NEPS
National Educational Panel Study

Research Data

Information on Competence Testing

NEPS Additional Study — Baden-Wuerttemberg
G8 Reform Study in Baden-Wuerttemberg

Students, Grade 12/13 2011/2012

LIfBi
LEIBNIZ INSTITUTE FOR
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Information on testing	
Test situation	Group testing in schools, 1 test instructor/test group (approx. 40 students)
Test sequence	Note: During the school performance tests, two domains each were processed parallel by half of the students each. The tests were rotated in such a way that each student had processed tests from all domains at the end of the test day. Natural sciences (competence in biology and/or physics) Competence in reading English and/or mathematics Cognitive basic skills Natural sciences (competence in biology and/or physics) Competence in English reading and/or mathematics The tests were conducted during one morning.
Test duration (pure processing time)	2 h 40 ½ min.
Breaks	2 breaks à 15 min. resp. 20 min.

Information on the individual tests

Construct	**Number of items**	**Allowed processing time**	**Mode of tests**	**Next measurement (until 2013)**
Competence in mathematics	21	30 min	mostly multiple choice, partly open answering format	-
Cognitive basic skills				
Perceptual speed	3 x 31 = 93	3 x 30 sec	paper-pencil	-
Reasoning	3 x 4 = 12	3 x 3 min	paper-pencil	-

Konstrukt	**Number of items**	**Allowed processing time**	**Survey mode**	**Next measurement (until 2013)**
Stage-specific measures				
Competence in English reading	33 (21 Items pro Test-heft)	30 min	multiple matching, multiple choice	-
Competence in physics	40 (19-21 Items pro Testheft)	45 min	mostly multiple choice, partly forced choice and open an-swering format	-
Competence in biology (EVAMAR Biology Test)	60 (je 36 Items pro Test-heft)	45 min	mostly multiple choice, partly open answering format	-

Preliminary note

The development of the test in the context of the additional study concerning the G8 reform in Baden-Wuerttemberg is based on framework concepts. They constitute overarching concepts on the basis of which education-relevant competences are to be shown. The developed test was used in each of the three studies comprising the additional study Baden-Wuerttemberg.

Mathematical competence

In the National Education Panel Study, the construct of *mathematical competence* is based on the idea of *mathematical literacy* as was defined, for example, in PISA. Thus, the construct describes "[…] an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded mathematical judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen." (OECD, 2003, 24). Regarding younger children, this idea refers to competent handling of mathematical problems in *age-specific contexts.*

Accordingly, mathematical competence in NEPS is operationalized by items assessing more than pure mathematical knowledge; instead, solving the items requires recognizing and flexibly applying mathematics in realistic, mainly extra-mathematical situations.

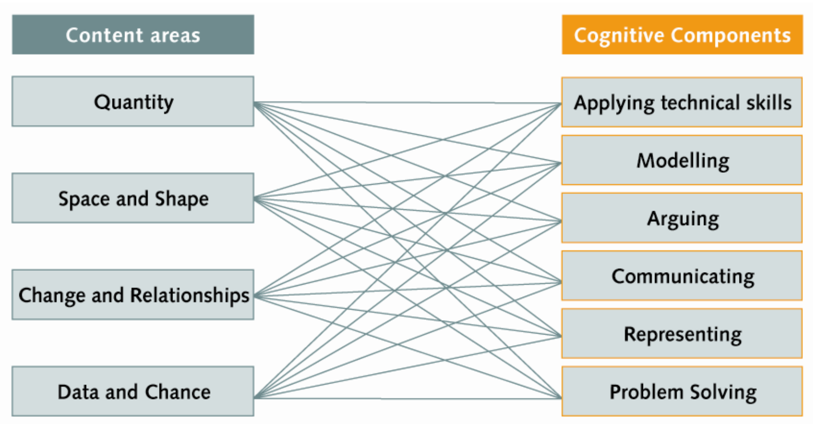

Fig. 1: Framework of mathematical competence in NEPS

The NEPS framework of mathematical competence distinguishes between content-related and process-related components (cf. Fig. 1). In detail, the content areas are characterized as follows:

- **Quantity** comprises all kinds of quantifications when numbers are used to organize and describe situations.
  Examples from the *elementary sector*: comparisons of sets, counting (ordinal/cardinal aspects of numbers), simple operations (e.g., adding)
  Examples from the *adult sector*: calculations of percentages and interests, calculations of area and volume, use of different units, simple equation systems
- **Space and Shape** includes all types of planar and spatial configurations, shapes or patterns.
  Examples from the *elementary sector*: recognizing geometric shapes, simple properties of shapes, perspective
  Examples from the *adult sector*: three-dimensional mathematical objects, geometric mappings, elementary geometric theorems
- **Change and Relationships** includes all kinds of (functional) relationships and patterns.
  Examples from the *elementary sector*: recognizing and continuing patterns, relationships among numbers, proportionality
  Examples from the *adult sector*: interpreting curves or function graphs, properties of linear, quadratic, and exponential functions, extremum problems

- **Data and Chance** comprises all situations involving statistical data or chance.
  Examples from the *elementary sector*: intuitively assessing probabilities, collecting and structuring data
  Examples from the *adult sector*: interpreting statistics, basic statistical methods, calculating probabilities

The cognitive components of mathematical thinking processes are distinguished as follows:

- **Applying technical skills** includes using known algorithms and remembering mathematical knowledge or calculation methods.
- **Modelling** includes the representation in a situation model and in a mathematical model as well as interpreting and validating results in real-life situations.
- **Arguing** includes assessing explanations and proofs, but also developing own explanations or proofs.
- **Communicating** requires communication on mathematical contents and includes, among other things, the correct and adequate use of mathematical technical terms.
- **Representing** comprises the use and interpretation of mathematical representations such as tables, charts or graphs.
- **Problem Solving** takes place, when there is no obvious approach, and, therefore, includes systematic trying, generalizing or examining special cases.

This differentiation renders the framework concept of mathematical competence in NEPS compatible with both the PISA studies and the German National Mathematics Education Standards. The test items used in NEPS refer to one content area that is mainly addressed by the item, but may well contain several cognitive components.

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Cognitive basic skills (non-verbal) – Perceptual speed and reasoning

In NEPS, cognitive basic skills are measured based on the differentiation between "cognitive mechanics" and "cognitive pragmatics" following Baltes, Staudinger and Lindenberger (1999). While the former is measured using task contents as education-independent, new and domain-unspecific as possible, the tasks for measuring cognitive pragmatics are based on acquired skills and knowledge (Ackerman, 1987). Consequently, some of the domain-specific performance tests used within the framework of NEPS may serve as indicators of pragmatics.

In contrast to this, the tests of basic cognitive skills aim at assessing individual differences of fluid cognitive abilities. While these are subject to age-related changes, in comparison to the education- and knowledge-related competences they prove to be less culture-, experience- and language-dependent and more strongly biologically determined. In this context, these tests provide an individual basis and differentiating basic function for the acquisition of education-dependent competences.

Among the facets of cognitive mechanics, two common marker variables stand out: perceptual speed (WG) and reasoning (SF).

Perceptual speed marks the basal speed of information processing (*"speed"*). In NEPS, this is measured by the Picture Symbol Test (NEPS-BZT). This is based on an improved version of the Digit-Symbol Test (DST) from the intelligence tests of the Wechsler family by Lang, Weiss, Stocker and von Rosenbladt (2007). Analogously to this improved version, the NEPS-BZT requires the reverse performance: to enter the correct figures for the preset symbols according to an answer key.

Reasoning serves as key marker of fluid intelligence (Gottfredson, 1997). The NEPS reasoning test (NEPS-MAT) is designed as a matrices test in the tradition of the RAVEN Test. Each item of the matrices test consists of several horizontally and vertically arranged fields in which different geometrical elements are shown – with only one field remaining free. The logical rules on which the pattern of the geometrical elements is based have to be deduced in order to be able to select the right complement for the free field from the offered solutions.

Both tests have been designed in such a way that they can be effectively used without changes to the item sets across as many age groups as possible and relatively independent from the subjects' mother tongue. Currently, they are administered as paper-and-pencil tests, while computer-aided administration is generally possible.

The results of both tests provide an estimator of basic cognitive skills which, however, is not directly comparable to the overall result of a traditional intelligence test (IQ). It rather permits controlling for differential initial capacities in the competence acquisition process.

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Competence in English reading

The reading competence tasks for English developed by the Institute of Quality Development in Education (Institut für Qualitätsentwicklung im Bildungswesen (IQB)) take into account the different aspects of written texts listed in the National Educational Standards (Nationale Bildungsstandards (KMK, 2003, 2004)) and the Common European Framework of References (Gemeinsamen Europäischen Referenzrahmen (GER; Europarat, 2001)). The task texts are characterized by a high degree of authenticity in relation to English-speaking cultures, i.e. In the sense of typical expository and narrative texts from English-speaking societies. .

Based on the National Educational Standards and the GER, the IQB developed test specifications that served as a basis for item development by trained experts. In order to ensure most effective recording of reading competence, maximum attention was paid to perfect fit in terms of text, item and answer format in the further development of tasks. .

The tasks used in the Thuringian study can be allocated to the levels B1 through C1 of the GER that are described as follows (Europarat, 2001, S. 227):

B1: […] At this level, it is possible to understand texts containing everyday or job-related language. […]

B2: […] At this level, it is possible to understand articles and reports on current topics if the author gives his opinion on a problem or expresses a certain perspective. […]

C1: […] At this level, it is possible to understand complex technical and literary texts as well as recognize differences in style. One can understand technical language in articles and technical instructions, even if they are outside one's own subject.

A detailed description of the English competence test developed by the IQB, including the reading competence test, is contained in Rupp, Vock, Harsch und Köller (2008).

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Competence in physics

The construct "Competence in Physics" is based on the concept of deepened Basic Education in Natural Sciences used within the framework of this test NEPS partial study in Thuringia as is to be acquired at the secondary-school level. Consequently, the operationalization of the construct is based on the EPA requirements for the Abitur physics exam (Einheitliche Prüfungsanforderungen für die Abiturprüfung in Physik) (KMK, 2004).

Based on the "Concept of the Education Standards for the Intermediate School-Leaving Certificate in Physics" (Konzeption der Bildungsstandards für den Mittleren Schulabschluss in Physik (KMK, 2005)), the EPA requirements describe deepened Basic Education in Natural Sciences using competences in four areas: *specialist knowledge, specialist methods, communication and reflection.* At the same time, basic and advanced technical contents are identified based on which the students are to be able to demonstrate the relevant competences. The former include basic

- Properties and applications of electrical, magnetic and gravitational fields,
- Phenomena and properties of mechanical and electromagnetic waves, including light,
- Features of quantum objects, including the associated epistemological aspects,
- Features of the structure matter, including examples of analytical methods (see. KMK, 2004).

These contents can be deepended based on Land-specific regulations and extended by further contents. The EPA gives examples of contents from astro physics, non-linear systems, dynamics (including vibrations), electronics, solid-state physics, theory of relativity and thermodynamics (see KMK, 2004).

Accordingly, the operationalization of the construct competence in physics is oriented towards the content-related requirements of the Thuringian curriculum for physics as a basic subject in the senior grades (Thüringer Kultusministerium, 1999). The curriculum particularly takes into account the basic contents listed in the EPA. Table 1 shows the allocation of the topics listed in the Thuringian curriculum to the basic contents contained in the EPA; in addition, the table also shows the respective instruction hours.

Tab. 1: Allocation of Topics to Basic Contents

Basic Topic	Topic	Instruction Hours
Fields	Electrical Fields and Interaction (1) Magnetic Fields and electromagnetic Induction (2)	38
Waves	Waves (4), Optics (5)	30
Quanta Matter	Quantum Physics (8)	22

In addition, the Thuringian curriculum considers specific contents listed as examples in the EPA, with the respective allocation being shown in Table 2.

Tab. 2: Allocation of Topics to Basic Contents

Basic Topic	Topic	Instruction Hours
Dynamics	Vibrations (3), Mechanics of the Rigid Body (6)	29
Thermodynamics	Thermodynamics (7)	22
Theory of Relativity	Special Theory of Relativity (9)	3

In the test, for each of the nine topics listed in the Thuringian curriculum, a number of tasks was used commensurate with the relative volume of hours allocated to the respective area. The tasks cover skills from the four areas of competence: specialist knowledge, specialist methods, communication and valuation, with the focus being on technical knowledge.

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Competence in biology

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The outline concept of the biology competence test originally developed within the framework of the Swiss EVAMAR (Evaluation der Maturitätsreform) project is based on a two-dimensional raster where one content-related and one cognitive dimension is crossed. As a further basis for constructing the tasks, the biological knowledge and skill elements determined by way of a content analysis were used which are a precondition to understand teaching material of the first semester of sixteen academic subjects surveyed at Swiss universities (see Eberle et al., 2008).

Content Areas

In formulating the content-related dimension, the outline concept of biologocal competence falls back on the analysis of four German-language standard biology textbooks at the secondary-school level (Secondary Level II) (Biologie Oberstufe, 2001; Biologie heute entdecken, 2004; Linder Biologie, 2005; Natura, 2006). First of all, 10 content areas can be distinguished which, following the textbook “Biologie Oberstufe“, were combined in six large content areas (see Table):

- **Cytology / Anatomy / Metabolism** with fine structure of the cell, biocatalysis, operating metabolism and energy turnover, photosynthesis
- **Information Processing / Behavior** with excitation and transmission, sensory organs, brain and perception, movement control, control of body functions, reflexes, conditioning, learning and behavior
- **Immunobiology** with unspecific and specific body defense, infectious diseases, immunity, tumors
- **Genetics / Developmental Biology** with molecular genetics, classical genetics with cyto, human and applied genetics, reproduction, embryonic development
- **Ecology** with ecofactors, relationships between organisms, man and environment
- **Systematics/ Evolution** with classification of organisms, variation, selection, genetic drift, analogy and homology

Cognitive Requirements Areas

The dimensioning of the cognitive requirements areas is directly based on the requirements areas (KMK, 2004) formulated in the EPA requirements for the Abitur biology exam (Einheitliche Prüfungsanforderungen in der Abiturprüfung Biologie). It is the only concept of cognitive requirements established so far which was explicitly formulated for the SII level.

Requirements Area I includes

- the availability of data, facts, rules, formulas, mathematical theorems etc. from a limited requirements area within the learned context
- the description and use of learned and practiced working techniques and operational procedures within a limited requirements area and in a repeated context

The biology subject includes

- the reproduction of basic knowledge (knowledge of facts, interrelations and methods)
- the use of known methods and model concepts in comparable examples
- the extraction of information from technical texts und conversion of this information into simple schemes (phylogenetic tress, flowcharts and the like)
- the written representation of data, tables, figures using the technical language
- the description of macroscopic and microscopic observations
- the description and recording of experiments
- experimenting according to instructions and creating microscopic specimen
- proper use of known software

Requirements Area II includes

- independently selecting, arranging, processing and representing known facts with the aid of predefined aspects in a context known through practice
- independently transferring acquired knowledge to comparable new problems, changed factual connections or modified operational procedures.

The biology subject includes

- the use of the basic concepts in new connections
- the application and adjustment of model concepts
- the properly, independently, structured and task-related representation of complex biological processes in connection with a task
- the selection of known data, facts and methods to create new connections
- the selective extraction of information from complex materials or a scientific publication under a predefined aspect
- the abstracting representation of biological phenomena such as the graphic representation and interpretation of an unknown microscopic specimen
- the use of known experiments and examination methods in new connections
- the analysis of unknown examination results under known aspects
- the evaluation and assessment of a known biological topic
- the differentiation of everyday concepts and scientific findings.

Requirements Area III includes

- planned and creative processing of complex problems with the aim to independently arrive at solutions, interpretations, valuations and conclusions

- deliberate and independent selection and adjustment of suitable, acquired methods and procedures in new situations.

The biology subject includes

- the development of independent access to a biological phenomenon, e.g. planning of a suitable experiment or thought experiment
- the independent, cohesive processing of different materials within the framework of an independently developed task
- the development of a complex thought model and/or independent modification of an existing model concept
- the development of well-founded hypotheses based on different facts, experimental results, materials and models
- the reflection of biological facts with reference to the imgae of man
- the material-related and differentiated valuation and assessment of biological applications
- argumentation based on non-ambiguous raw data: data preparation, error analysis and creation of connections
- the critical reflection of biological technical terms against the background of complex and contradictory information and observations

Tab.1: Outline Concept of Biological Competence in NEPS

		Content Area (based on German-language standard biology textbooks SII)					
		Cytology / Anatomy / Metabolism	Information Processing / Behavior	Immunobiology	Genetics/ Developmental biology	Ecology	Systematics / Evolution
Cognitive Requirements Area (EPA Biology)	I: Reproducing and practiced application						
	II: Restructuring and Transferring						
	III: Evaluating and Resolving Problems						

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