

MAPPING COMPETENCY ACQUISITION IN HIGHER EDUCATION AND ITS INFLUENCES – A META-STUDY

MAPEO DE LA ADQUISICIÓN DE COMPETENCIAS EN LA EDUCACIÓN SUPERIOR Y SUS INFLUENCIAS - UN META-ESTUDIO

Miriam Toepper

Olga Zlatkin-Troitschanskaia

Dominik Braunheim

ABSTRACT

Introduction: In the 10-year research program "Modelling and Measuring Competencies in Higher Education (KoKoHs)" that ran from 2011 until 2020, more than 100 theoretically sound models and corresponding tests were developed to analyze the level and development of students' competencies. Using these newly developed assessments, generic and domain-specific competencies of more than 75,000 students at more than 350 German universities in numerous disciplines (e.g., economics, teacher education) were measured in 39 interdisciplinary collaborative KoKoHs projects.

Method: In these measurements, a nationally and internationally unique database was created that contains information on the level, acquisition, and development of competencies, as well as corresponding personal and contextual influences, among students at different stages throughout their studies. A comprehensive meta-analysis of the students' competencies as well as of the central factors influencing the acquisition of competencies in higher education had not been conducted so far. The existing KoKoHs data had only been analyzed in isolation within the individual KoKoHs projects until then. Accordingly, the obtained results related only to the individual project level. To address this research deficit, the meta-study presented in this paper conducted a research synthesis, i.e., a systematic and structured meta-analysis of the KoKoHs database.

Results: The meta-study describes the acquisition of competencies in higher education across domains and provides empirical evidence on generalizable versus specific influencing factors and, thus, evidence-based practical knowledge for higher education practice and policy.

Key words: Academic competence, Domain-specific skills, Generic skills, Tests, Assessments, Higher Education, Meta-analysis

RESUMEN

Introducción: Durante los 10 años del programa de investigación "Modelización y medición de competencias en la educación superior (KoKoHs)", entre el 2011 y 2020, se desarrollaron más de 100 modelos teóricos junto con las pruebas correspondientes para analizar el nivel y el desarrollo de las competencias de los estudiantes. Utilizando estas nuevas métricas de evaluación, se midieron las competencias genéricas y de áreas específicas de más de 75.000 estudiantes en más de 350 universidades alemanas en numerosas disciplinas (por ejemplo, economía, formación de profesores) en 39 proyectos interdisciplinarios en colaboración con KoKoHs.

Métodos: Con estas mediciones se creó una base de datos única a nivel nacional e internacional que contiene información sobre el nivel, la adquisición y el desarrollo de competencias, así como las correspondientes influencias personales y contextuales, de estudiantes en diferentes etapas a lo largo de sus estudios. Hasta ahora no se había realizado un meta-análisis exhaustivo de las

competencias de los estudiantes ni de los factores centrales que influyen en la adquisición de competencias en la educación superior. Los datos existentes de KoKoHs sólo se habían analizado hasta entonces de forma aislada dentro de los proyectos individuales de KoKoHs. Como consecuencia, los resultados obtenidos se referían únicamente al nivel de proyecto individual. Para subsanar este déficit de investigación, el meta-estudio que se presenta en este documento realizó una síntesis de la investigación, es decir, un meta-análisis sistemático y estructurado de la base de datos de KoKoHs.

Resultados: El meta-estudio describe la adquisición de competencias en la educación superior en diferentes áreas del conocimiento y proporciona pruebas empíricas contrastando los factores que influyen la adquisición de conocimientos específicos y generales. Por tanto, este estudio provee resultados basados en evidencia empírica para informar de manera práctica la reglamentación de la educación superior.

Palabras clave: Competencia académica, Habilidades en áreas específicas, Habilidades genéricas, Pruebas, Evaluaciones, Educación Superior, Meta-análisis

Date of receipt: 31 march 2021.

Date of acceptance: 14 may 2021.

1. INTRODUCTION

This paper presents the KoKoHs-Map project: “Mapping Competency Acquisition in Higher Education and its Influences. A Meta-study on the Results of the KoKoHs Funding Programs (2011-2020),” its background (Section 1.1), research questions (Section 1.3), conceptual and methodological framework, underlying data and limitations (Section 2). Based on the meta-overview of the central results (Section 3), implications for practice (Section 4) and further research (Section 5) are outlined.

1.1 PROJECT BACKGROUND IN (GERMAN) HIGHER EDUCATION RESEARCH, POLICY, AND PRACTICE

Educational policy reforms and societal developments have changed higher education (HE) extensively in recent decades (OECD 2015). In the European Union, the Bologna reform resulted in far-reaching restructuring in HE (Adelman 2009), which aimed at focusing more strongly on students ‘learning outcomes’ (Zlatkin-Troitschanskaia et al. 2015; 2017a; Coates 2014; OECD 2015). In Germany, the reform’s implementation was characterized by an increased orientation of study programs, courses, and examinations towards ‘students’ competencies’ (HRK [German Rectors’ Conference] 2012). With the policy, questions about the effectiveness and efficiency of HE regarding its three main goals – research orientation, labor market focus (“employability”), and personal development – gained in importance (Wissenschaftsrat [German National Science Council] 2015). The output and outcomes of HE, as well as quality assurance and development, have been examined for the last decade (Zlatkin-Troitschanskaia et al. 2016; 2017a; 2018; Blömeke et al. 2013; OECD 2012).

Societal developments, such as the ongoing expansion of HE and progressive internationalization, including increased international mobility and digitalization, pose long-term challenges for HE (OECD 2008; 2012; 2015). The heterogeneity of the student body has increased in terms of their demographic, social and cultural background, their previous education, and their study entry requirements (e.g., prior knowledge) (Brändle & Häuberer 2015). Currently, social inequalities are increasingly shifting from upstream levels of the education system to HE (Lörz et al. 2016). Mechanisms of social selection can be observed in access to HE, the degree programs and educational institutions chosen, stays abroad during studies, as well as dropouts and changes of study programs (Müller & Schneider 2013; Reimer & Pollak 2010). A lack of equal opportunities has been observed with regard to gender and migration background in several study domains, such as the STEM disciplines (science, technology, engineering, and mathematics) and economics. This is also reflected in constantly high failure rates in HE (Heublein 2014; Klöpping et al. 2017). Fair opportunities for all students in accessing HE and during their studies, as well as appropriate differentiated and effective learning opportunities to achieve the targeted learning outcomes and competencies in the heterogeneous student body, must be provided. This objective is considered one of the greatest tasks and challenges for HE in the 21st century (OECD 2014; 2015).

Taking into account the three central dimensions of HE in the 21st century – *professional knowledge*, *employability* and *personal development* (Wissenschaftsrat [German National Science Council] 2015) – this ‘triad’ is consistent with a holistic concept of competence in empirical educational research (Blömeke et al. 2015; Weinert 2001). Accordingly, HE not only focuses on the acquisition of domain-specific knowledge, but also on the development and promotion of so-called interdisciplinary, generic competencies, which are becoming increasingly important according to current surveys in industry and business (DIHK 2015; Wagenaar 2017). Such a portfolio of competencies, acquired during HE studies, should allow graduates to pursue a successful professional career as well as enable lifelong learning, which is necessary in an increasingly changing world of work (NRC 2012; Rychen & Salganik 2003).

Up until the previous decade, there was little evidence-based knowledge, especially about the learning outcomes and (actually acquired) competencies of HE students and graduates (Zlatkin-Troitschanskaia et al. 2016; Coates 2014). This highly critical deficit, also for HE policy and practice, was primarily due to the fact, that there were hardly any theoretical-conceptual models that enabled a differentiated and precise description of competencies to be acquired during studies in HE (Kuhn & Zlatkin-Troitschanskaia 2011). About ten years ago, there was also a lack of tests, both at the international and national level, to measure competencies and their acquisition in HE objectively, validly and reliably (see the meta-analysis by Zlatkin-Troitschanskaia et al. 2016; Coates 2014). An analysis of the national state of research in 2010 (Kuhn & Zlatkin-Troitschanskaia 2011) on the assessment of student competencies documented considerable systematic deficits in assessment practice in Germany and in competence research in HE, which contradicted current developments and challenges of competence orientation. A study by the German National Science Council (Wissenschaftsrat 2012) revealed that the traditionally established assessments in HE in form of grades say little about the competencies actually acquired by students and are hardly comparable across Germany (or internationally).

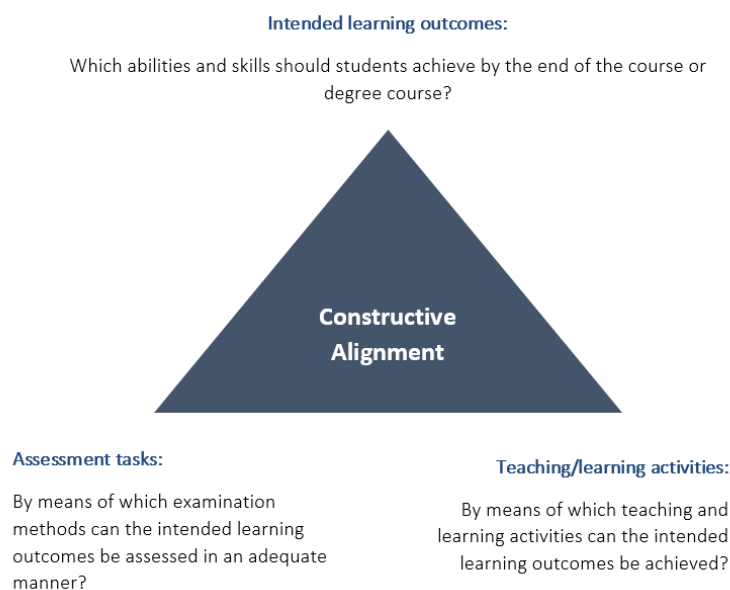
1.2 THE KOKOHS PROGRAMS (2011-2020)

To develop effective measures to address the challenges outlined above, well-founded empirical findings on acquisition and development of academic competencies in HE and their main influencing factors in teaching and learning are required. To this end, the research program “Modelling and Measuring Competencies in Higher Education (KoKoHs)” was established by the German Federal Ministry of Education and Research (BMBF) in 2011. In the last decade, central facets of academic competencies and their influencing factors in major study disciplines selected in KoKoHs were comprehensively analyzed.

Over the course of two consecutive funding phases, “Competence Modelling and Assessment in Higher Education” and “Competence Models and Instruments for Competence Assessment in Higher Education - Validations and Methodological Innovations” (hereinafter referred to as “KoKoHs 2011-2020”), theoretical-conceptual and empirical analyses were carried out for selected study domains such as teacher education and economics as well as for generic, cross-domain competencies. Theoretical-conceptual competency models (based primarily on subject didactics and learning psychology) and corresponding measurement instruments were developed and comprehensively validated according to the international standards for educational and psychological tests (AERA et al. 2014).

Concerning the theoretical-conceptual modeling of academic competencies in KoKoHs, a holistic notion of competence (Weinert, 2001) that goes far beyond individual domain-specific knowledge and cognitive skills has been established in competence-related empirical educational research in Germany. Weinert’s definition (2001, p. 2433) of competencies as “combinations of those cognitive, motivational, moral, and social skills available to (or potentially learnable by) a person [...] that underlie the successful mastery through appropriate understanding and actions of a range of demands, tasks, problems, and goals” was adopted for higher education contexts focused in the KoKoHs research program. In the course of KoKoHs, this holistic understanding of competence has been further developed. According to Blömeke, Gustafsson and Shavelson (2015), competencies can be described as a continuum that includes complex cognitive characteristics and affective-motivational facets underlying observable behavior of students. Cognition and affective-motivational facets are considered components of disposition. These are linked to situation-specific skills, for instance the perception, evaluation and interpretation of a situation, and the final decision to act accordingly. These skills are closely interlinked and ultimately lead to specific actions, equated with performance, which in turn can be predicted by disposition.

Figure 1: ‘Constructive alignment’ triad (based on Biggs & Tang 2011)



Source: Zlatkin-Troitschanskaia et al. 2017a, p. 4

The development of corresponding test instruments follows the model of “curriculum-instruction-assessment triad” by Pellegrino et al. (2001) that propose the closed “constructive” alignment between competencies/students’ outcomes to be measured, curricular content to be addressed in these assessments, and the implications for academic instruction to be then based on the assessment results (see Figure 1). More specifically, the design of the KoKoHs assessments was based on the key phases as defined in the evidence-centered approach (Mislevy et al. 2003; Mislevy 2016).

The developed models and assessments allow for the description and measurement of students' competencies and their acquisition through HE (entry phase, course of studies, transition into the profession) in a differentiated and reliable manner. The more than 100 model-based tests, including innovative video-, computer- and simulation-based performance assessments, have been successfully tested throughout Germany. The assessments developed and validated in KoKoHs allow for the objective and reliable measurement of students’ domain-specific and generic competencies that students acquire in the course of their studies, that graduates require in their careers and that employers expect in the professional and social context of the 21st century. Over the last decade, partially representative samples of over 75,000 students and graduates from various study domains at more than 350 universities nationwide were assessed in cross-sectional or longitudinal validation studies (Zlatkin-Troitschanskaia et al. 2014; 2016; 2018; 2020b) (For a comprehensive and differentiated documentation on all developed KoKoHs assessments and their central quality criteria and areas of application, see Zlatkin-Troitschanskaia et al. 2020b). The validation studies produced a nationally and internationally unique database that promises far-reaching insights into the level and development of student competencies in their selected facets; that includes empirical indications regarding central personal and contextual factors/conditions that can significantly influence the acquisition of competencies in HE. Subsequently, based on these assessments, the answers to the questions of *how competence facets are developed in central study domains and how their acquisition can be effectively promoted in HE* can be expected to carry fundamental implications for curricula and instruction in the academic domains focused on in KoKoHs as well as for HE policy and practice in general. To this end, an overarching structured analysis and

synthesis of the entirety of KoKoHs data and results on competence acquisition and their influencing factors in HE has been conducted (see the next Section).

1.3 KOKOHS MAP: FOCUS AND RESEARCH QUESTIONS

Prior to KoKoHs-Map, the results and findings obtained only referred to the individual project level of the 39 collaborative interdisciplinary projects in KoKoHs (for an overview, see Zlatkin-Troitschanskaia et al. 2017a; 2020a, b). This substantially limited the possible depth and explanatory power of the findings. Moreover, the analyses so far available in the individual KoKoHs projects naturally focus on the single competence facets, influencing factors, and study programs or domains for which project-specific competence models and tests were developed and tested.

A research synthesis, i.e., a systematic and structured meta-analysis (Borenstein et al. 2010; Hunter & Schmidt 1990; Roberts et al. 2007; for education sector, e.g., Montgomery & Rupp 2005) of the present (inter)nationally unique database from KoKoHs, promises to describe the acquisition of competencies in HE across study programs and domains, as well as to generate empirical indications of generalizable versus specific influencing factors or conditions for success in HE and, thus, to provide evidence-based knowledge for HE practice and policy. In this context, analyses are particularly relevant which, in addition to factors specific to HE, also allow for the identification of domain-, group- and student-specific factors that go beyond the focus of individual KoKoHs studies and could thus provide an essentially systematic basis of knowledge.

Hence, the *overarching objective of the KoKoHs-Map project* is:

- (1) on the basis of a conceptual and methodological framework specifically developed for KoKoHs-Map (see Section 2.2.1 and 2.2.2),
- (2) to create a unified (secondary) database based on the information and findings from the individual KoKoHs projects (see Section 2.2.3), and
- (3) to analyze this data systematically in the sense of a research synthesis, to produce, in addition to *a mapping of the research landscape on competencies in HE*, a differentiated analysis on the level of competencies and the central factors influencing the acquisition of competencies by students and graduates.

Thus, for the first time, a KoKoHs cross-program overview of

- (i) data collected in the KoKoHs projects and
- (ii) findings obtained is merged, which, as a systematic and structured representation, allows a mapping of empirical competence research in HE.

Secondly, through overarching secondary analyses of the data base, a systematic reappraisal and consolidation of the hitherto individual and isolated research findings from the KoKoHs projects is carried out. Based on the research synthesis,

- (4) implications for further research as well as for HE policy and practice are derived (see Section 4.2).

To achieve these four goals and reach the research synthesis, the following *central research questions* were guiding the KoKoHs-Map study:

1. Which reference standard is suitable for the comparative analysis of competencies (as objects to be compared) across all KoKoHs projects?
2. How can students' competence levels in HE be described and scaled?
3. How can the development of students' competencies in HE be described and scaled?
4. Which personal and institutional factors can significantly explain the acquisition of students' competencies?
5. What systematic correlations in students' acquisition process of domain-specific and generic competence facets do the KoKoHs findings show?
6. Which problems can be identified in the meta-analysis that hinder the comparability and replication of the findings?

7. What are the implications for the diagnosis, intervention, and prediction of competence acquisition in HE?

2 METHODOLOGICAL FRAMEWORK AND DATA BASE

2.1 KOKOHS-MAP'S COMPOSITION

In preparation for the research synthesis in KoKoHs-Map, we used established concepts of meta-analyses (Berliner 2002) as the foundation to develop an appropriate synthesis model. The underlying aim was to collect and systematically process the information and findings from all KoKoHs projects and to create a structured database that allows for investigating the seven research questions.

The findings from the individual KoKoHs projects were merged to form an overarching research synthesis, and the prepared database was then analyzed step-by-step to answer the research questions. For the merging and analysis of the heterogeneous data from the KoKoHs projects, a well-founded, methodological framework was created (Section 2.2.1).

To obtain the information necessary for the realization of the meta-project goals, in the process of collecting and selecting the information needed for the creation of the unified database, all KoKoHs project documents, such as reports and publications, were gradually included in the analysis to obtain necessary information and to create the unified database including all central constructs and variables (Section 2.2.3). Using this approach, a database that allows for the investigation of all research questions was created.

Due to the high heterogeneity of the data sources and information, the analysis and the necessary procedures for investigating the research questions were also quite complex and challenging, especially regarding the aggregation of data and correlational analyses across projects. To optimally exploit the potential of the information obtained in the methodologically appropriate way, numerous step-by-step analyses were carried out, based both on the overall data set for all documented KoKoHs projects and on the partial data sets for the selection of the KoKoHs projects, which presented more possibilities for a synthesis due to comparable constructs, designs, or analyses. For the KoKoHs cross-project analysis, a more descriptive focus was chosen to provide generalizable results and indications that can be generalized across most projects.

2.2 PREPARATION AND CREATION OF THE DATABASE

2.2.1 Literature review and choice of methodology for the meta-analysis

A meta-analytical approach is necessary for cross-project analysis and to identify the generalizable implications that go beyond the results of the individual KoKoHs projects. The aggregation of the results and the systematic comparison of the KoKoHs project findings using a common metric can highlight cross-project and generalizable findings on student competencies and, their acquisition and central influencing factors as well as on the connections between contextual study conditions and student characteristics and competence acquisition in or across study domains.

To develop a suitable methodological approach in KoKoHs-Map, a systematic literature review on the methodology of meta-analyses in international research was conducted. Numerous concepts and methods of meta-analysis were found (for an overview, see Gessler & Siemer 2020), ranging from simple "mapping" to critical re-analyses of the data.

KoKoHs-Map aims to exploit the potential of the information and findings generated in KoKoHs using appropriate methods. Therefore, the usability of a "classical" secondary statistical meta-analysis through the aggregation of all primary data and the evaluation of the generated meta-data and meta-variables was also examined (Borenstein et al. 2010; Hunter & Schmidt 1990; Roberts et

al. 2007; for an application in the field of education, see, e.g., Montgomery & Rupp 2005). One advantage of this approach lies in the simplified replicability, while the disadvantages would have been particularly extensive due to (1) a general problem of data (in)completeness, and (2) the danger of statistical blurring of (significant) individual results. Due to the limited access to research data from KoKoHs projects, the degree of data incompleteness was high, or alternatively a large number of projects would not have been part of the analysis. The second problem is that in a project such as KoKoHs-Map, there is a significant risk of undermining the numerous substantial findings of the individual projects, since the constructs they used were in parts hardly comparable on a common metric/scale due to their operationalizations by means of different competence models and tests. Moreover, the KoKoHs projects are characterized by different designs and samples, and the results of smaller studies would be statistically underrepresented in this approach.

Due to these specificities of the KoKoHs information base and the corresponding limitations, other methods of meta-analysis were necessary, which focus primarily on the analysis of secondary information and data, i.e., the project reports and publications. This approach ensures access to data from all projects, and thus is advantageous in that the central results of all projects can be taken into account and are not lost in statistical aggregation procedures.

The data synthesis of different sources, however, entails specific risks and deficits. The objective is, therefore, not the complete replication of the aggregated results of all surveys or individual findings but a systematic and structured synthesis of the results into a cross-project “competence construct” on the basis of suitable indicators. The primary disadvantage of this approach, however, is that it presents fewer statistical possibilities for analyzing the aggregated database. Without the primary data, correlational analyses, e.g., are hardly possible. Moreover, there is a risk of over-interpretating the findings, because the focus of the KoKoHs projects was usually on the development and testing/validation of the developed test instruments; as a result, the validation data, due to their construct and design specificity, hardly provide a methodologically acceptable starting point for strict statistical comparisons. Accordingly, in the KoKoHs-Map analyses, the focus was on a conceptual form of comparison that makes descriptive differences detectable and comparable.

2.2.2 Research synthesis

According to Oakley (2017), the aim of a systematic research synthesis is to obtain a more comprehensive, reliable and objective picture of the object of study than is possible from individual studies. Accordingly, the central research findings of the KoKoHs projects become the central starting point of the research synthesis through document analysis (project reports and publications). Based on the categorical definition approach of Gessler and Siemer (2020), a systematic research analysis comprises the following four steps:

- (1) Definition of the scope of the analysis, in particular specification of the central research questions and the focus of the analysis;
- (2) Data selection, i.e., the specification of the search space, the systematic search and initial structuring (pre-selection) of the research field;
- (3) Data evaluation, meaning the structured, criteria-driven analysis and synthesis of the data;
- (4) Data report, i.e., comprehensive reporting that includes key findings and implications, the limitations and the discussion of challenges and further research perspectives.

Following this approach, the analysis first requires the definition of central research questions (Section 1.4), and a structured and criteria-driven data selection (Section 2.2.3). The data selection in KoKoHs-Map was pre-structured based on which of the two funding phases the projects belong to as well as further criteria such as belonging to one of the domain-specific or cross-domain clusters (Section 2.2.3). For the subsequent step, a systematic and criteria-driven analysis and synthesis of the selected data, further inclusion and exclusion criteria were formulated depending

on the focus of the individual KoKoHs project and the applied analysis method. The data preparation and analysis (as described in Sections 2.2.3 and 3), are linked to the research questions, which constitute the structural framework of the analysis. The documentation of the three steps and especially of the underlying criteria and the applied synthesis methods is intended to minimize the risk of subjective bias, which can generally be inherent in research analyses (Gessler & Siemer 2020). The limitations and challenges as well as implications for further research are outlined in Sections 2.2.4 and 4.

2.2.3 Data selection

In the KoKoHs-Map project, the results and central findings of all projects of the two KoKoHs funding phases between the years 2011-2020 were to be mapped and synthesized across projects. To create a suitable database, researchers from the 39 collaborative projects were asked to take a questionnaire-based survey on the research data gathered in their respective project (incl. scale manuals, etc.). Despite the standardized procedure, the feedback and information provided, in particular from the projects of the first funding phase (2011-2015), was heterogeneous and in part incomplete (for further limitations and implications, see Section 2.2.4).

To fill the data gaps, all KoKoHs-related publications and research reports from 2011-2020 were comprehensively documented for the first time within KoKoHs-Map, structured by project and thematic focus (Table 1 in the Supplement).

During these analysis steps, every project's respective research methodology was critically examined. A detailed description of the samples, a precise description of the tests and all validation work and central results/findings were included in the data processing. These contributed to a differentiated "mapping" of competence research, in which all KoKoHs projects were included. As detailed information regarding the projects is mainly available from the main surveys, the analyses in KoKoHs-Map focus thereon.

The thematic focus of the projects ranged from competence assessment, competence comparisons (between (expertise) groups etc.) and competence development, to the conception of complex competence structures and classifications through typologies in various fields. In addition to the main tests, which primarily served to assess competencies, most projects also measured socio-demographic data and context variables (e.g., degree program, semester) and used further tests to assess generic abilities (e.g., intelligence, self-regulation), beliefs and motivation.

Based on this comprehensive and differentiated database, a meta-data set comprising the central information of the KoKoHs projects was generated by means of the step-by-step aggregations. The analyses focused primarily on the categorization along the three differentiated clusters: professional, domain-specific competence (DK), pedagogical competence (PK) and generic competence (GK). Various effects of personal characteristics and contextual variables were also assessed and considered across projects. In addition to the differentiated descriptive presentation, which provides a structured overview of the KoKoHs research, correlation analyses along the research questions were also conducted in KoKoHs-Map, showing the commonalities and differences in the results and research findings across KoKoHs projects and indicating some generalizable evidence.

2.2.4 Challenges and limitations of the data and the research field

Owing to data protection reasons, only the published research data and/or analyses and findings were generally available but not the original raw data. Therefore, to validate the various data and information per collaborative project, we included all published information in the analysis. This necessary step to complete and validate the information base additionally exacerbated the existing heterogeneity of the KoKoHs-Map database.

The iterative analysis approach in KoKoHs-Map was gradually adapted to account for these challenges and limitations. The statistical investigations regarding the research questions focused on aggregative and descriptive procedures as well as on more qualitative comparative and summative analyses. The analyses in KoKoHs-Map incorporated the project results and research findings into structured and systematic comparative contexts, which highlighted commonalities and differences in the data. Nonetheless, the large heterogeneity of the projects, their research foci, participant groups, methods, variables, and analyses posed a challenge with regard to conducting the comparative analyses. As a result, some specifics and nuances of the competency tests were inevitably disregarded to ensure comparability across several projects, as far as this was still justifiable in terms of content and methodology.

Correlation analyses and causal interpretations of the results were only possible to a limited extent. Although the statistical analyses in KoKoHs-Map suggest several generalizable results across projects, reliable, evidence-based causal statements based on the available data are hardly possible. Accordingly, the findings focused more on generalizable and systematic results, primarily in relation to one of the three clusters and domains.

The development, adaptation, testing, validation, and redesign of new competence models and instruments in HE are also accompanied by specific challenges and limitations, which the KoKoHs projects were confronted with: There is larger structural and institutional heterogeneity in HE compared to the school level. The content taught and the teaching-learning settings also vary greatly within and between domains, study programs, and institutions. This makes establishing curricular and instructional validity across institutions challenging. This aspect is particularly relevant for the use of the competence assessment instruments in HE practices and their broad transfer into HE.

3 RESULTS

While the report published in 2010 on the current state of competence research in German HE showed notable deficits, particularly regarding evidence-based findings on the learning outcomes of students and graduates (Kuhn & Zlatkin-Troitschanskaia 2011), about a decade later, the situation has changed significantly. KoKoHs developed more than 100 theoretical-conceptual models and corresponding assessments for selected large study domains as well as for cross-domain competencies, and comprehensively validated them according to international standards (AERA et al. 2014). These models and assessment frameworks enable a differentiated, precise and operationalizable description of competencies acquired during HE studies in central study disciplines or at the end of HE, as well as of their main influencing factors.

A meta-data set with comparable indicators on core constructs (i.e., student competence) of all 39 collaborative KoKoHs projects was gradually created. In addition to the comprehensive descriptive analyses, which provide information about the scope of the KoKoHs research, correlation analyses were conducted, which show the systematic similarities and differences with regard to the competence levels determined in the individual projects and central influencing factors, such as effects of personal and contextual characteristics.

In the following, we provide an overview and synthesis of the main results of the KoKoHs-Map research mapping and synthesis as well as the meta-analytical considerations regarding the research questions.

1. Which reference norm is suitable for the comparative analysis of competencies across all KoKoHs projects?

One of the objectives of the KoKoHs-Map analysis was to determine a reference norm that makes the research results from the heterogeneous KoKoHs projects presentable on a common metric and comparable in terms of at least in one criterion. Since the focus of all projects was on competence (sub-)facets, which – despite the high heterogeneity – generally followed an

overarching competence framework model (Section 1.2), the average competence level of students and graduates, which was assessed in terms of the various facets of domain-specific and interdisciplinary competence, was chosen and transformed as a benchmark for this common reference norm, i.e., the rate of correct solutions in competence tests (in %). In the aggregated data set, the average level of competence was determined for the majority of the KoKoHs projects (N=20). On average, 57.43% of the competence items were solved correctly, with no major deviations downwards and only a few outliers upwards.

2. How can students' competence levels in HE be described and scaled?

The students in the DK cluster performed better than those in the other two clusters. Remarkably, the difference in terms of competence levels between PK and GK shows a small effect and the difference between FK and GK even shows a medium effect. Domain-specific competencies generally seem to be promoted more intensively and with greater focus in HE than interdisciplinary competencies. Students' generic competencies are systematically weaker than their domain-related competencies and require more effective fostering within HE.

When comparing the different study phases (beginning, middle, end of studies), the students assessed at the end of studies performed significantly better in all projects and in the aggregated data set. No significant differences in the average competence levels between students at the beginning and in the middle of their studies were identified. However, since many instruments used in the surveys conducted at the beginning of studies were based on entrance tests, the competence scores from the entrance tests are difficult to compare with those of competence tests used for assessments during the course of studies.

3. How can the development of students' competencies in HE be described and scaled?

Here, we focused on projects with longitudinal designs, which tracked the development of competencies over a fixed period and assessed students at several points (three projects from the FK cluster, two from the PK cluster and one from the GK cluster). Moreover, five projects with cross-sectional studies were also considered, which specifically compared early and late study phases.

In all these projects, significant increases in competence were determined over the survey period, i.e., during students' studies. Furthermore, students' personal characteristics (e.g., gender, prior education) were important influencing factors for both the initial competence level at the beginning of their studies and for the development of competence during their studies. Specific, targeted pedagogical interventions can also influence competence development (Siebert-Ott et al. 2015). The learning opportunities offered in the respective degree programs mostly led to increases in competence during studies (Münchow et al. 2020). Remarkably, initial individual differences in entry-level competencies rarely decreased during the course of studies (Kraitzek et al. 2020; Schlax et al. 2020).

4. Which personal and institutional factors can significantly explain the acquisition of students' competencies?

In (and across) the three clusters, numerous/various influencing factors were assessed in the projects. KoKoHs-Map investigated the extent to which differences in specific personal characteristics, such as socio-demographics (e.g., age, gender), personality traits (e.g., Big-5, Neo-FFI), general abilities and beliefs (e.g., intelligence tests (figural, verbal, etc.)), and general knowledge tests, influence initial (and continuing) differences in competence levels during students' studies. There were various systematic correlations between the competence levels and personal differences, which were also specific to the respective domain. In GK, correlations between facets of intelligence and the respective competence construct were found with above-average frequency (~67%). In PK, the study length's positive effects on competence levels were significantly

pronounced more frequently (60%) than in the other two clusters. Pedagogical competencies seemed to be linked more to a learning effect and generic competencies more to students' personal characteristics. In DK, no significant correlations were found in the aggregated data set, but in the individual projects focusing on competence development, effects of gender (Schlax et al. 2020), migration background, language skills (Hammer et al. 2015), previous education, and length of study (and, thus, also learning effects) on competence levels became evident (e.g., Kuhn et al. 2020; Vogelsang et al. 2020).

5. What systematic correlations in students' acquisition process of domain-specific and generic competence facets do the KoKoHs findings show?

Some influences seem to be domain-specific, such as in the PK cluster between subjects like mathematics, economics, and physics (Kuhn et al. 2020; Vogelsang et al. 2020). Within the DK cluster, the students performed better than in the other two clusters, however the evidence regarding the influencing factors is not consistent here. In PK, there were stronger correlations with the duration of studies and attended learning opportunities, whereas within the GK cluster there were higher correlations with personal characteristics. With regards to the domains assessed in KoKoHs, comparable analyses and statements on possible domain-specificity across the projects and the respective domains were only possible to a limited extent, since not only different competence constructs were assessed in the domains, but also different constructs to measure individual and contextual factors. The first evidence-based indications of domain-specificity were obtained from two projects in which students from two domains were comparatively examined in quasi-experimental designs. Within the (multifaceted) competence constructs, some of the (sub-)facets were domain-specific (e.g., subject knowledge) and others were domain-unspecific (e.g., metacognitive skills in applying subject knowledge) (e.g., Kuhn et al. 2020). Therefore, certain competence facets can (and should) be promoted only within domains, while others can be promoted across domains in HE.

6. Which problems can be identified in the meta-analysis that hinder the comparability and replication of the findings?

Central challenges lie in the projects' data and information documentation. Systematic problems were caused in particular by non-uniform, partly inconsistent or incomplete data and information bases in the projects. The projects in the two funding phases were generally highly diverse in terms of their focus on competence and all essential project characteristics, such as project duration, study domains and programs examined, competence models and tests, study and survey designs and samples. The specific challenges of the research field in HE as well as the collaborative structure in KoKoHs also point to major problems; e.g., limitations in study design and restricted field access (e.g., only one measurement point, limited inclusion of students from the fields of study, unrepresentative samples, focus on only certain isolated facets of related constructs, etc.) represent systematic problems for competence measurement in HE. Due to the heterogeneous data documentation and publication, the problems in the information and data basis were significantly exacerbated. These problems represent a general limitation in HE research and should be systematically and explicitly taken into account in the design of future research programs to ensure the quality and the development of empirical HE research.

7. What are the implications for the diagnosis, intervention, and prediction of competence acquisition in HE?

The generated comparable database and the mapping of the KoKoHs research based on it, the research synthesis and the meta-analytical consideration within KoKoHs-Map allow for evidence-based statements and implications for HE research, policy, teaching and testing practice. The generalizable findings from KoKoHs-Map emphasize the central importance of study entry

diagnostics as well as the use of (formative) assessments to design effective instructional interventions and performance-oriented examination formats. Competence diagnostics offers an additional instrument for the systematic design of effective teaching-learning measures and can thus significantly contribute to study success. Students' (study-relevant) competencies at the beginning of their studies represent the decisive entry conditions that are of key importance for successful studies and graduation. For further research, instruments and analyses attempting to explain and predict academic study and learning success should be supplemented by further studies on the aspects and factors playing a role in the successful transfer into HE practice.

Further implications regard the design of future research programs in this research field requiring professional information and data management across projects to ensure the optimal utilization of the generated data and developed instruments. Legal conformity and (research) ethics (e.g., AERA 2011) require stronger systematic anchoring in HE research. These aspects are also crucial prerequisites for a successful transfer of the developed instruments and the generated knowledge into HE practice.

4 IMPLICATIONS

The results KoKoHs-Map established from competence assessments provide an evidence-based foundation for the development of curricula and instruction in higher education as outlined below (see Figure 1 in Sec. 1.2).

4.1 UNIVERSITY TEACHING AND EXAMINATION PRACTICE

Competence tests in the study entry phase

The eight KoKoHs projects focusing on the study entry phase developed instruments that can validly assess students' individual (study-relevant) prior knowledge as well as their performance potential, thus allowing for initial valid indications of study success or failure (e.g., Kühling-Thees et al. 2020). Such instruments and the findings obtained allow for the development of more tailored teaching-learning opportunities for the study entry phase, which can enable both the effective promotion of individual potential and the systematic reduction of deficits, and thus have a decisive influence on the successful integration of students into academic education and on their academic success.

One of the central recommendations based on the KoKoHs findings is the systematic integration of competence assessments in the initial phase of HE, to effectively contribute to reducing the high dropout rates often observed in the first semesters (e.g., Kühling-Thees et al. 2020). Standardized entrance tests can be used at the beginning of studies to examine students' study-relevant cognitive and non-cognitive entrance requirements, which are decisive for the later acquisition of competencies in the degree programs and for academic success. Targeted and effective measures, such as preparatory courses to promote domain-specific and interdisciplinary competencies, can be developed and offered to first-year students.

Individual pre-university education plays an important role in successful entry into HE and academic success (e.g., Happ et al. 2018; Behrend et al. 2015). Students who have already completed a course of study or a non-academic vocational training often have significantly higher study-related preconditions when entering HE than students who enter HE directly after graduating from high school. However, students who already have vocational qualifications and job-related skills and experience often have deficits in their academic knowledge, especially in basic subjects such as mathematics, which can be a major problem for studying in most domains. Therefore, another central recommendation from the KoKoHs findings pertains to validly assessing individual potentials and/or deficits in subject-related and interdisciplinary competencies (e.g., self-regulation) and taking them into account appropriately in teaching and the organization of the

introductory study phase to effectively integrate students, to support their learning, to help them achieve their study goals, and to dismantle the existing systematic exclusion mechanisms in HE. Lecturers are often unable to diagnose the study preconditions of their learning groups in a precise and reliable manner due to the lack of valid tests. Suitable and effective support measures for students, such as preparatory courses, require valid information about their actual subject-related prior knowledge (or deficits) at the beginning of academic studies. Self-assessments are also a promising approach to entrance tests, allowing students to test their study-relevant competencies and select study preparation courses according to their abilities. Adaptive testing with individualized feedback is also an important instrument. On this basis, suitable, internally differentiated study-accompanying measures, such as specific tutorials and preparatory courses, can be recommended for the further course of studies.

Promoting diversity and equal opportunities

In most projects, the competence tests revealed significant gender differences in the three clusters as well as in the domains and study programs, also indicating gender effects of certain forms of examination. Female students systematically achieved worse results in some task formats, such as multiple-choice, than their male counterparts (e.g., Schlax et al. 2020). Such effects were observed not only in STEM subjects, but also in social sciences and economics (e.g., Brückner et al. 2015). In several study domains, such as engineering, the proportion of female students is still relatively low, challenging these HE domains to make their courses more attractive to women. An effective strategy in the development of teaching and examination formats that are equally attractive, valid, and fair for all genders is a key recommendation for HE practice.

Similar findings can be seen for students with a migration background (Hammer et al. 2015). In addition to socio-cultural factors, students' native language and their proficiency in the language of instruction are an important factor influencing their performance in competence tests and their academic studies (e.g., Happ et al. 2019). Insufficient language skills among students for whom German is a second language, e.g., create difficulties for those who aim to enter a university and also reduce their chances of achieving good academic results, indicating a lack of specific support for this group of students in their studies. While in KoKoHs these findings refer to both students with a migration background and international students, comparative studies examining students with a refugee background show even more alarming results (Reinhardt et al., 2020) and point to systematic problems in the area of diversity and equal opportunities, especially for foreign students at German universities.

Due to increasing internationalization in HE, multilingualism is gradually gaining attention in educational studies. Students with different native languages and foreign language skills come together in courses, which are increasingly held not only in German, but also in English. Many universities respond to the linguistic heterogeneity of students and high requirements in both German and English (especially in the introductory phase) with special support programs such as language courses for migrants and exchange students to provide better support for these groups at the beginning of their studies. However, initial language deficits were not sufficiently compensated for over the course of studies, which is also evident in the findings on competence acquisition even at the end of their studies.

Use of KoKoHs assessments in regular university teaching and examination practice

Initial attempts to apply the results of KoKoHs projects in HE practice already constitute examples of successfully integrating the instruments into teaching and examination. New courses aiming at the targeted teaching and effective promotion of subject-specific as well as interdisciplinary competences are being introduced into HE curricula, which can serve to mitigate the undesirable effects of heterogeneous student performance (e.g., Saas et al. 2020). Concrete potential applications for the KoKoHs assessments arise particularly in the context of diversity orientation

and successful integration in the study entry phase, e.g., for the valid assessment of the "competence to study effectively" of first-year and prospective students (e.g., Kühling-Thees et al. 2020). Some of the KoKoHs instruments can be used in student entry diagnostics to objectively and validly assess students' entry preconditions and to predict their study performance and success. The results obtained can be applied directly to teaching and study management and serve as an empirical basis for effective study guidance services and an addressee-oriented design of teaching-learning offerings.

Some projects have already implemented initial specific, competence-oriented instructional interventions in study courses, such as case study-based laboratory learning in the STEM subjects (e.g., Vogelsang et al. 2020). The project results also inform the revision of curricula and study objectives towards greater competence orientation in individual study programs (e.g., Lemmrich et al. 2020). Some competence models and instruments are also used in the evaluation of study programs, e.g., as orientation for accreditations at the participating universities (e.g., Kaiser & König 2020). These first implementations can be considered as guidelines on how best practice concepts in competence-oriented teaching and examination practice can be developed and successfully established for the various areas of academic education using KoKoHs models and tests.

In addition to their use as diagnostic instruments for assessing students' competence facets and their development during study phases (e.g., study entrance phase), the use of instruments as part of innovative examination concepts is also possible; e.g., videos depicting authentic, real-life situations can be used for oral examinations (e.g., Saas et al. 2020). Simulation-based assessments can be used to create an examination that approximates real-life practical requirements. Text-, video- and computer-based tasks and case studies can also be used as teaching-learning tools for students (e.g., in didactics courses) and in this way significantly contribute to preparation for and orientation towards professional practice in academic studies.

4.2 PERSPECTIVES FOR FURTHER RESEARCH

Causal analyses of the influences and relationships between students' competencies and the contextual influencing factors, the teaching and learning processes in HE, and the learning outcomes can now be measured empirically, based on the developed and validated competence models and instruments. However, further longitudinal studies and multilevel analyses that can overcome the aforementioned limitations are needed. Although the psychometric suitability of the developed tests for assessing the level of competence and the students learning outcomes has been established, a valid assessment of the development of these competencies and their influences remains a methodological and practical challenge. The predictive and prognostic validity of the tests should also be further investigated.

The valid approaches to measure learning success in practice still have some systematic deficits, e.g., with regard to controlling the decisive input and context factors that can influence learning progress, but also a valid assessing of teaching-learning processes. With regard to the effective promotion of competencies in HE, there is also still a need for experimental randomized studies with targeted interventions and control group designs. Further (replication) studies are also needed to increase the external validity of the results.

Based on the KoKoHs results of the past ten years, research on international adaptations of competency models and assessments should also be continued and, in further comparative studies, international validation efforts should be supported to contribute to strengthening the international connectivity and competitiveness of HE research. This aspect is of particular importance in the global HE context and will remain so in the coming decades.

5 CONCLUSION AND OUTLOOK

Competence models and instruments developed and tested for different areas of application provide a sound basis for assessing learning outcomes in HE and also the assessment of competence development during studies (or later practical phases, e.g., teacher training). After the development of applicable assessments and their testing at numerous universities, the next step is the integration of these assessments into HE practice. A major challenge is to embed such competence tests in regular teaching-learning practice and in the assessment and evaluation in domains and disciplines.

The systematical implementation of the developed tests in transfer studies into regular teaching and learning practice is currently the focus of seven projects in the next running funding phase from 2020 until 2022. This transfer phase is oriented towards the curriculum-instruction-assessment triad by Pellegrino, Chudowsky and Glaser (2001; see Figure 1 in the Section 1.2) and aims to systematically transfer the KoKoHs assessments as a central aspect of this triad into HE practices. The overarching goal is to enable HE practitioners to effectively support teaching and learning at their institution and to promote competence orientation through the targeted and professional use of KoKoHs assessments. This includes the (further) development of computer-based feedback tools for students and teachers as well as practical guidelines for the interpretation and use of assessment results.

The KoKoHs researchers are also aiming to document and analyze the transfer strategies precisely and in close cooperation with the practitioners at the universities on site. In addition to other established tests, the use of formative assessments during the (entire) study program is a promising solution, as teachers (and students) are provided with a tool of partly performance-oriented and computer-based tasks, which can be used flexibly and adaptively in study programs to assess the development of competencies (e.g., in fundamental domain-specific concepts) in a valid and reliable way and to provide students feedback and learning recommendations based thereon. Measurement procedures that are not (necessarily) used repeatedly throughout the entire degree program, but only once, e.g., at the beginning of the degree program, and have a high predictive validity with regard to learning progress are also of practical relevance.

In the transfer projects, the focus is not only on the use of KoKoHs assessments for entry diagnostics, for formative and summative evaluation of the students' level of competence, and its development during their studies, but also on the cooperation with the actors at the universities and strengthening their competence and professional handling of the assessments through counselling and support, so that the results can be interpreted appropriately and, e.g., differences within and between groups of students and also institutions can be analyzed. Tests that are tailored to the specific needs of each institution in the projects are implemented in practice and complemented by tailor-made feedback instruments so that practitioners in HE can effectively use the instruments. An assessment carried out at the beginning of studies to diagnose students' competencies in a particular area can be used to tailor learning opportunities in the introductory phase to students' specific needs and deficits, to track their progress during this phase through (repeated) measurements, and to provide them, their teachers, and the university administration with information on the students' overall performance of the group in relation to their learning needs, e.g., how many students are likely to need special support services or how many students are at risk of dropping out. The KoKoHs transfer projects can contribute significantly to developing and establishing effective models and best practice approaches in HE.

REFERENCES

- Adelman, C. (2009). *The Bologna Process for U.S. Eyes: Re-learning Higher Education in the Age of Convergence*. Institute for Higher Education Policy.
- AERA (American Educational Research Association). (2011). Code of ethics. *Educational Researcher*, 40, 145–156.
- AERA, APA, & NCME (2014). *Standards for educational and psychological testing*. AERA.
- Behrendt, S., Dammann, E., Ștefăniță, F., Markert, B. & Nickolaus, R. (2015). Physical-technical prior competencies of engineering students. *Empirical Research in Vocational Education and Training*, 7(2), DOI 10.1186/s40461-015-0013-9.
- Berliner, D. C. (2002). Educational research: The hardest science of all. *Educational Researcher*, 31 (8), 18–20.
- Biggs, J., & Tang, C. (2011). *Teaching for Quality Learning at University*. McGraw-Hill and Open University Press.
- Blömeke, S., Gustafsson, J.-E., & Shavelson, R. (2015): Beyond dichotomies: Competence viewed as a continuum. *Zeitschrift für Psychologie*, 223 (1), 3–14.
- Blossfeld, H.-P., Roßbach, H.-G., & von Maurice, J. (Eds.) (2011). Education as a Lifelong Process – The German National Educational Panel Study (NEPS). *Zeitschrift für Erziehungswissenschaft*. Sonderheft 14.
- Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2010). *Introduction to meta-analysis*. Wiley.
- Brändle, T., & Häuberer, J. (2015). Social capital of non-traditional students at a German university. Do traditional and non-traditional students access different social resources? *International Journal of Higher Education*, 1 (4), 92–105.
- Brückner, S., Förster, M., Zlatkin-Troitschanskaia, O., Happ, R., Walstad, W. B., Yamaoka, M., & Asano, T. (2015). Gender effects in assessment of economic knowledge and understanding: Differences among undergraduate business and economics students in Germany, Japan, and the United States. *Peabody Journal of Education*, 90(4), 503-518.
- Coates, H. (2014). *Higher education learning outcomes assessment: International perspectives*. Peter Lang.
- DIHK (Association of German Chambers of Industry and Commerce) (2015). *Ausbildung 2015. Ergebnisse einer DIHK-Online-Unternehmensbefragung. [Training 2015. Results of a DIHK online company survey.]* Available online at <https://www.dihk.de/ressourcen/downloads/dihk-ausbildungsumfrage-2015.pdf>.
- Gessler, M., & Siemer, C. (2020). Umbrella review: Methodological review of reviews published in peer-reviewed journals with a substantial focus on vocational education and training research. *International Journal for Research in Vocational Education and Training*, 7 (1), 91–125. <https://doi.org/10.13152/IJRVET.7.1.5>
- Hammer, S., Carlson, S., Ehmke, T., Koch-Priewe, B., Köker, A., Ohm, U., Rosenbrock, S., & Schulze, N. (2015). Kompetenz von Lehramtsstudierenden in Deutsch als Zweitsprache. *Zeitschrift für Pädagogik [Competence of student teachers in German as a second language. Journal for Pedagogy]*, 61, 32–54.
- Happ, R., Nagel, M., Zlatkin-Troitschanskaia, O., & Schmidt, S. (2019). How migration background affects master degree students' knowledge of business and economics. *Studies in Higher Education*, 1–16. doi.org/10.1080/03075079.2019.1640670
- HRK (German Rectors' Conference) (2012). *Kompetenzorientierung im Studium. Vom Konzept zur Umsetzung. [Competence Orientation in Studies. From concept to implementation.]* Available online at https://www.hrk-nexus.de/fileadmin/redaktion/hrk-nexus/07-Downloads/07-02-Publikationen/impulse_Onlineversion.pdf
- Heublein, U. (2014). Student Drop-out from German Higher Education Institutions. *European Journal of Education*, 49 (4), 497–513.
-

- Hunter, J. E., & Schmidt, E. L. (1990). *Methods of meta-analysis: Correcting error and bias in research findings*. Sage.
- Kaiser, G. & König, J. (2020). Analyses and Validation of Central Assessment Instruments of the Research Program TEDS-M. In O. Zlatkin-Troitschanskaia, H. A. Pant, M. Toepper & C. Lautenbach (Eds.), *Student Learning in German Higher Education: Innovative Measurement Approaches and Research Results* (pp. 29-52). Springer VS.
- Kraitzek, A., Förster, M., & Zlatkin-Troitschanskaia, O. (2020). Influences on Master's Degree Students' Economic Knowledge. In O. Zlatkin-Troitschanskaia, H. A. Pant, M. Toepper & C. Lautenbach (Eds.), *Student Learning in German Higher Education: Innovative Measurement Approaches and Research Results* (pp. 401-429). Springer.
- Kuhn, C., & Zlatkin-Troitschanskaia, O. (2011). *Assessment of Competencies Among University Students and Graduates: Analyzing the State of Research and Perspectives* (Working Papers Chair of Business Education Issue No. 59). Mainz: Johannes Gutenberg University.
- Kuhn, C., Zlatkin-Troitschanskaia, O., Lindmeier, A., Jeschke, C., Saas, H., & Heinze, A. (2020). Relationships between Domain-Specific Knowledge, Generic Attributes, and Instructional Skills – Results from a Comparative Study with Pre- and In-Service Teachers of Mathematics and Economics. In O. Zlatkin-Troitschanskaia, H. A. Pant, M. Toepper & C. Lautenbach (Eds.), *Student Learning in German Higher Education: Innovative Measurement Approaches and Research Results* (pp. 75-104). Springer.
- Kühling-Thees, C., Happ, R., Zlatkin-Troitschanskaia, O. & Pant, H.A. (2020a). The Impact of Entry Preconditions on Student Dropout and Subject Change in Business and Economics. In O. Zlatkin-Troitschanskaia, H. A. Pant, M. Toepper & C. Lautenbach (Eds.), *Student Learning in German Higher Education: Innovative Measurement Approaches and Research Results* (pp. 351–370). Springer VS.
- Lemmrich, S., Hecker, S.-L., Klein, S., Ehmke, T., Koch-Priewe, B., Köker, A. & Ohm, U. (2020). Linguistically Responsive Teaching in Multilingual Classrooms Development of a Performance-Oriented Test to Assess Teachers' Competence. In O. Zlatkin-Troitschanskaia, H. A. Pant, M. Toepper & C. Lautenbach (Eds.), *Student Learning in German Higher Education: Innovative Measurement Approaches and Research Results* (pp. 125–140). Springer VS.
- Lörz, M., Netz, N., & Quast, H. (2016). Why do students from underprivileged families less often intend to study abroad? *Higher Education*, 72 (2), 153–174.
- Mislevy, R. J. (2016). How Developments in Psychology and Technology Challenge Validity Argumentation. *Journal of Educational Measurement*, 53 (3), 265–292.
- Mislevy, R. J., Steinberg, L. S., & Almond, R. G. (2003). On the structure of educational assessments. *Measurement: Interdisciplinary Research and Perspectives*, 1, 3–67.
- Montgomery, C., & Rupp, A. (2005). A meta-analysis for exploring the diverse causes and effects of stress in teachers. *Canadian Journal of Education*, 28 (3), 461–488.
- Müller, S., & Schneider, T. (2013). Educational pathways and dropout from higher education in Germany. *Longitudinal and Life Course Studies*, 4 (3), 218–241.
- NRC (National Research Council) (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. The National Academics Press.
- Oakley, A. (2017). Foreword. In D. Gough, S. Oliver and J. Thomas (Eds.), *An Introduction to Systematic Reviews* (pp. xiii–xvi). Sage.
- OECD (Organisation for Economic Co-operation and Development) (2015). *Education at a Glance 2015: OECD Indicators*. OECD Publishing.
- OECD (Organisation for Economic Co-operation and Development) (2012). *Assessment of Higher Education Learning Outcomes. Feasibility Study Report: Volume 1. Design and Implementation*. <http://www.oecd.org/edu/skills-beyond-school/AHELOFSReportVolume1.pdf>
- OECD (Organisation for Economic Co-operation and Development) (2008). *Measuring improvements in learning outcomes: Best practices to assess the value-added of schools*. OECD.

- Pellegrino, J. W., Chudowsky, N., & Glaser, R. (2001). *Knowing what students know: The science and design of educational assessment*. National Academy Press.
- Reimer, D., & Pollak, R. (2010). Educational expansion and its consequences for vertical and horizontal inequalities in access to higher education in West Germany. *European Sociological Review*, 26 (4), 415–430.
- Reinhardt, F., Deribo, T., Zlatkin-Troitschanskaia, O., Happ, R., & Nell-Müller, S. (2020). The Influence of Refugee Students' Personal Characteristics on Study Success in Online Education. *Journal of International Migration and Integration*, 1–22.
- Roberts, B. W., Kuncel, N. R., Viechtbauer, W., & Bogg, T. (2007). Meta-analysis in personality psychology: A primer. In R. W. Robins, R. C. Fraley and R. F. Krueger (Eds.), *Handbook of research methods in personality psychology* (pp. 652-672). New York, NY, US: The Guilford Press.
- Rychen, D. S., & Salganik, L. H. (Ed.). (2003). *Key Competencies for a Successful Life and a Well-Functioning Society*. Hogrefe & Huber.
- Saas, H., Kuhn, C., & Zlatkin-Troitschanskaia, O. (2020). Ein videobasiertes Lehr-Lernformat als innovativer hochschuldidaktischer Ansatz in der wirtschaftspädagogischen Lehrerbildung. *Zeitschrift für Erziehungswissenschaft*. [A video-based teaching-learning format as an innovative university didactic approach in business education teacher training. *Journal for Educational Science*.]
- Schlax, J., Zlatkin-Troitschanskaia, O., Kühling-Thees, C., & Brückner, S. (2020). Influences on the Development of Economic Knowledge over the first Academic Year: Results of a Germany-Wide Longitudinal Study. In O. Zlatkin-Troitschanskaia, H. A. Pant, M. Toepper & C. Lautenbach (Eds.), *Student Learning in German Higher Education: Innovative Measurement Approaches and Research Results* (pp. 371-399). Springer.
- Siebert-Ott, G., Fischbach, J., & Schindler, K. (2015). Akademische Textkompetenzen modellieren – Entwicklung und Beschreibung eines Kompetenzmodells für das Bewerten von Schülertexten. [Modelling Academic Text Competencies - Developing and describing a competency model for assessing student texts.] In B. Koch-Priewe, A. Köker, J. Seifried & E. Wuttke (Eds.), *Kompetenzerwerb an Hochschulen: Modellierung und Messung [Competence acquisition at universities: Modelling and measurement]* (pp. 129-151). Klinkhardt.
- Vogelsang, C., Borowski, A., Kugelmeyer, C., Riese, J., Buschhüter, D., Enkrott, P., Kempin, M., Reinhold, P., Schecker, H., & Schröder, J. (2020). Development of Prospective Teachers' Professional Knowledge and Skills during a One-Semester School Internship. In O. Zlatkin-Troitschanskaia, H. A. Pant, M. Toepper & C. Lautenbach (Eds.), *Student Learning in German Higher Education: Innovative Measurement Approaches and Research Results* (pp. 105-124). Springer.
- Wagenaar, R. (2017). What do we know - What should we know? Measuring and comparing achievements of learning in European Higher Education: initiating the new CALO-HEE approach. In O. Zlatkin-Troitschanskaia, H.A. Pant, M. Toepper, C. Kuhn & C. Lautenbach (Eds.) (2018), *Assessment of Learning Outcomes in Higher Education – Cross-national Comparisons and Perspectives*. Springer.
- Weinert, F. E. (2001). Concept of Competence: A Conceptual Clarification. In D. S. Rychen & L. H. Salganik (Eds.), *Defining and Selecting Key Competencies* (pp. 45-65). Hogrefe and Huber Publishers.
- Wissenschaftsrat [German National Science Council] (2015). *Empfehlungen zum Verhältnis von Hochschulbildung und Arbeitsmarkt. Zweiter Teil der Empfehlungen zur Qualifizierung von Fachkräften vor dem Hintergrund des demographischen Wandels. [Recommendations on the relationship between higher education and the labour market. Second part of the recommendations on the qualification of skilled workers against the background of demographic change.]* Wissenschaftsrat. Available online at <https://www.wissenschaftsrat.de/download/archiv/4925-15.pdf>.

- Wissenschaftsrat [German National Science Council] (2012). *Prüfungsnoten an Hochschulen im Prüfungsjahr 2010. Arbeitsbericht. Mit einem Wissenschaftspolitischen Kommentar des Wissenschaftsrates.* [Examination grades at universities in the examination year 2010. Working report. With a science policy commentary by the Science Council.] Wissenschaftsrat. Available online at <https://www.wissenschaftsrat.de/download/archiv/2627-12.pdf>.
- Zlatkin-Troitschanskaia, O., Kuhn, C. & Toepper, M. (2014). Modelling and assessing higher education learning outcomes in Germany. In H. Coates (Ed.). *Higher Education Learning Outcomes Assessment – International Perspectives* (pp. 213-235). Peter Lang.
- Zlatkin-Troitschanskaia, O., Pant, H. A. & Coates, H. (2016). Assessing Student Learning Outcomes in Higher Education – Challenges and International Perspectives. *Assessment and Evaluation in Higher Education*, 41 (5), 655-661.
- Zlatkin-Troitschanskaia, O., Pant, H. A., Lautenbach, C., Molerov, D., Toepper, M. and Brückner, S. (2017a). *Modeling and Measuring Competencies in Higher Education: Approaches to Challenges in Higher Education Policy and Practice.* Springer VS.
- Zlatkin-Troitschanskaia, O., Pant, H. A., Nagel, M.-T., Molerov, D., Lautenbach, C. and Toepper, M. (2020b). *Portfolio of KoKoHs Assessments - Test Instruments for Modeling and Measuring Domain-specific and Generic Competencies of Higher Education Students and Graduates.* pfalzdruck.
- Zlatkin-Troitschanskaia, O., Pant, H. A., Toepper, M. and Lautenbach, C. (Eds.) (2020a). *Student Learning in German Higher Education: Innovative Modelling and Measurement Approaches and Research Results.* Springer VS.
- Zlatkin-Troitschanskaia, O., Pant, H. A., Toepper, M., Lautenbach, C. and Molerov, D. (2017b). Valid Competency Assessment in Higher Education: Framework, Results, and Further Perspectives of the German Research Program KoKoHs. *AERA Open*, 3 (1), 1-22.
- Zlatkin-Troitschanskaia, O., Shavelson, R. J. and Kuhn, C. (2015). The international state of research on measurement of competency in higher education. *Studies in Higher Education*, 40 (3), 393-411.
- Zlatkin-Troitschanskaia, O., Toepper, M., Pant, H. A., Lautenbach, C. and Kuhn, C., (Eds.) (2018). *Assessment of Learning Outcomes in Higher Education – Cross-national Comparisons and Perspectives.* Springer VS.

SUPPLEMENT

Table 1: Overview of all KoKoHs projects, analyzed competencies and developed assessments

Acronym	Name of Project	Areas of Focus	Paper-Pencil-Test	Number of Items Paper-Pencil	Computer / Video-Test	Number of Items Computer-Video Test	A different Format
AkaTex	<i>Academic Text Competencies of First-Year and Advanced Students</i>	Academic text competencies required at university and in professional life					Discourse Paper (shorter form of a term paper)
ÄKHOM	<i>Medical Competencies: Hamburg-Oldenburg-München</i>	Medical knowledge of students in the practical training year / Precursor format for possible standardized final examination in medicine	X	19			
ASTRALITE	<i>Assessment und Training of Scientific Literacy AstraLite-Kosovo AST: Argument-Structure-Test</i>	Students' competencies when dealing with scientific literature			X	40	
BilWiss-Beruf	<i>The Role of Educational Knowledge for Career Entry</i>	Teachers' pedagogical knowledge (focusing on student learning and development, educational methods, diagnosis, school pedagogics, education theory and history, teaching profession)	X	119 (short version 65)			
BilWiss-UV	<i>Returns and Development of Educational Knowledge—Validation of a Competence Test for Teacher Students</i>	Prospective teachers' and in-service teachers' educational knowledge	X	119			
DaZKom	<i>Professional Competencies of Prospective Secondary School Mathematics Teachers in 'German as a Second Language'</i>	German as a second language (GSL), competencies of mathematics teachers, multilingualism	X	51/31			
DaZKom-Video	<i>Performance-Oriented Measurement of German as a Second Language Competence (GSL-Competence) of (Pre-Service) Teachers</i>	Video-based competence measurement of prospective teachers in the field of "German as a second language"			X	24	
ELMaWi	<i>Assessing Subject-Specific Competencies in Teacher Education in Mathematics and Economics – A Quasi-Experimental Validation Study with a Focus on Domain-Specificity</i>	Competencies of students, trainee teachers, and mathematics and economics teachers. Subject-specific, subject-didactic, and generic knowledge and skills (content knowledge (CK); pedagogical content knowledge (PCK))	X	CK-E: 14 PCK-E: 11 CK-M: 11 PCK-M: 13	X	AS-E: 7 RS-E: 7 AS-M: 9 RS-M: 9	
ExMo	<i>Conveying and Assessing Competencies in Experimental Lessons: Modeling, Validating, and Developing of a Test Instrument</i>	Pedagogical content knowledge of prospective biology teachers, teaching and	X	22			

		assessing students' competencies in experimental lessons					
HEED	<i>Higher Entrepreneurship Education Diagnostics</i>	Entrepreneurial knowledge /entrepreneurial competence	X	40			
KOM-ING	<i>Modeling and Measuring Competencies in Engineering Mechanics in the Training of Mechanical Engineers</i>	Competencies in engineering mechanics	X	104			
KoM@ING	<i>Modeling and Assessing Mathematical Competency as an Individual Competency in Engineering</i>	Mathematical knowledge in engineering (engineering mathematics, engineering mechanics, materials science and design engineering)	X	36 (short version)			Categorization systems; Low Inferential Analysis; Student Expert Solutions
Ko-MeWP	<i>Modeling and Measuring Content Knowledge and Pedagogical Content Knowledge in Business and Economics Education</i>	Content knowledge and pedagogical content knowledge in accounting	X	187/49			
KomMa	<i>Structure, Level, and Development of Kindergarten Teachers' Professional Competencies in Mathematics</i>	Kindergarten teachers' professional competencies in mathematics (expert knowledge, pedagogical content knowledge, pedagogical knowledge)	X	70			
KomPaed	<i>Modeling and Measuring Task-Related Skills in Occupational Activities in Educational Fields</i>	Generic and task-related competencies required by graduates for successful participation in occupational activities in educational fields	X	41			
KOMPARE	<i>COMPARE – Competent Argumentation with Evidence. Measurement and Modeling in Education Sciences and Transfer from Medical Studies</i>	Evidence-based reasoning competence; medicine and education sciences (pedagogy, psychology, teaching)			X	30 18 40	
Ko-NaMa	<i>Simulation-based Measurement and Validation of a Competence Model for Sustainability Management</i>	Validation study on students' performance in sustainability management in companies / Intervention design	X	184	X	72	
KOSWO	<i>Competencies in Dealing with Scientific Primary Literature</i>	Competencies in dealing with scientific primary literature			X	241	
Ko-WADiS	<i>Evaluating the Development of Scientific Literacy in Teacher Education</i>	Scientific reasoning competence in biology, chemistry, and physics	X	123			
KUI	<i>Teaching Competencies in Informatics</i>	Teaching competence in information technology (subject-didactic teacher competencies, professional beliefs, and motivational orientations for computer science teachers)	X	83			
LeScEd	<i>Learning the Science of Education</i>	Research competence in study programs in education (procedures of social science	X	182			

		research, scientific reasoning and communication, and epistemological beliefs about the nature of educational scientific knowledge)						
MuliTex	<i>Process-Based Assessment of Multiple Documents Comprehension</i>	Students' competencies in processing and understanding multiple text sources			X	67		
M³K	<i>Modeling and Measuring Pedagogical Media Competence</i>	Pedagogical media competence (media didactics, media education and media-related school development, media-related attitudes, self-efficacy beliefs as well as media-technical knowledge)	X	102				
MoKoMasc h	<i>Modeling Competencies of Mechanical Engineering Students in the Areas of Construction, Design, and Production Engineering</i>	Competencies of mechanical engineering students in the areas of construction, design, and production engineering	X	36				
PlanvoLL-D	<i>The Role of Professional Knowledge of Pre-Service German Teachers in their Lesson Planning: Validation and Methodological Innovation</i>	Competencies of pre-service teachers in lesson planning (based on curricula) / knowledge differentiation	X	18				
Profile-P	<i>Professional Knowledge of Student Teachers of Physics</i>	Professional knowledge of physics prospective teachers (expert knowledge, pedagogical content knowledge (PCK), content knowledge (CK) explaining competence), (Profile-P DET: Dialogical Explanation Test)	X (Profile-P PCK and CK)	43 (Profile-P PCK) and 48 (Profile-P CK)	X (Profile-P DET)	12 evaluation categories		
ProfiLe-P+	<i>Professional Competence in Academic Physics Teacher Education</i>	Instructional knowledge and skills of physics teachers	X	91	X	85		
Pro-KomMa	<i>Professionalization of Early Childhood Teacher Education: Convergent, Discriminant and Prognostic Validation of the KomMa Models and Tests</i>	Pedagogical knowledge and skills in mathematics in the preschool contexts	X	70				
PRO-SRL	<i>Product and Process-Oriented Modeling and Assessment of Self-Regulated Learning Competencies in Tertiary Education</i>	Self-regulated learning competencies in tertiary education (economics, teacher education, psychology and electrical engineering)	X	366/96	X	Situational Judgement Test: 71, Short version: 45	Standardized diaries, portfolios	
PRO-SRL-EVA	<i>Product- and Process Oriented Modeling and Assessment of Self-Regulation Competencies in Higher Education – Further Validation</i>	Self-regulated learning of university students			X	200		
SEKO	<i>Teachers' Self-Regulation as a Generic Aspect of Professional Competence: Stability and Change in Teacher Training at University and Predictive Validity</i>	Teachers' occupational self-regulation (as an aspect of professional competence)	X	32				
SOSCIE	<i>A Conceptualization and International Examination of a Level-Related Competency Model</i>	Pedagogical content knowledge of prospective history teachers	X	165				

	<i>Regarding Professional Competencies of Prospective History Teachers</i>						
TEDS-Validierung	<i>Validation of the Instruments from the International Comparative TEDS-M study and its Follow-Up TEDS-FU</i>	Professional competencies of math teachers [P-PID and M-PID: Situational General Pedagogical Knowledge and Situational Didactical Knowledge of Mathematics Teachers] [CME: Classroom Management Teacher Expertise]			X		P-PID and M-PID: 42 CME: 24
ValiDis	<i>Competence Modeling and Assessment: Validation of the Test Score Interpretations of a Scientific Reasoning Test</i>	Validation study on students' scientific reasoning	X	63			
WiKom-Sowi	<i>Modeling and Measuring of Scientific Competency in the Social Sciences</i>	Scientific competencies in social sciences (psychology, sociology, and political science)	X	Scientific competence in political science: 173 Research competence Psychology: 120 Scientific competence in Sociology: 191			
WiWiKom	<i>Modeling and Measuring Competencies in Business and Economics Among Students and Graduates</i>	Students' business and economic competence (economic knowledge and thinking; practice-related knowledge)	X	204			
WiWiKom II	<i>Assessment of Students' Development of Professional Business and Economic Competencies over the Course of their Studies - A Quasi-Experimental Longitudinal Study</i>	Assessment of knowledge development among business, economics, and social sciences students	X	45			
WiWiSET	<i>Validation of an Entrance examination in the Study Domain of Business and Economics – A National and International Comparative Study of Universities and Universities of Applied Sciences</i>	Domain-specific competencies at the beginning of studies in economics, prognosis of study dropout / academic success in business and economics	X	25/16			

ABOUT THE AUTHORS

Miriam Toepper

Miriam Toepper is a research assistant at the Department of Business and Economics Education at Johannes Gutenberg University Mainz (JGU). She has been working in the national research program “Modeling and Measuring Competencies in Higher Education (KoKoHs)” since 2013. Her research focuses on competency modeling and performance-based assessment in international HE research.

Contact information:

Miriam Toepper

Department of Business and Economics Education

Johannes Gutenberg University Mainz

55099 Mainz, GERMANY

phone +49 6131 39-26035

e-mail: miriam.toepper@uni-mainz.de

Professor Dr. Olga Zlatkin-Troitschanskaia

Olga Zlatkin-Troitschanskaia has been Chair of Business and Economics Education at JGU, since 2006. She earned her doctoral degree from Humboldt University of Berlin in 2004 and her postdoctoral qualification in 2006. She has published widely on empirical educational research in vocational and higher education. She has directed numerous third-party funded national and international research projects and has been coordinating the national research program ‘Modeling and Measuring Competencies in Higher Education (KoKoHs)’ since 2011. Her research has earned various awards and honors. She is a member of many national and international research academies, advisory and editorial boards and serves as an expert consultant to ministries, foundations, and academic journals.

Contact information:

Professor Dr. Olga Zlatkin-Troitschanskaia

Gutenberg School of Management and Economics

Johannes Gutenberg University Mainz

55099 Mainz, GERMANY

phone +49 6131 39-22009

e-mail: lsTroitschanskaia@uni-mainz.de

Dominik Braunheim

Dominik Braunheim is a research assistant at the Department of Business and Economics Education at Johannes Gutenberg University Mainz (JGU). He has been working in the national research project “KoKoHs-Map: Mapping Competence Acquisition in Higher Education and its Influences. A Meta-study on the Results of the KoKoHs Funding Line (2011-2020)” since 2020. His research focuses on higher education students’ critical reasoning and the evaluation of contradicting sources within the online media landscape.

Contact information:

Dominik Braunheim

Gutenberg School of Management and Economics

Johannes Gutenberg University Mainz

55099 Mainz, GERMANY

phone +49 6131 39-24039

e-mail: doBraunh@uni-mainz.de