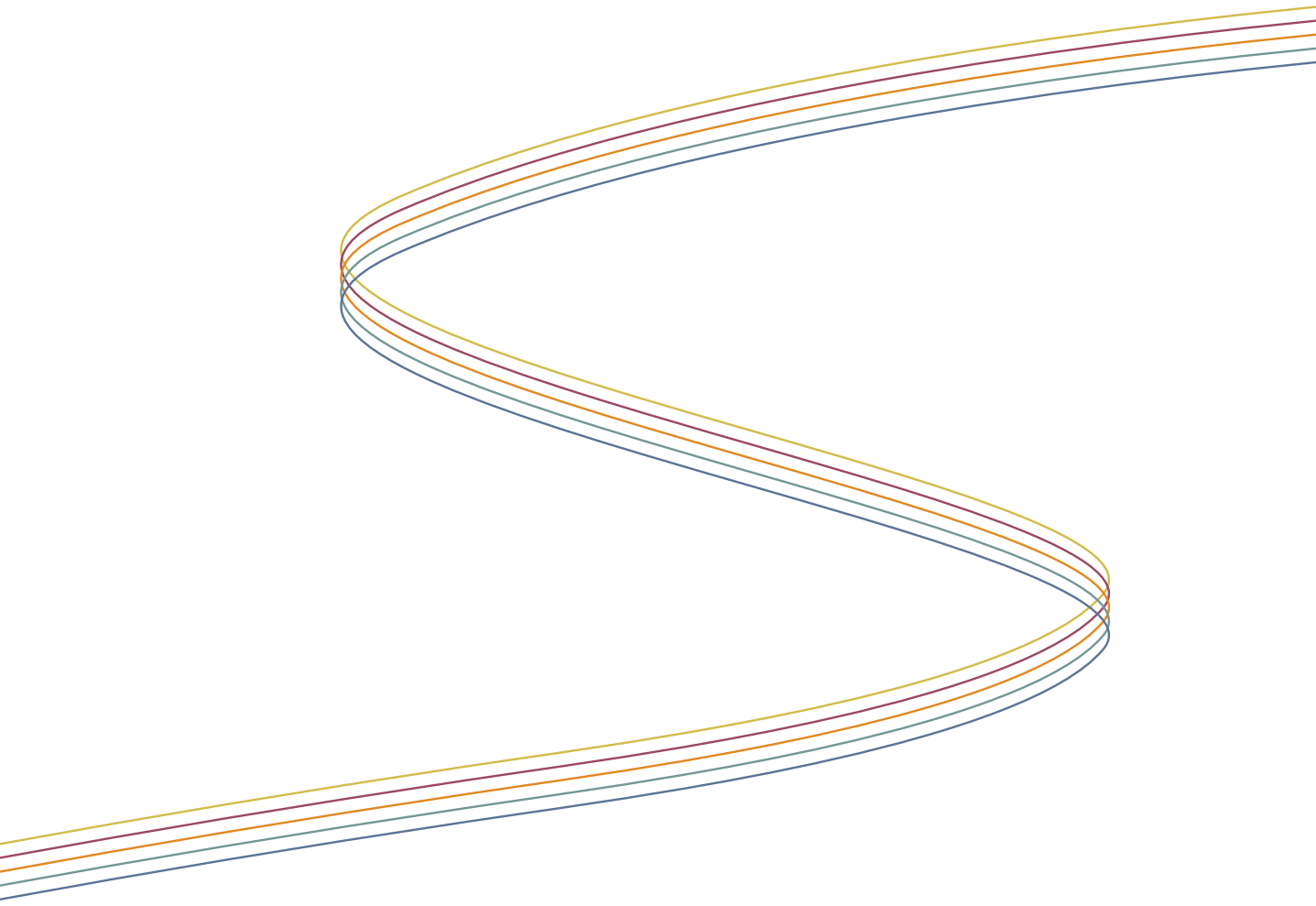

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EDITORIAL TEAM	Julia Arnold, Olaf Köller, Irene Neumann, Stefan Petersen, Ute Ringelband, Kerstin Schütte, Julia Schwanewedel
DESIGN / LAYOUT / TYPE SET	Sonja Dierk, Selina Schnetger, Karin Vierk / IPN
COVER DESIGN	Sonja Dierk, Selina Schnetger, Karin Vierk / IPN
DOCUMENTATION / PUBLICATIONS	Alexandra Jobmann
ENGLISH EDITING / TRANSLATION	Dorothy Duncan (pp. 32–49), Cornelia Gerigk (pp. 10–31; 50–170), Ulrike Hemstock (pp. 5–9)
PRINT	Schmidt & Klaunig, Kiel
PHOTOS	p. 9 © Britta Hüning / fotorismus für LERN p. 11 © Karin Vierk / IPN; p. 12 © Emanuel Kaiser, Sonja Dierk / IPN p. 15 © WavebreakmediaMicro / Fotolia.com; p. 29 © Christian Schwier / Fotolia.com; p. 32 © grimaldello / Fotolia.com; p. 35 © contrastwerkstatt / Fotolia.com p. 37 © auremar / Fotolia.com; p. 38 © industrieblick / Fotolia.com; pp. 40 / 42 © goodluz / Fotolia.com; p. 44 © auremar / Fotolia.com pp. 55 / 58 © Sonja Dierk / IPN; p. 65 © IPN; p. 66 © Sonja Dierk / IPN; p. 70 © IPN; p. 74 © Sonja Dierk / IPN p. 77 © goodluz / Fotolia.com; p. 80 © gpointstudio / Fotolia.com p. 84 © Syda Productions / Fotolia.com; p. 92 © Monkey Business / Fotolia.com; p. 97 © Robert Kneschke / Fotolia.com p. 105 © Karin Vierk / IPN; p. 111 © Sonja Dierk / IPN; p. 119 © Lorenz Kampschulte / IPN pp. 122 / 124 / 126 / 128 / 130 / 132 © IPN p. 135 © connel_design / Fotolia.com

IPN · Leibniz Institute for Science and Mathematics Education

Olshausenstrasse 62
24118 Kiel, Germany

Postal address:
IPN · 24098 Kiel, Germany

Tel.: +49 431 880-5084
Fax: +49 431 880-5212

csec@ipn.uni-kiel.de
www.ipn.uni-kiel.de

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PREFACE

IPN – 50 Years of Research in Domain-Specific Teaching and Learning

In 2016, the Leibniz Institute for Science and Mathematics Education (IPN) celebrated its 50th anniversary – it was founded in 1966 as a research institute for science education. Since its expansion in 2008, the IPN's research agenda also comprises mathematics education. As an institute of the Leibniz Association the IPN receives basic funding from the federal government and the federal states (Länder). The Leibniz Association is a network of 88 scientifically, legally, and economically independent research institutes and scientific infrastructure facilities in Germany. Leibniz institutes perform strategic topic-oriented research and offer scientific services with national impact while striving to find scientific solutions for major societal challenges. The IPN is closely affiliated with Kiel University. The six department heads of the IPN hold full professorships at Kiel University. Future generations of teachers trained at Kiel University thus benefit directly from new insights into science and mathematics teaching and learning. The IPN and Kiel University also collaborate on a variety of joint research projects.

Professor Olaf Köller, IPN Managing Director of Research.

To advance and promote science and mathematics education through research, the IPN investigates domain-specific teaching and learning processes from a multi-level perspective. The IPN's research approach is based on six core assumptions:

- Mathematics and science education is a central prerequisite for successful individual participation in society.
- The achievements in mathematics and science education are dependent on the interplay of individual resources (antecedents) on the one hand, and in-school and out-of-school opportunity structures on the other hand.
- The nature and structure of in-school learning opportunities are the result of processes of social negotiation that occur at various levels (education systems, school supervisory authorities, schools, classes) and have considerable effects on students' educational pathways.
- Out-of-school opportunities to learn are determined mainly by family background and peers, and are much less amenable to societal influence. However, mathematics and science learning can be facilitated, for example, by out-of-school learning sites (learning laboratories, museums, etc.).
- The research on, and advancement of, mathematics and science education requires an empirical approach that – drawing on expertise in the respective disciplines – requires quantitative and qualitative

research methods of the social and natural sciences and is interdisciplinary.
- Subject-based educational research across multiple disciplines requires close collaboration between the various disciplines represented at the IPN. At the same time, the increasingly complex research questions require collaboration with experts of additional disciplines through research associations.

From Research Areas to Research Lines: Changes in 2015 and 2016

Until the end of 2015, the IPN's organization followed a matrix concept consisting of a dimension of departments and a dimension of Research Areas. However, the IPN's current major research projects do not allow for such a structure any longer, because they cannot clearly be allocated to one department or one Research Area. For this reason, the IPN followed its Scientific Advisory Board's explicit recommendation and implemented comprehensive Research Lines in 2016. As the former Research Areas, these Research Lines allow for research across departments and disciplines; in addition, they demonstrate the IPN's focus on investigating educational processes across the lifespan. The Research Lines at the IPN further highlight the fact that the institute's work in educational research is highly relevant for society at-large and follows the Leibniz' mission of *theoria cum praxi*. Based on this perspective the IPN pursues the following five Research Lines:

- Educational Processes in Preschool Education
- The Development of Competencies in School and Their Importance for Transitions Within the Education System
- Professional Competence
- Science Communication and Enrichment
- Methodological Research and Software Development

These Research Lines do not form strictly separated work areas, but rather have theoretical and empirical overlap. For example, professional development of preschool teachers is studied in Research Line 1 (Educational Processes in Preschool Education) but calls for close cooperation with Research Line 3 (Professional Competence). The IPN disposes of a cohesive structure within which these five Research Lines are addressed. Specifically, the institute has six departments: Biology Education, Chemistry Education, Educational Measurement, Educational Research, Mathematics Education, and Physics Education. This organization by disciplines reflects the idea that in-school and out-of-school educational processes are to a considerable extent domain-specific, and that their systematic inves-

tigation requires researchers with high expertise in the respective subject and its teaching. The Department of Educational Research complements this domain-specific approach by providing a generic, educational, and psychological perspective on learning and instruction research. With its expertise in statistical and methodological procedures, the Department of Educational Measurement helps to firmly establish the state-of-the-art in social scientific research throughout the institute. The departmental structure facilitates a high level of research quality and its visibility in each discipline. It also entails that all researchers remain actively engaged in their respective reference disciplines and that this subject-specific expertise is reflected in the junior scientists' qualifications.

The six departments collaborate within the five Research Lines specified above. Large, mainly longitudinal, research projects with national significance are complemented by smaller micro-analytically based projects, often funded by the German Research Foundation (DFG) or the Federal Ministry of Education and Research (BMBF). The IPN conducts many projects that require the infrastructure of a research institution due to their design and duration; it thus conduces to scientific progress in a way impossible for universities.

The current biennial research report covers the two years that mark the transition from Research Areas to Research Lines. The Board of Directors therefore decided to publish a research report that neither reflects the Research Areas nor the Research Lines but rather the large central research projects conducted in 2015 and 2016. These projects, however, fit nicely into the five newly established Research Lines.

IPN Board of Directors *(from left to right)*: Bent Hinrichsen (Administration), Ilka Parchmann (Chemistry Education), Oliver Lüdtke (Educational Measurement), Knut Neumann (Physics Education), Olaf Köller (Educational Research), Aiso Heinze (Mathematics Eduation), and Ute Harms (Biology Education).

Cooperation Within Research Networks

In recent years the IPN was able to significantly expand the institute's national and international research networks. The cooperation with the local Kiel University has been extended, particularly in research on professional competence in teacher education and the science-based development of outreach concepts for knowledge transfer to society. A number of joint projects in the field of professional competence were made

possible by successful bids in the Leibniz Association's competition (Senatsausschuss Wettbewerb, SAW). In the area of science outreach, the IPN and Kiel University were able to secure funding for establishing a Leibniz ScienceCampus funded for four years by the Leibniz Association, the federal state of Schleswig-Holstein, Kiel University, and the IPN.

With regards to strategic expansion, the IPN is strongly involved in the two Leibniz Research Alliances Education Research and Energy Transition. The bi- and multi-lateral cooperation established within the Leibniz Education Research Alliance will be expanded and further strengthened in the coming years.

In the field of large-scale assessment, the IPN is one of the three institutions – next to the Technical University of Munich and the German Institute for International Educational Research (DIPF) – constituting the Centre for International Student Assessment (ZIB), which is funded by the BMBF and the federal states. As for the previous survey, the center was responsible for the national project management (NPM) of the Programme for International Student Assessment (PISA) 2015. In addition to the NPM, the ZIB focusses on research in educational measurement. In 2015, the ZIB received a positive evaluation and will continue its work at least until 2022.

On an international level, the IPN has initiated or intensified collaborations with renowned universities and research institutions in the Netherlands, Switzerland, Luxemborg, Denmark, England, Sweden, Norway, Israel, the United States, Australia, and Chile.

Gender Equality and Family-Friendly Institute

The IPN is an equal opportunity employer with a strong and committed interest in affirmative action to promote gender equality. A major aim, with regards to equal opportunities, is a significant increase of women in leading positions. Target numbers have been defined by the so-called cascade model in which a defined percentage of women must propagate upwards through all academic levels. In order to achieve this important goal, the IPN carries out a variety of actions at different levels of the scientific career. To increase the opportunities of high-potential female post-docs, the IPN has introduced three positions for female independent junior researchers (in line with the Emmy Noether Programme of the DFG).

One of the IPN's approaches to establish equal opportunities is creating family-friendly conditions for studies, teaching, and research. The basic certificate attesting to the IPN's family-friendly human resources policy was already awarded in 2006. Since then the IPN success-

fully completed the re-audit in 2009, 2013, and 2016. Among the measures taken, the IPN is continuously working to extend the childcare service. Thus, working parents receive support to progress in their research and thereby their academic careers.

Support for the Doctoral Students

The doctoral students at the IPN (65% salary level TVL E 13) are members of the IPN graduate school and participate in its structured program; the IPN graduate school was established in 2013. Under the program's curriculum, students are required to participate in lectures, seminars, and workshops, which are designed to introduce students to the methodological aspects of educational research and to provide training in qualitative and quantitative research. Courses also offer instruction in univariate and multivariate statistics, with a focus on procedures used in non-experimental social research (regression and factor analyses, structural equation modeling). With regards to their own thesis, the IPN's doctoral students receive interdisciplinary support from two mentors (usually at the post-doc level), each mentor representing a different discipline (e.g., Biology Education and Chemistry Education, or one science subject accompanied by psychology or educational science). All doctoral students also have the opportunity to spend three to six months abroad, with financial support from the IPN.

And Finally Our Thanks

The IPN's research is made possible by the support of numerous funding bodies. On behalf of all IPN employees, I would like to thank them for financing our work. Our thanks also goes to the IPN's Foundation Board and to the Scientific Advisory Board, who have monitored our work over the past two years and provided valuable guidance. Most importantly, I would like to express our gratitude to the many children, adolescents, and adults who contributed their time and effort which allowed us to advance and promote science and mathematics education through our empirical research.

Professor Olaf Köller
IPN Managing Director of Research