NEPS
National Educational Panel Study

Research Data

Information on Competence Testing

NEPS Additional Study — Thuringia
Organizational Reform Study in Thuringia

Students, Grade 12 2010/2011

LEIBNIZ INSTITUTE FOR
EDUCATIONAL TRAJECTORIES

Leibniz Institute for Educational Trajectories (LIfBi)
Wilhelmsplatz 3, 96047 Bamberg
Director: Prof. Dr. Sabine Weinert
Executive Director of Research: Dr. Jutta von Maurice
Executive Director of Administration: Dr. Robert Polgar
Bamberg; July 30, 2018

Information on testing	
Test situation	Group testing in schools, 1 test instructor/test group (approx. 25 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
Test duration (pure processing time)	174 minutes
Breaks	Only short breaks between the individual tests

Information on the individual tests

Construct	**Number of items**	**Allowed processing time**	**Survey mode**	**Next measurement**
Competence in biology (EVAMAR Biology Test)	126 (18 Items/test booklet)	45 min	mostly multiple choice, partly open answering format	- -
Competence in physics	55 (17-18 Items/test booklet)	45 min	mostly multiple choice, partly forced choice as well as open answering format	- -
Competence in English reading	33 (21 Items/test booklet)	30 min	multiple matching, multiple choice answering format	- -
Competence in mathematics	40 (19-21 Items/test booklet)	30 min	mostly multiple choice, partly open answering format	- -
Cognitive basic skills (KFT)	65	24 min	multiple choice answering format	- -

Preliminary note

The development of the test in the context of the additional study concerning the reform of the Gymnasiale Oberstufe in Thuringia 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 both studies comprising the reform study Thuringia – A70 and A71.

Competence in biology

Johannes Kottonau | University of Zurich

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 crossing one content-related with one cognitive dimension. As a further basis for task construction, the biological knowledge and skill elements determined by way of a content analysis were used which form a precondition to understand teaching material of the first semester of 16 academic subjects surveyed at Swiss universities (see Eberle et al., 2008).

Content areas

In formulating the content-related dimension, the outline concept of biological 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). So far, this is the only concept of cognitive requirements established that is explicitly formulated for the SII level.

Requirements area I includes

- availability of data, facts, rules, formulas, mathematical theorems etc. from a limited requirements area within the learned context
- 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

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

Requirements area II includes

- independent selection, arrangement, processing and representation of known facts with the aid of predefined aspects in a context known through practice
- independent transfer of acquired knowledge to comparable new problems, changed factual connections or modified operational procedures.

The biology subject includes

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

- development of independent access to a biological phenomenon, e.g. planning of a suitable experiment or thought experiment
- independent, cohesive processing of different materials within the framework of an independently developed task
- development of a complex thought model and/or independent modification of an existing model concept
- development of well-grounded hypotheses based on different facts, experimental results, materials, and models
- reflection of biological facts with reference to the image of man
- material-related and differentiated evaluation 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	Immuno-biology	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						

List of references

Biologie heute entdecken. (2004). *Allgemeine Ausgabe für SII*. Braunschweig: Schroedel.

Biologie Oberstufe. (2001). *Gesamtband*. Berlin: Cornelsen.

Eberle, F., Gehrer, K., Jaggi, B., Kottonau, J., Oepke, M. & Pflüger, M. (2008). *Evaluation der Maturitätsreform 1995. Schlussbericht zur Phase II.* Bern: Staatssekretariat für Bildung und Forschung SBF.

KMK (2004). Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland: Einheitliche Prüfungsanforderungen in der Abiturprüfung Biologie“ (Beschluss der Kultusministerkonferenz vom 01.12.1989 i.d.F. vom 05.02.2004). Internet: http://www.kmk.org/doc/beschl/EPA-Biologie.pdf. Zugriff am 21.02.08.

Linder Biologie. (2005). *Gesamtband SII, 22. Auflage*. Braunschweig: Schroedel.

Natura. (2006). *Grundlagen der Biologie für Schweizerische Maturitätsschulen*. Zug: Klett und Balmer.

Competence in physics

The construct *Competence in Physics*, as used in the tests administered within the framework of this NEPS partial study in Thuringia, is based on the concept of deepened Basic Education in Natural Sciences 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 deepened based on state-specific regulations and extended by further contents. The EPA gives examples of contents from astrophysics, 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	Quantum Physics (8)	22
Matter		

In addition, the Thuringian curriculum considers specific contents listed as examples in the EPA, with the respective allocation 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 were 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.

List of references

Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland [KMK]. (2004). Einheitliche Prüfungsanforderungen in der Abiturprüfung Physik (Beschluss der Kultusministerkonferenz 01.12.1989 i.d.F. vom 05.02.2004). Abgerufen von http://www.kmk.org/fileadmin/veroeffentlichungen_beschluesse/1989/1989_12_01-EPA-Physik.pdf

Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland [KMK]. (2005). Bildungsstandards im Fach Physik für den Mittleren Schulabschluss. Beschluss vom 16.12.2004. München: Luchterhand.

Thüringer Kultusministerium (1999). Lehrplan für das Gymnasium – Physik. Saalfeld: SATZ+DRUCK Centrum Saalfeld.

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 representative 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).

List of references

Europarat (2001). Gemeinsamer europäischer Referenzrahmen für Sprachen: lernen, lehren, beurteilen. Berlin: Langenscheidt.

KMK (2003). Bildungsstandards für die erste Fremdsprache (Englisch/Französisch) für den Mittleren Abschluss [National educational standards for the first foreign language (English/French) for the Mittlerer Schulabschluss]. München: Luchterhand.

KMK (2004). Bildungsstandards für die erste Fremdsprache (Englisch/Französisch) für den Hauptschulabschluss [National educational standards for the first foreign language (English/French) for the Hauptschulabschluss]. München: Luchterhand.

Rupp, A. A., Vock, M., Harsch, C. & Köller, O. (2008). Developing standards-based as-sessment tasks for English as a first foreign language – Context, processes, and out-comes in Germany. Münster: Waxmann.

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.

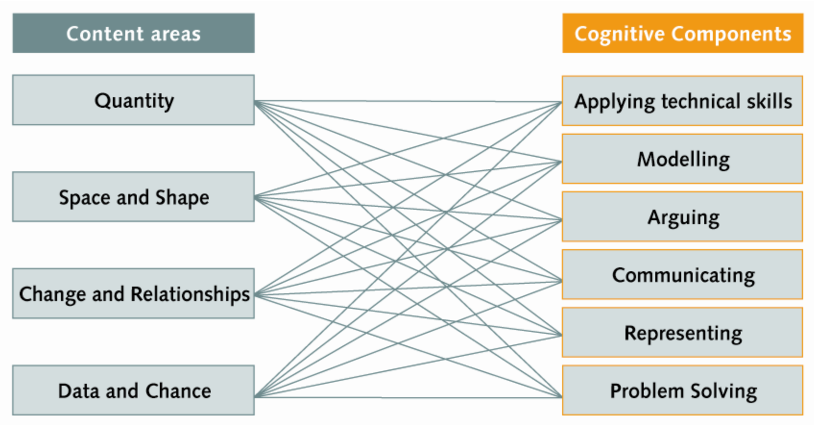

Fig. 1: Framework of mathematical competence in NEPS

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.

List of references

Organisation for Economic Co-Operation and Development [OECD] (2003). The PISA 2003 assessment framework – mathematics, reading, science and problem solving knowledge and skills. Paris: OECD.

Assessment of cognitive basic skills in the NEPS study concerning the reform of the Gymnasiale Oberstufe in Thuringia

The test of cognitive skills for grades 4 to 12, revision (KFT 4-12 + R; Heller & Perleth, 2000) was used to assess cognitive basic skills. The KFT 4-12 + R was developed on the basis of the Lorge-Thorndike-Intelligence-Test (1954-57; Lorge, Thorndike & Hagen, 1964) for the assessment of the students' level of overall cognitive performance. It follows factor-analytical tradition and comprises verbal, quantitative, and figural-spatial dimensions, for whose assessment three sequences of tasks each are available.

In the NEPS study concerning the reform of the *Gymnasiale Oberstufe* in Thuringia each skill dimension was taken into consideration with one sequence of tasks: “word analogies” (subtest V3, verbal dimension), “numerical series” (subtest Q2, quantitative dimension) and “figure analogies” (subtest N2, figural-spatial dimension). In different intelligence models, the three sequences of tasks can be classified as follows (vgl. Heller & Perleth, 2000): they can be described as *reasoning* factors in the Thurstone model; in the Berlin intelligence-structure-model (Jäger, 1984) they can be assigned to the operation *Verarbeitungskapazität (processing capacity)*; according to Guilford they exact the mental operation *cognition* and handling of the mental products *relations* (word and figure analogies)and *systems* (numerical series) respectively. The task sets for grade 12 were employed and both test forms A+B were used.

The subtest V3 “word analogies” consists of 20 items which are pairs of words whose components have a specific relation to each other. The task consists of forming a second, comparable pair of words for each of the 20 items. A third word is given for this purpose and the matching one is to be chosen from five alternative answers. The 20 items have to be completed within 7 minutes.

The subtest Q2 “numerical series” consists of 20 items which are a sequence of 5 numbers each following each other according to a specific rule. Out of five alternative answers the number with which the sequence can be continued is to be chosen. The numerical series have to be completed within 9 minutes.

The subtest N2 “figure analogies” consists of 25 items. The items' structure parallels that of subtest V3, though pairs of figures are depicted instead of pairs of words. The figure pairs have to be completed within 8 minutes.

List of references

Heller, K. A. & Perleth, C. (2000). KFT 4-12+R Kognitiver Fähigkeitstest für 4. bis 12. Klassen, Revision - Manual. Weinheim: Beltz.

Jäger, A. O. (1984). Intelligenzstrukturforschung: Konkurrierende Modelle, neue Entwicklungen, Perspektiven. Psychologische Rundschau, 35, 21-35.

Lorge, I., Thorndike, R. L. & Hagen, E. (1964). The Lorge-Thorndike Intelligence Tests. Boston: Houghton Mifflin.