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## DFG Research Unit 'CORE' Critical Online Reasoning in Higher Education

### **'CORE' Working Papers No. 1**

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(Eds.)**

**Critical Online Reasoning in Higher Education (CORE) –  
Overview of the Research Unit: Objectives, framework, structure,  
and research projects**

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## ***CORE Working Papers on the DFG Research Unit “Critical Online Reasoning in Higher Education”***

The *CORE Working Papers* series publishes papers from the DFG funded Research Unit “Critical Online Reasoning in Higher Education” (CORE), including project background information, technical reports, and preliminary results that are intended for rapid dissemination and scientific exchange within CORE as well as with the broad research community. Publication as a *CORE Working Paper* does not preclude publication elsewhere. Responsibility for the content lies with the authors. The content does not necessarily reflect the views of the series editors.

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# Critical Online Reasoning in Higher Education (CORE)

## Overview of the Research Unit:

### Objectives, framework, structure and research projects

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## **Critical Online Reasoning in Higher Education (CORE) – Overview of the Research Unit**

### **Abstract**

Approximately three million students at more than 420 institutions of higher education in Germany use the Internet daily to obtain information to complete assignments and prepare for exams. Studies reveal that students lack the skills to properly search, filter, evaluate, and integrate information gained from the highly diverse and overabundant online content. The need to understand, evaluate and consequently strengthen the skills of knowledge acquisition through Internet based media is crucial.

The interdisciplinary and international research unit “Critical Online Reasoning in Higher Education (CORE)” (FOR 5404) funded by the German Research Foundation (DFG) for an initial period of four years (2023 – 2027) aims to explore the online learning behaviors and online information landscapes that students in medicine, physics, economics, and social sciences use for their studies.

### **Key Words**

Critical Online Reasoning; Online Learning Environment; Digital Learning; Higher Education; Online Information Landscape; Critical Information Problems; Behavioral Data; Multimodal Text Data; Longitudinal Assessment; Scenario-based Tests; Economic Education

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## Research Unit Critical Online Reasoning in Higher Education (FOR CORE) Framework, Research Design, and Structure

Olga Zlatkin-Troitschanskaia, Dimitri Molerov, Jennifer Fischer & Johannes Hartig

### Introduction

Students in higher education are learning increasingly online (Grothaus et al., 2021; Maurer et al., 2020). In recent surveys, they claim the Internet is their main source of information for completing course-related assignments. In contrast to formal, on-site or digital learning environments moderated by a lecturer who preselects learning materials, self-directed online studying requires a particular skill-set to determine which sources are reliable as learning materials and which information is accurate and useful for knowledge building (Osborne et al., 2022). Despite the large body of research on media use in formal teaching-learning settings, little is known about students' self-directed learning on the Internet, including the effects of new AI-tools like ChatGPT, their processing and selection of online information, and the key influences on students' use of online sources in higher education.

Therefore, as of September 2023, the German Science Foundation (DFG) is funding the interdisciplinary research unit "Critical Online Reasoning in Higher Education" (CORE)" (FOR 5404). CORE aims to understand how students in higher education actively and purposefully acquire, discern, and use accurate information from reliable online sources in a typically mixed-quality information online landscape like the Internet to build warranted knowledge, complete course-related tasks, and study successfully. Based on the FOR's extensive prior work, including the development of validated models and assessments (e.g., Maurer et al., 2020; Nagel et al., 2020,2022; Zlatkin-Troitschanskaia et al., 2021a), the first funding phase (2023–2027) addresses the students' COR development in online learning environments with a multilayered conceptual framework, a longitudinal panel study, and innovative research infrastructure (incl. a digital assessment platform Azure Lab). CORE research combines the strengths of numerous disciplinary and interdisciplinary approaches and involves qualitative, quantitative, and mixed-method analyses to generate new integrative theories and models, timely research findings, and a unique set of educational research data that offer a new path for long-term research and development in higher education.

### Conceptual Framework

#### *Information Landscape*

In CORE, we systematically investigate the online information landscape (IL), which includes all sources and content accessible on the World Wide Web that students use for their university studies as well as for solving COR tasks in online assessments. While conducting an online search on a domain-specific or generic topic, its time-bound composition includes a set of Web sources that vary in domain, modality, genre, quality, and other characteristics and requires specific students' skills to derive warranted knowledge and a reliable task solution. Various skills can be crucial for accessing some parts of the IL and attaining particular learning goals (e.g., only experts may be able to detect errors in data), while, in other cases, use of online information varies less according to skill than to the presence of specific cues. While research suggests an interdependence between students' skills and the (online) IL they assess and use for learning, the online IL has rarely been examined for educational purposes. To address this research desideratum, the IL framework is based on the integration of several theories to analyze the central characteristics of online sources and their influences on COR. This includes the analyses of

- (a) the correctness and comprehensibility of content based on the evaluation criteria of established theories, such as media bias (see B04; e.g. Maurer et al., 2018);
- (b) linguistic features of the sources based on the theories of text and cognitive linguistics (see B05; e.g. Bisang & Czerwinski, 2020; Mehler et al., 2018);

- (c) narrative framings and latent meaning structures based on theories of narratology and reconstructive hermeneutics (see B06; e.g. Shiller, 2019).

### *Critical Online Reasoning*

CORE research is based on a newly developed, integrated theoretical-conceptual framework of a key skillset deemed crucial for acquiring accurate information online and using it for learning that we refer to as critical online reasoning (COR) (Molerov et al., 2020). COR consists of three overarching and overlapping cognitive facets:

- (1) online information acquisition (OIA) skills, e.g., selecting search engines or databases, specifying search queries;
- (2) critical information evaluation (CIE) skills, e.g., evaluating website credibility based on cues; and
- (3) argumentative skills, e.g., using evidence to generate and justify a valid argument based on the synthesis of information accessed (REAS), including accounting for common errors and biases and considering and weighting (contradictory) arguments and (covert) perspectives of (partly conflicting) information sources.

In addition, metacognitive skills regulate the state- and situation-specific activation, continuation, and conclusion of COR processes (MCA) within the encompassing information acquisition context, e.g., recognizing the need to use COR in learning contexts.

The COR concept leans heavily on previously developed process and phase models of (online) information search, selection, and evaluation, especially the Information problem-solving on the Internet (IPS-I) model (Brand-Gruwel et al., 2009), and it includes insights e.g., into cues of sources from related research on 'Web credibility' (e.g., Wierzbicki, 2018) and multiple-source comprehension (MSU, Braasch et al., 2018), where COR-related skills have been investigated.

Based on a research review (Zlatkin-Troitschanskaia, Hartig et al., 2021b), we also developed a taxonomy for online student learning, created with a focus on knowledge acquisition from Internet sources. The taxonomy describes the typical situations in which students use the Internet. Two broad areas have become evident: One is Internet use in specific study and practice-related tasks within one study domain, such as creating a diagnostic plan in medicine. The other is the cross-domain area, which covers broad topics such as discussion forums on climate change. Therefore, we distinguish between two typical application contexts of COR: Everyday situations in the study without reference to a specific domain as well as domain-specific situations. Since students face domain-specific as well as cross-domain requirements in their studies, we focus on both COR contexts. We refer to COR in the generic context as GEN-COR and COR in the domain-specific context as DOM-COR. Accordingly, we differentiate between GEN- and DOM-COR processes and performance. For instance, while a successful GEN-COR student faces everyday critical information problems and may need to primarily identify suitable information and honest, competent experts to trust, a successful DOM-COR student may need to act as said (budding) domain expert and research on specialist platforms, consult studies, interpret (reported) domain facts and data, and draw more nuanced conclusions (or display conducive online behaviors) (Zlatkin-Troitschanskaia et al., 2021a). To examine both application contexts, students were presented with corresponding tasks based on real Internet or Internet-like simulations.

### **Study Design**

To investigating a key skillset for online learning, i.e., COR, and the sources students access and use when learning and solving COR tasks (i.e., the online IL), the research unit (FOR) draws on a novel interdisciplinary conceptual and methodological approach. To determine students' COR levels, their development over university studies, and key COR covariates, the FOR examines qualitative and quantitative multimodal data, including:

- (1) students' sociodemographic background and learning characteristics (e.g., prior domain knowledge, general intellectual skills, reading skills, epistemological beliefs),
- (2) students' Web behavior and information processing (log data including all search activities collected during COR task-solving process),
- (3) online sources and information/content the students access, select and use during COR task-solving,
- (4) learning opportunities the students have taken (e.g., lectures) and general (online) media use, and
- (5) the learning success indicators including domain knowledge development and grades in their university studies.

We aim to investigate COR as well as online information environments in representative study disciplines that are both large and at the same time exemplary. For this purpose, we chose study domains that are in high demand: medicine and economics. Correspondingly, we assess COR performance on GEN- and DOM-COR tasks in economics (Econ) and medicine (Med) among students of these domains. To control for expected domain-specific effects, we included students of sociology (Soc) and physics (Phys) as comparison groups respectively.

To validly measure COR skills in open (i.e., real Internet-based) and closed (i.e., Internet-like simulations) scenario-based tasks, students are immersed in a realistic situation and asked to solve a constructed or real domain-specific course assignment or task using the Internet or the Internet-like simulation. Each COR task is based on the joint conceptual and assessment taxonomy and encompasses a multitude of behavioral indicators classified in a taxonomy of

- (a) the three COR facets (OIA, CIE, REAS);
- (b) three developmental levels (basic, advanced, proficient, based on the Model of domain learning (MDL by Alexander, 2004), and specific to the DOM-COR assessment
- (c) the three requirement areas/contexts (i.e., fundamental Econ/Med reasoning, practical Econ/Med reasoning, transdisciplinary reasoning).

In the longitudinal study design, assessments (booklets) are administered at eight participating universities throughout Germany at four annual measurement points, starting with first-year students in the four selected domains of economics, medicine, sociology, and physics in the winter term 2023 and following them throughout their undergraduate studies to 2026. The targeted sample size (accounting for expected drop-out and panel mortality) is N=1200 students (300 per domain). Fine-grained analyses of COR-task solving processes are explored in experimental studies with smaller samples (N=20 per domain) and in additional accompanying studies (e.g., to account for ChatGPT use, N=200).

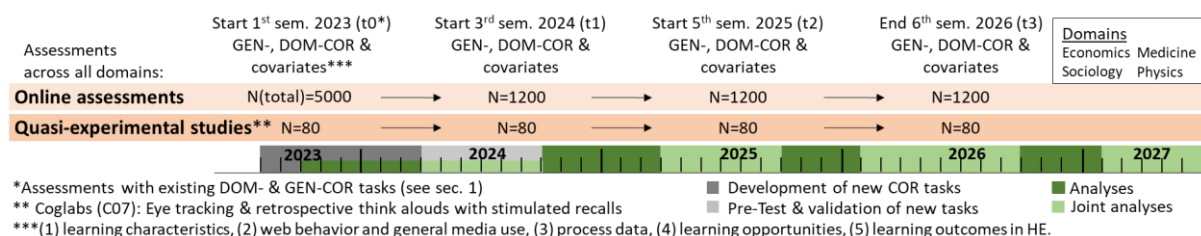


Figure 1: Study design.

Analyses in the FOR focus not only on students' COR process and performance, but also on the information landscape (IL) students encounter online. When solving COR tasks on the Internet, all sources visited and used are recorded and stored in a common data corpus. The FOR focuses on the characteristics of the (main) logged sources that students select and use as basis in their responses to COR tasks, in particular identifying features that are expected to contribute to the students' (decision of) relying on those sources and pieces of information. For example, they may promote/claim or diminish/contest



qualities such as comprehensibility, (non-)distraction, accuracy, authority, competence, imparted author confidence, certainty, positive or negative stance, cues for (high/low) credibility, loadedness or bias, etc. Coding manuals are compiled for the topic areas and range of logged sources at hand (as excerpts of the 'IL' online). Research approaches range from qualitative content coding of media products, to qualitative typological and quantitative computational linguistic analyses, to narrative structures analyses such as metaphors and reconstruction of latent meanings.

Process analyses during task-solving from think-alouds to eye-tracking on specific websites to logfile analyses are aimed at uncovering process indicators of (un)successful COR performance. Integrative cross-project analyses are expected to reveal overarching patterns of (un)successful performance and relations of COR development with influence variables as well as with study outcomes in the educational big data set. This provides a necessary basis for the improvement of learning materials and practitioner training in higher education and design learning interfaces to consider the affordances and risks of learning in an online environment.

Findings from the 1<sup>st</sup> research phase (2023 – 2027) will be used during the 2<sup>nd</sup> phase to devise innovative instructional interventions to help university students develop the COR skills needed to search for, critically assess, and use online information in higher education. These interventions will help universities adapt to the rapidly growing trend of Internet-based learning and fulfil their educational mandate in the Information Age.

### **Research Structure**

To understand the development of COR skills in higher education in relation to the 'mapped' online Information Landscape, our joint research program consists of three interrelated areas: A, B and C, each with two to three projects.

The three projects in Area A investigate the development and correlations of GEN- and DOM-COR in the two main domains (Economics and Medicine) and in the comparison domains (Sociology and Physics) over the course of the study program. To this end, the A projects develop valid assessment tasks from the academic/life world on the Internet and Internet-like simulations and use them in the longitudinal panel study via the joint assessment platform. The recorded and analyzed COR skills include searching, selecting, evaluating sources and information on the Internet, and drawing conclusions from them. The A projects are also responsible for analysing the main personal and contextual influencing factors on COR, such as courses attended and domain knowledge. All COR and contextual data are provided to the B and C projects for further analyses.

The three Area B projects analyze the online information environments (IL), in which the COR processes take place. B projects use the common data corpus to examine the characteristics and quality of the online sources visited and used when solving GEN and DOM COR tasks. Features of the online information selected by students are analyzed in depth using qualitative and quantitative methods from media, communication and literary studies, (computer) linguistics and (subject) didactics. They focus on those features which, according to the preliminary studies, may be particularly relevant for COR processes and performance. This includes the analyses of all content used, also from mass and social media, for its correctness and comprehensibility. These analyses are supported by computational linguists, and expanded to include detailed linguistic features. In addition, narrative framings and latent meaning structures of the sources used are analyzed qualitatively. In this way, the critical information quality indicators, which have rarely been accessible to learning research to date, are identified in the three B projects and will flow into the further analyses in the A and C projects. In this way, the central features of online IL are uncovered and examined regarding their correlation with students' COR skills. In addition to psychological research on primarily subjectively assessed (quality) characteristics of sources, CORE also draws on objectively describable information quality criteria from media and communication science, (computer) linguistics and (subject) didactics. The (subject) specific online

information environments for the subject/topic areas focused on in CORE are also recorded and taken into account in the analyses.

All COR performance and process data from Area A, including the sources used as well as all annotated characteristics of this information from Area B are fed into the joint database in Area C and analyzed integratively. To this end, new analysis models for this unique multimodal data, also using machine learning concepts, are developed. In addition, in in-depth quasi-experimental studies, the processing procedures during COR task solving are examined in more detail and strategies underlying successful COR performance are determined. The recorded online navigation and information processing processes (log data) of the students are analyzed using integrated methods. Eye-tracking methods are also used to analyze which specific areas of information students pay attention to when selecting and using online information. The in-depth process analyses serve to identify specifically used information as well as (un)successful strategies for task processing. By integrating the various strands of data (log data, sources/information used, task solutions, etc.), predictive models are developed that use students' previous performance and information characteristics to predict the desired task solution strategies and probability of success, and enable computer-based feedback to students. These analyses form the basis for the development of effective approaches to promoting COR skills in higher education and their evaluation in experimental intervention studies in the 2<sup>nd</sup> research phase.

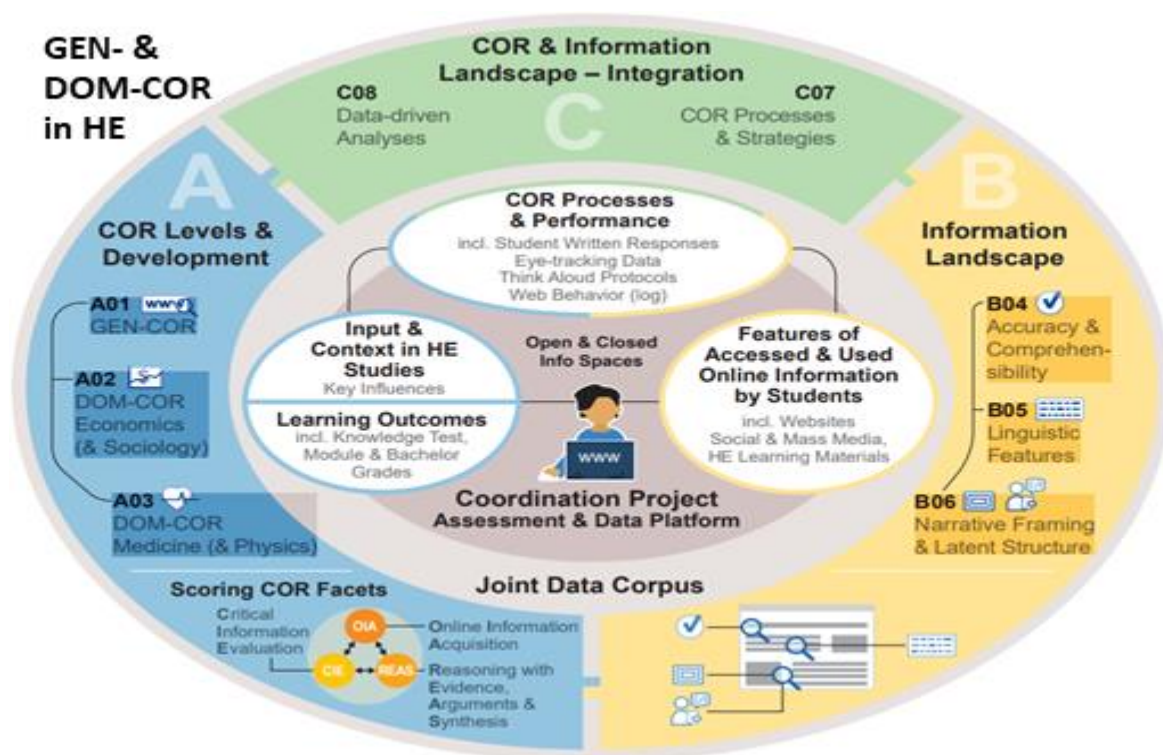


Figure 2. CORE research structure.

### Working Structure

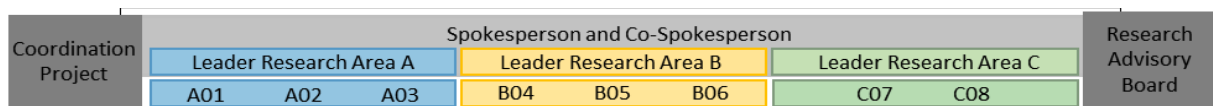
The German Research Foundation (DFG) has allocated over 5 million euros of funding to the research group (FOR) over four years (2023 – 2027). The FOR CORE is a consolidated group of over 60 (inter-)national researchers from 16 disciplines including a strong community of young researchers (PhD Candidates & Postdocs) with established collaborative working structures and methods for interdisciplinary mix-method research.

To achieve its objectives, an effective working and coordination structure has been established in the FOR. The spokesperson Olga Zlatkin-Troitschanskaia, the co-spokesperson Johannes Hartig, one leader for each of the three research areas (A: Martin Fischer, B: Mita Banerjee, and C: Stefan Küchemann), with one postdoc (Maruschka Weber) and one PhD candidate (Anna Horrner) as representatives of the group of young researchers, constitute the Steering Committee, which meets monthly and primarily makes cross-project strategic decisions.

The spokesperson is also head of the coordination project (CP) and has a key mediator role in the FOR. She is responsible for all cross-project joint FOR activities and for strengthening the FOR cohesion and impact. The co-spokesperson acts as deputy and heads measurement activities and the longitudinal study design. Area leaders orchestrate day-to-day coordination in the respective areas. In addition, cross-project work is also conducted in thematic task-force groups, which are constituted by one representative from each project. These are the current working groups in the FOR: "Survey and test booklet design", "COR task development", "Scoring development", "Annotation of text data" and "Chat-GPT study". In the latter group, an additional study is being planned and implemented in the FOR, focusing on the use of ChatGPT and its correlation with COR skills and study success.

The FOR Research Advisory Board (RAB) comprises leading international experts who advise the Steering Committee on the overall research plan and evaluate the FOR's work and progress annually. The research work in the nine projects is additionally being supported by eight international PIs from the USA, Canada and the Netherlands.

Figure 3. The FOR's management structure:



## References

- Alexander, P. A. (2004). A model of domain learning: Reinterpreting expertise as a multidimensional, multistage process. In D. Y. Dai, & R. J. Sternberg (Eds.), *Motivation, emotion, and cognition* (pp. 273–298). Erlbaum.
- Bisang, W. & Czerwinski, P. (2020). Performance in knowledge assessment tests from the perspective of linguistic typology. In O. Zlatkin-Troitschanskaia (Ed.), *Frontiers and advances in positive learning in the age of information (PLATO)* (pp. 207–235). Springer Nature Switzerland. [https://doi.org/10.1007/978-3-030-26578-6\\_16](https://doi.org/10.1007/978-3-030-26578-6_16)
- Braasch, J. L. G., Bråten, I., & McCrudden, M. T. (Eds.). (2018). *Handbook of multiple source use*. Routledge.
- Brand-Gruwel, S., Wopereis, I., & Walraven, A. (2009). A descriptive model of information problem solving while using internet. *Computers & Education*, 53(4), 1207–1217. <https://doi.org/10.1016/j.compedu.2009.06.004>
- Grothaus, C., Dolch, C., & Zawacki-Richter, O. (2021). Use of digital media in higher education across country contexts. *International Journal of Emerging Technologies in Learning*, 16(20), 64–83. <https://doi.org/10.3991/ijet.v16i20.24263>
- Maurer, M., Schemer, C., Zlatkin-Troitschanskaia, O., & Jitomirski, J. (2020). *Positive and negative media effects on university students' learning: Preliminary findings and a research program*. Springer. [https://doi.org/10.1007/978-3-030-26578-6\\_8](https://doi.org/10.1007/978-3-030-26578-6_8)
- Maurer, M., Quiring, O. & Schemer, C. (2018). Media effects on positive and negative learning. In O. Zlatkin-Troitschanskaia, G. Wittum, & A. Dengel (Eds.). *Positive Learning in the Age of Information (PLATO) - A Blessing or a Curse?* (pp. 197-208). Springer.

- Mehler, A., Hemati, W., Welke, P., Konca, M., & Uslu, T. (2020). Multiple Texts as a Limiting Factor in Online Learning: Quantifying (Dis-) similarities of Knowledge Networks. *Frontiers in Education*, 5. <https://doi.org/10.3389/educ.2020.562670>
- Mehler, A., Zlatkin-Troitschanskaia A., Hemati W., Molerov D., Lücking A., & Schmidt S. (2018a). Integrating computational linguistic analysis of multilingual learning data and educational measurement approaches to explore student learning in higher education. In: O. Zlatkin-Troitschanskaia et al. (Eds.), *Positive Learning in the Age of Information (PLATO) – A Blessing or a Curse?* (pp. 145–193). Springer. DOI: 10.1007/978-3-658-19567-0\_10
- Molerov, D., Zlatkin-Troitschanskaia, O., Nagel, M.-T., Brückner, S., Schmidt, S., & Shavelson, R. (2020). Assessing university students' critical online reasoning ability: A conceptual and assessment framework with preliminary evidence. *Frontiers in Education*. <https://doi.org/10.3389/educ.2020.577843>
- Nagel, M.-T., Schäfer, S., Zlatkin-Troitschanskaia, O., Schemer, C., Maurer, M., Molerov, D., Schmidt, S., & Brückner, S. (2020). How Do University Students' Web Search Behavior, Website Characteristics, and the Interaction of Both Influence Students' Critical Online Reasoning? *Frontiers in Education*. doi: 10.3389/educ.2020.565062
- Nagel, M.-T., Zlatkin-Troitschanskaia, O. & Fischer, J. (2022). Validation of newly developed tasks for the assessment of generic critical online reasoning (COR) of university students and graduates. *Frontiers in Education*, 7. <https://doi.org/10.3389/educ.2022.914857>
- Osborne, J., Pimentel, D., Alberts, B., Allchin, D., Barzilai, S., Bergstrom, C., Coffey, J., Donovan, B., Kivinen, K., Kozyreva, A., & Wineburg, S. (2022). *Science Education in an Age of Misinformation. Report*. Stanford. <https://sciedandmisinfo.stanford.edu/>
- Schmidt, S., Zlatkin-Troitschanskaia, O., Roeper, J., Klose, V., Weber, M., Bültmann, A.-K., & Brückner, S. (2020). Undergraduate students' critical online reasoning – process mining analysis. *Frontiers in Psychology*, 11, 576273. <https://doi.org/10.3389/fpsyg.2020.576273>
- Shiller, R. (2019). *Narrative economics: How stories go viral and drive major economic events*. Princeton UP. <https://doi.org/10.4000/oeconomia.1112>
- Wierzbicki, A. (2018). *Web content credibility*. Springer.
- Wineburg, S., McGrew, S., Breakstone, J., & Ortega, T. (2016). Evaluating Information: The Cornerstone of Civic Online Reasoning. Stanford Digital Repository. <http://purl.stanford.edu/fv751yt5934>
- Zlatkin-Troitschanskaia, O., Brückner, S., Nagel, M.-T., Bültman, A.-K., Fischer, J., Molerov, D., & Schmidt, S. (2021a). Performance assessment and digital training framework for young professionals' generic and domain-specific online reasoning in law, medicine and teacher practice. *Journal of Supranational Policies of Education*, 13, 9–36. <https://doi.org/10.15366/jospoe2021.1>
- Zlatkin-Troitschanskaia, O., Hartig, J., Goldhammer, F., & Krstev, J. (2021b). Students' online information use and learning progress in higher education – A critical literature review. *Studies in Higher Education*, 46(10), 1996–2021. <https://doi.org/10.1080/03075079.2021.1953336>

## Overview of the FOR CORE projects

### Coordination Project (CP)

Olga Zlatkin-Troitschanskaia, Jennifer Fischer, Dimitri Molerov & Lisa Martin de los Santos Kleinz

#### Abstract

The CP has to ensure continuous, effective collaboration among all FOR participants and all national and international cooperation partners, through targeted communication and information management structures and activities that support the advancement as well as alignment of the conceptual and methodological collaborations within and across the FOR projects. The Steering Committee and the RAB are also supported by the CP in all management and coordination activities in the FOR. This involves the implementation of digital internal and external communication as well as the assessment platform for all FOR projects. The implementation of the joint assessment platform is based on the Azure Lab platform established and used in the prior project Bridge (Zlatkin-Troitschanskaia et al., 2021a). The platform is currently being further developed by C08 to meet FOR's specific needs and to allow all FOR researchers easy and secure access to the assessment tool and data collected. This joint platform also enables effective centralized issuance of feedback to participants and participating universities.

Intensive and continuous collaboration within the FOR and with its cooperation partners is key to successful research and development in the FOR. A close and continuous collaboration across locations is ensured by regular meetings. The CP organizes all FOR conferences and workshops with the international PIs and the RAB to ensure steady exchange and cooperation. This includes the close collaboration with a Mercator Fellow of the FOR, Prof. Patricia Alexander, a distinguished Professor at the University of Maryland, Director of the Learning Research Lab and a long-term cooperation partner.

Organizing support measures for young researchers in CORE (YORE) to advance their professional development and gender and minority equality measures is also part of the CP work. The FOR aims to promote diversity among the FOR, provide equal opportunities, and empower all minority groups, e.g., through further qualification. It endorses consistent, transparent, and equal conditions for all researchers, facilitating a network for women and parents, and tailored programs for all researchers with special needs.

To promote the national and international visibility of the FOR research, the CP prepares and supports cross-project publications and contributions to (inter-)national conferences. This includes several joint special issues with open access in internationally renowned journals, joint symposia and presentations at renowned conferences, and the frequent organization and publication of CORE working papers.

To draw cross-disciplinary conclusions and contribute to integration of the FOR results into a (inter-)national research landscape, meta-analyses of FOR findings are conducted and published by the CP. In addition, the CP supports and coordinates the external research transfer of key findings and know-how from the FOR to gain visibility and deepen connectivity to the (inter-)national expert community through targeted transfer workshops with practitioners and the general public. These workshops help to integrate FOR research findings into university teaching and learning through internal discussion forums and public presentations on FOR findings and their practical implementation. The CP also promotes the public relations work of the FOR, including conceptualizing, setting up, and updating the FOR homepage in German and English, regularly preparing and publishing the FOR's key research findings through various further media channels (including social media), and collaborating with university press offices.

#### Research Contribution to the FOR CORE

The CP conducts systematic syntheses of the research work and key results, and meta-analyses with the cross-project research findings to strengthen the interconnectedness and to identify and showcase overarching FOR findings.

**Project details**

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Homepage	<a href="https://core.uni-mainz.de/">https://core.uni-mainz.de/</a>

## AREA A – Critical Online Reasoning Development

### A01: Generic Critical Online Reasoning (GEN-COR) Skills – Measurement, Development and Comparative Analyses across Academic Domains

Johannes Hartig, Frank Goldhammer, Carmen Köhler, Carolin Hahnel, Philine Drake, Jannick Illmann & Marcus Schrickel

#### **Abstract**

Over the past years, university students have increasingly used information from the Internet to learn about subjects relevant to their studies (Zlatkin-Troitschanskaia, Hartig et al., 2021). However, accessing and acquiring knowledge in online environments presents students with specific challenges (Metzger & Flanagin, 2013; Nagel et al., 2020). Accordingly, students need a specific set of skills to meet these challenges. In our research unit (FOR), this skill set is referred to as generic (GEN) and domain-specific (DOM) critical online reasoning (COR) (Molerov et al., 2020). In the A01 project, we aim to explain students' GEN-COR and to describe its development within and across study domains using a longitudinal design. To this end, the current GEN-COR test (Molerov et al., 2020) will undergo an extension and validation process to evaluate the proficiency of students in higher education regarding GEN-COR skills required in the Information Age. We plan to test the assumed three-facet structure of this COR skill set, the separability of GEN-COR and DOM-COR skills, the role of media-specific and linguistic features of (online) information used in COR tasks and/or by students in their GEN-COR performance, the explanation of GEN-COR by conventional literacies of information processing, and the development of GEN-COR during students' progress over their academic studies. We assess GEN-COR using tasks in the open information space on the Internet, which will be further evaluated in terms of their validity for measuring complex multifaceted higher-order skill constructs, such as COR. In addition, we use standardized simulation-based tasks in closed information spaces.

#### **Aims and Research Questions**

Based on the newly developed complex scenario-based tasks to measure GEN-COR we aim to capture university students' information use behavior in real-world Internet environments. The tasks address general or everyday information problems that do not require domain-specific expertise. As an example, students may be presented with questions regarding the recycling of certain waste products or potential health risks associated with housing conditions. They will then be required to conduct research on the Internet and write a critical statement that includes arguments for and against a product or behavior, based on the evidence they have found. Furthermore, researched web sources are also to be evaluated by the students in terms of their quality. In addition to written responses, behavioral data will be collected, such as search terms used, web pages visited, and scrolling movements, to analyze relevant aspects of the COR task-solving process. These include, for example, the efficiency of search strategies and the inclusion of additional information for verification when assessing web sources.

A01 aims to provide insight into (1) the performance-based assessment of GEN-COR, (2) respective construct-related validity evidence regarding the dimensional structure, the relation to conventional literacies, and effects of media-specific and linguistic task features, (3) the longitudinal assessment of GEN-COR development, and (4) the key predictors of GEN-COR development during academic studies.

### **Contribution to the FOR CORE**

A01 will create a unique longitudinal database; its findings will contribute to a deeper understanding of how GEN-COR skills interact with situational demands in complex online information environments. The measurement approaches using the Internet and log data as sources of evidence will apply to other domains and skill constructs. For the research unit (FOR), the measurement of GEN-COR is vital to critically test the generic vs. domain-specific nature of the COR skills and to provide control variables when predicting learning outcomes. The GEN-COR assessment will provide data and findings that will be used in all FOR projects, e.g., GEN-COR as a control variable when estimating the effects of DOM-COR. To obtain a deeper understanding of individual differences and to derive a criterion-referenced description of scales, the web sources used in the tasks will be evaluated regarding, e.g., linguistic features potentially affecting COR task difficulties together with B projects, and in-depth analyses of task-solving behavior will be conducted together with C projects.

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### **References**

- Metzger, M. J., & Flanagin, A. J. (2013). Credibility and trust of information in online environments: The use of cognitive heuristics. *Journal of Pragmatics*, *59*, 210–220. <https://doi.org/10.1016/j.pragma.2013.07.012>
- Molero, D., Zlatkin-Troitschanskaia, O., Nagel, M.-T., Brückner, S., Schmidt, S., & Shavelson, R. J. (2020). Assessing university students' critical online reasoning ability: A conceptual and assessment framework with preliminary evidence. *Frontiers in Education*, *5*, 577843. <https://doi.org/10.3389/educ.2020.577843>
- Nagel, M.-T., Schäfer, S., Zlatkin-Troitschanskaia, O., Schemer, C., Maurer, M., Molero, D., Schmidt, S., & Brückner, S. (2020). How Do University Students' Web Search Behavior, Website Characteristics, and the Interaction of Both Influence Students' Critical Online Reasoning? *Frontiers in Education*, *5*, 565062. <https://doi.org/10.3389/educ.2020.565062>
- Zlatkin-Troitschanskaia, O., Hartig, J., Goldhammer, F., & Krstev, J. (2021). Students' online information use and learning progress in higher education – A critical literature review. *Studies in Higher Education*, *46*(10), 1996–2021. <https://doi.org/10.1080/03075079.2021.1953336>



## **A02: Development of Economics Students' Domain-Specific Critical Online Reasoning (DOM-COR) Skills over the Course of Their Bachelor Studies and Key Factors Influencing DOM-COR**

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### **Abstract**

Today's educators urgently need valid assessments that capture students' skills in evaluating critically and using online information to be able to design effective programs that prepare students for competent (self-directed) learning using the Internet. The A02 project addresses this highly practically relevant research deficit in higher education economics. It develops a research program to overcome the theoretical-conceptual and methodological deficits and to provide the diagnostic and action-guiding knowledge necessary for practice. In A02, domain-specific (DOM) critical online reasoning (COR) in economics and its development over time are modeled and analyzed as the key dependent variables. The longitudinal design with four test points at equidistant intervals of one academic year includes the three study phases of a bachelor's degree course in economics. A02 examines the extent to which the levels and development of DOM-COR throughout bachelor studies can be explained by the personal and contextual study-related variables. Predictors of the development of DOM-COR include degree programs, study tracks, courses, and further learning opportunities taken. This approach allows us to differentiate between the effects of economic courses on the development and levels of DOM-COR utilizing a longitudinal design and a comparison group of social science students to analyze the impact of domain-specific learning on DOM-COR in economics. To avoid confounded estimates of the effects, A02 includes student characteristics as control variables. A02, also analyzes which learning opportunities in or outside of higher education influence the DOM-COR-development of the different students (sub)groups.

### **Aims and Research Questions**

The first research objective addresses the empirical analysis of DOM-COR skills development and their covariates. This objective includes three main research questions (RQ):

RQ1: How can DOM-COR development in economics be measured validly in terms of psychometrics? To answer RQ1, we assess DOM-COR using newly developed and pretested scenario-based performance assessments that simulate and elicit real-life, professional decision-making situations in economics in the real Internet and Internet-like simulations.

RQ2: How do DOM-COR skills develop over the course of economics studies and how do they relate to GEN-COR skills, course contexts, learning success, and other covariates of interest? To investigate RQ2, we conduct a longitudinal panel study with four measurement points over bachelor studies.

RQ3: To what extent are DOM-COR skills transferable across domains (economics and sociology)? To address RQ3, which focuses on the domain-specificity of DOM-COR, we use the "known-groups" method to determine the level of DOM-COR in the target and control groups cross-sectionally as well as longitudinally by comparing the DOM-COR progressions of Econ students with those of the comparison group (Soc students). For the target group, the acquisition of DOM-COR-relevant skills in the Econ domain can be assumed in the Econ studies, whereas Soc students should primarily rely on cross-domain skills for the solution of DOM-COR tasks in Econ and primarily use everyday experience or knowledge from (previous) educational processes.

The second research objective concerns the use of research results in the research unit (FOR) and findings/transfer to research and practice.

### **Contribution to the FOR CORE**

The findings on students' DOM-COR skills in economics, their development, key determinants within and across the analyzed domains, and relation to learning success provide a unique basis for the conceptual development of instructional interventions using Internet-like simulations to foster the required DOM-COR skills in effectively in higher education. Through such interventions, we can investigate the extent to which DOM-COR skills can be improved within economic domains, and ways in which such approaches can be transferred across (more or less structured) domains such as economics and sociology. A better understanding of student-used sources and the timing of DOM-COR development allows us to pinpoint precise time frames for instructional interventions during the 2<sup>nd</sup> research phase. Additionally, analyzing the online information landscape and learning materials students use together with the B projects allows critical appraisal of fit and better integration of real-world online information sources into higher economics education.

A02 generates unique data and findings on the development of the students' DOM-COR skills as well as the key personal and institutional influence factors for which A02 controls. A02 will contribute substantially to the interinstitutional and cross-domain research on students' domain-specific information use, online learning, and success in higher education, and it will drive (inter)national advances urgently needed in this field.

A02 provides data and findings that will be further used for subsequent analyses in all FOR projects, e.g., log data and scores in C07 and for integrated analyses in C08, comparison with GEN-COR data in A01, textual data (e.g., accessed Web pages) in B projects.

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- Alexander, P. A. (2004). A model of domain learning: Reinterpreting expertise as a multidimensional, multistage process. In D. Y. Dai, & R. J. Sternberg (Eds.), *Motivation, emotion, and cognition* (pp. 273–298). Erlbaum.
- Hoyt, G. M. (2022). Critical thinking and economic instruction. *The Journal of Economic Education*, 53(1), 69–70. <https://doi.org/10.1080/00220485.2021.2004281>
- Kearney, M. S. (2022). What does critical thinking mean in teaching economics? *The Journal of Economic Education*, 53(1), 85–87. <https://doi.org/10.1080/00220485.2021.2004283>
- Maurer, M., Schemer, C., Zlatkin-Troitschanskaia, O., & Jitomirski, J. (2020). *Positive and negative media effects on university students' learning: Preliminary findings and a research program*. Springer. [https://doi.org/10.1007/978-3-030-26578-6\\_8](https://doi.org/10.1007/978-3-030-26578-6_8)

- Mislevy, R. J., Haertel, G., Riconscente, M., Rutstein, D. W., & Ziker, C. (2017). *Assessing model-based reasoning using evidence-centered design: A suite of research-based design patterns*. Springer. <https://doi.org/10.1007/978-3-319-52246-3>
- Molerov, D., Zlatkin-Troitschanskaia, O., Nagel, M.-T., Brückner, S., Schmidt, S., & Shavelson, R. (2020). Assessing university students' critical online reasoning ability: A conceptual and assessment framework with preliminary evidence. *Frontiers in Education*. <https://doi.org/10.3389/feduc.2020.577843>
- Nagel, M.-T., Zlatkin-Troitschanskaia, O. & Fischer, J. (2022). Validation of newly developed tasks for the assessment of generic critical online reasoning (COR) of university students and graduates. *Frontiers in Education*, 7. <https://doi.org/10.3389/feduc.2022.914857>
- Schrader, P. G., Lawless, K., & Mayall, H. (2008). The model of domain learning as a framework for understanding internet navigation. *Journal of Educational Multimedia and Hypermedia*, 17(2), 235–258.
- Walstad, W. B., Rebeck, K., & Butters, R. B. (2013). The Test of Economic Literacy: Development and results. *The Journal of Economic Education*, 44(3), 298–309. <https://doi.org/10.1080/00220485.2013.795462>
- Weber, H., Becker, D., & Hillmert, S. (2019). Information-seeking behaviour and academic success in higher education: Which strategies matter for grade differences among university students and how does this relevance differ by field of study? *Higher Education*, 77, 657–678. <https://doi.org/10.1007/s10734-018-0296-4>
- Zlatkin-Troitschanskaia, O., Brückner, S., Fischer, J. Molerov, D., & Schmidt, S. (2021a). Performance assessment and digital training framework for young professionals' generic and domain-specific online reasoning in law, medicine and teacher practice. *Journal of Supranational Policies of Education*, 13, 9–36. <https://doi.org/10.15366/jospoe2021.13.001>
- Zlatkin-Troitschanskaia, O., Hartig, J., Goldhammer, F., & Krstev, J. (2021b). Students' online information use and learning progress in higher education – A critical literature review. *Studies in Higher Education*, 46(10), 1996–2021. <https://doi.org/10.1080/03075079.2021.1953336>

## A03: Development of DOM-COR Skills in Medical Students During Their Pre-clinical Studies

Jan Zottmann, Anna Horrer, Jochen Kuhn, Jana Jünger, Jochen Roeper & Martin R. Fischer

### Abstract

In light of the advancements in medical information, medical education is challenged with equipping students with the skills necessary to effectively navigate this information landscape and make sound judgments (cf. Berndt et al., 2021). Developing critical online reasoning (COR) skills as part of medical studies has become essential – such skills are critical when students use the Internet to retrieve information about patient cases and solve professional problems (Wiblom et al., 2017). A lack of domain-specific (DOM-)COR skills may lead to misconceptions or misapplication of knowledge, ultimately compromising patient safety (Mamede et al., 2019). Thus, project A03 aims to develop valid assessments to (1) adequately describe DOM-COR in medical students, (2) predict DOM-COR development during academic studies, and (3) predict learning outcomes. Scenario-based tasks are utilised to measure three DOM-COR cognitive skill facets (Molerov et al., 2020): searching for online information (OIA facet); critical evaluation of the information (CIE facet); evidence-based reasoning and synthesizing of the information (REAS facet). A longitudinal study over the first three years of medical studies will examine effects of the medical curriculum on the development of DOM-COR skills based on a random sample of n=300 medical students and a comparison group of n=300 physics students. We evaluate the medical curriculum by analyzing Internet-based tasks and Internet-like simulations. Our goal is to identify the impact of courses and research activities on student performance. We also consider other key influencing factors such as individual learning prerequisites and interactions with specific properties of DOM-COR tasks or online materials used.

### Aims and Research Questions

The A03 project has three main objectives:

**1. Description of DOM-COR:** We empirically assess medical students' DOM-COR performance based on three facets of the COR construct: OIA facet; CIE facet; REAS facet. DOM-COR tasks are designed to simulate and elicit professional real-life decision-making with three different reasoning contexts: fundamental scientific reasoning, practical clinical reasoning, and transdisciplinary reasoning.

*Research Question 1)* To what extent can distinct medical DOM-COR skill profiles be identified in medical students (compared to physics students) based on the three DOM-COR skill facets?

**2. Prediction of DOM-COR development:** Comparing medical and physics students allows us to estimate the impact of medical education on DOM-COR development. We consider which courses students take during their studies. We also control for the role of individual learning prerequisites in DOM-COR development.

*Research Question 2)* To what extent do students' medical DOM-COR skills develop over the course of academic studies in medicine and physics?

*Research Question 3)* To what extent is the medical DOM-COR performance of medical and physics students affected by individual learning prerequisites over the course of academic studies?

**3. Prediction of learning outcomes:** Student learning outcomes (e.g., domain knowledge test scores, module and examination grades) are measured both through self-reporting during academic studies and through standardized validated assessments.

*Research Question 4)* To what extent can medical DOM-COR skills predict study progress and students' learning outcomes (compared to GEN-COR skills and individual learning prerequisites) in medicine and physics students?

### **Contribution to the FOR CORE**

Findings on medical DOM-COR skills, their development, their key determinants within and across domains, as well as their relation to key learning outcomes provide a unique basis for the conceptual development of innovative training interventions to foster DOM-COR skills effectively. Through such interventions, we can explore how and to what extent DOM-COR skills can be improved within domains, and whether and how these approaches might be transferable across domains such as medicine and economics (together with A02). Analyses of the online information landscape and learning materials (together with B projects) allow for critical appraisal of fit and better integration of 'real-world' online information sources into medical education (e.g., in the context of specific seminars and as part of course offerings related to scientific reasoning, evidence-based medicine, and critical medical decision-making). A03 provides data and findings that will subsequently be used for analyses in all research unit (FOR) projects: e.g., log data and scores in C07 and for integrated analyses in C08; DOM-/GEN-COR comparison data in A01; textual data (e.g., web pages accessed) in projects B04, B05, and B06. A03 will generate unique data on students' development of medical DOM-COR skills, as well as on personal and institutional influencing factors for which we control. Thus, we aim to make a significant contribution to inter-institutional and cross-domain research on students' domain-specific information use (e.g. Fischer et al., 2014), online learning, and learning outcomes in higher education.

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- Berndt, M., Schmidt, F. M., Sailer, M., Fischer, F., Fischer, M. R., & Zottmann, J. M. (2021). Investigating statistical literacy and scientific reasoning & argumentation in medical-, social sciences-, and economics students. *Learning and Individual Differences, 86*, Article 101963. <https://doi.org/10.1016/j.lindif.2020.101963>
- Fischer, F., Kollar, I., Ufer, S., Sodian, B., Hussmann, H., Pekrun, R., Neuhaus, B., Dorner, B., Pankofer, S., Fischer, M. R., Strijbos, J. W., Heene, M., & Eberle, J. (2014). Scientific Reasoning and Argumentation: Advancing an Interdisciplinary Research Agenda in Education. *Frontline Learning Research, 2*(3), 28-45. <https://doi.org/10.14786/flr.v2i2.96>
- Mamede, S., Figueiredo-Soares, T., Eloi-Santos, S., De Faria, R. M. D., Schmidt, H. G., & Van Gog, T. (2019). Fostering novice students' diagnostic ability: The value of guiding deliberate reflection. *Medical Education, 53*(6), 628-637. <https://doi.org/10.1111/medu.13829>
- Molerov, D., Zlatkin-Troitschanskaia, O., Nagel, M.-T., Brückner, S., Schmidt, S., & Shavelson, R. (2020). Assessing university students' critical online reasoning ability: A conceptual and assessment framework with preliminary evidence. *Frontiers in Education, 5*, Article 577843. <https://doi.org/10.3389/educ.2020.577843>

Wiblom, J., Rundgren, C.-J., & Andree, M. (2017). Developing Students' Critical Reasoning About Online Health Information: a Capabilities Approach. *Research in Science Education*, 49, 418-427. <https://doi.org/10.1007/s11165-017-9674-7>

## AREA B – Information Landscape

### **B04: Analysis of the Accuracy and Comprehensibility of Media Content Used by Medical and Economics Students in Higher Education Online Learning Settings**

Christian Schemer, Marcus Maurer, Alice Laufer & Tobias Scherer

#### **Abstract**

Recent research indicates that news media and social media play a significant role in how students acquire information and learn in higher education (Kimmerle et al., 2015; Maurer et al., 2020). While some students benefit from these media sources, others do not learn anything or even develop misconceptions (Maurer & Reinemann, 2006; Schemer et al., 2021; Theocharis et al., 2021). Although previous research has provided valuable evidence on various factors related to the information content and student learning characteristics (Maurer et al., 2018, 2020; Nagel et al., 2020), we still have limited knowledge about how these influences extend to real-world information settings (i.e., the Internet). The B04 project aims to examine the extent to which information sources vary in terms of accuracy and comprehensibility and how this variation affects students' performance in both generic (GEN) and domain-specific (DOM) critical online reasoning (COR) tasks. B04 focuses on analyzing the information landscape of students, using a quantitative content analysis of the websites they access when solving GEN- and DOM-COR tasks. The accuracy of the information is assessed manually, while the comprehensibility is measured using a combination of automated methods and human coding. The data from this content analysis is then combined with data on students' COR-performances provided by the A projects of this research unit (FOR). Finally, we rely on data from the FOR panel survey to investigate the relationship between students' general media and information use, COR development, and learning outcomes over time.

#### **Aims and Research Questions**

B04 aims to characterize the information landscape that students use in GEN- and DOM-COR tasks. Specifically, this will be achieved by focusing on the accuracy of the content (i.e., incompleteness, bias, incorrectness) and comprehensibility (i.e., linguistic and stylistic level) of the online content used by medical and economics students when completing these tasks. B04 is also interested in analyzing how students differ in the information sources they use and how this changes throughout their academic studies. Additionally, B04 aims to understand how the accuracy and comprehensibility of the information sources used affect students' actual GEN- and DOM-COR performance.

Based on these analyses, B04 aims to develop a theoretically sound and empirically driven framework that explains the interplay between different types and characteristics of information used in COR tasks and the processes that govern students' information selection, evaluation, and reasoning. Finally, we are interested in studying the long-term relationships between types of general online information use, GEN- and DOM-COR skills, and their learning outcomes in higher education.

#### **Contribution to the FOR CORE**

B04 uses data from the COR assessments and panel survey conducted in A-projects to explain COR performance. The examination of inter-individual differences and the strategies of high-performers and deficiencies of low-performers in COR tasks are shared with C07. Together with B05 and B06, which analyze the comprehensibility of the same information sources using different methodologies (B05: linguistic analysis, B06: qualitative-reconstructive analysis), we contribute to a comprehensive

understanding of the beneficial and detrimental role of various online information sources for higher education learning among students in medicine and economics.

In the 1<sup>st</sup> research phase, B04 describes students' information landscape and integrates the findings from the COR assessments and the survey data into an overall framework of how COR evolves and shapes learning outcomes among students, as well as the role that accuracy and comprehensibility of the sources that students encounter play in the process. The examination of short-term and long-term influences of students' information diet on COR performance and learning outcomes provides a unique foundation for the conceptual development of instructional interventions, e.g., using Internet-like simulations, to effectively foster COR skills in the 2<sup>nd</sup> research phase.

B04 specifically provides FOR projects with content analysis data on accuracy and comprehensibility needed to analyze students' COR performance and skills. To analyze influences on COR performance and learning outcomes, B04 especially receives data on comprehensibility from B05 as well as COR and panel data from A projects.

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- Kimmerle, J., Moskaliuk, J., Oeberst, A., & Cress, U. (2015). Learning and collective knowledge construction with social media: A process-oriented perspective. *Educational Psychologist, 50*, 120-137.
- Maurer, M., & Reinemann, C. (2006). Learning versus knowing. Effects of misinformation in televised debates. *Communication Research, 33*, 489-506.
- Maurer, M., Quiring, O., & Schemer, C. (2018). Media effects on positive and negative learning. In O. Zlatkin-Troitschanskaia, G. Wittum & A. Dengel (Eds.), *Positive Learning in the Age of Information (PLATO) – A Blessing or a Curse?* (pp. 197-208). Springer VS.
- Maurer, M., Schemer, C., Zlatkin-Troitschanskaja, O., & Jitomirski, J. (2020). Positive and Negative Media Effects on University Students' Learning: Preliminary Findings and a Research Program. In O. Zlatkin-Troitschanskaia, G. Wittum & A. Dengel (Eds.), *Frontiers and Advances in Positive Learning in the Age of Information (PLATO) – A Blessing or a Curse?* (pp. 109-119). Springer.
- Nagel, M.-T., Schäfer, S., Zlatkin-Troitschanskaia, O., Schemer, C., Maurer, M., Molerov, D., Schmidt, S., & Brückner, S. (2020). How Do University Students' Web Search Behavior, Website Characteristics, and the Interaction of Both Influence Students' Critical Online Reasoning? *Frontiers in Education*. doi: 10.3389/educ.2020.565062



- Schemer, C., Ziegele, M., Schultz, T., Quiring, O., Jakob, N., & Jakobs, I. (2021). Political Information Use and Its Relationship to Beliefs in Conspiracy Theories Among the German Public. *Journalism & Mass Communication Quarterly*, first published December 14, 2021.
- Theocharis, Y., Cardenal, A., Jin, S., Aalberg, T., Hopmann, D. N., Stromback, J., Esser, F.; de Vreese, C., Castro, L., Van Aelst, P., Corbu, N., Koc-Michalska, K., Matthes, J., Schemer, C., Sheafer, T., Splendore, S., Stanyer, J., Stepinska, A., Stetka, V. (2021). Does the Platform Matter? Social Media and COVID-19 Conspiracy Theory Beliefs in 17 Countries. *New Media & Society*, published online October 9, 2021

## B05: Modeling the Information Landscape (IL) for Assessing and Analyzing DOM-COR and GEN-COR

Walter Bisang, Alexander Mehler, Patryk Czerwinski & Maxim Konca

### Abstract

Project B05 focuses on the effects of linguistic features on students' Critical Online Reasoning (COR). It aims to create a comprehensive linguistic feature model using an extended version of distributional semantics, through a collaborative effort of comparative-linguistic analysis and computational linguistics. Given that the same linguistic feature unfolds different effects depending on the reading context (Gabbard et al. 2014, List & Alexander 2019) a dynamic model is needed (Rouet et al. 2019, Mehler et al. 2020) which accounts for the interaction of linguistic features on COR. The project aims to predict COR performance by means of a linguistic feature grammar, taking into account three factors: (i) student navigation of different COR facets (OIA, CIE, REAS; Molerov et al. 2020), (ii) measurement areas such as *text*, *multiple text*, *genre*, *register*, and the *information landscape*, and (iii) specific domains within GEN-COR and DOM-COR, including economics and medicine. In this way, the B05 project goes beyond existing computational models (e.g., of text readability, McNamara et al. 1996 and later) by (i) scaling with the IL, (ii) emphasizing contextual features and the context of multiple texts (List & Alexander 2019), the latter being defined as fragments of various texts that are utilized by students as part of an open IL for tackling COR tasks. The project develops a model of multiple texts that allows predicting their continuation given a model of their beginning up to the prediction point. The prediction concerns the part of the text that a student will read next in terms of its linguistic structure surpassing current non-computational research on multiple texts.

### Aims and Research Questions

To ground the methodology of our group in a linguistic theory, the B05 project aims to answer the following research questions about COR:

RQ1: What linguistic features of texts read or written by students in the course of their task-solving allow prediction of their COR performance?

RQ2: Which features are language-, domain- or topic-, genre-, text- or multiple text-specific?

RQ3: How do the COR facets condition the influence of linguistic features and what role have GEN-COR and DOM-COR in this respect?

The following methods will be used:

- Linguistics/qualitative part: Fine-grained manual linguistic annotation of specific features whose semantics are associated with text interpretation (e.g., mood/modality, evidentials, information structure, clause combining) in the lexicon, morphology, and syntax (Bisang & Czerwinski, 2020). Analysis of a representative sample of low/high performers, covering multiple texts consulted by the students, as well as the students' answers.
- Computational Linguistics/ quantitative part: Development of a linguistic feature grammar using evolutionary algorithms to traverse feature spaces for the fine-grained modeling of multiple texts; using transformer-based neural networks for predicting the continuation of multiple texts given the reading history of a student; integration of qualitative and quantitative analyses by means of a computational hermeneutic circle in which the quantitative part generates statistical evaluations and predictions that are interpretable as a result of the qualitative part's linguistic motivation and testing (Mehler et al., 2018).

### **Contribution to the FOR CORE**

The results of the linguistic analysis will be fed back to the A projects dealing with GEN-COR and DOM-COR (Economics, Medicine) and inform their overall models of information contained within the tasks, the individual students' handling of it, and the correlation with performance on COR facets.

Since linguistic features are by far the smallest units of information analyzed in the research unit, they can be seen as important atoms or building blocks that affect the domains under research in other B projects concerned with

- content properties in media research: Checking texts for accuracy (truth status, mood/modality or evidentiality) and comprehensibility (morphosyntactic complexity, readability) (B04 project) and
- narrative structures as they are reflected in information structure, semantic relations between clauses, and morphosyntactic complexity (B06 project).

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- Bisang, W., & Czerwinski, P. (2020). Performance in knowledge assessment tests from the perspective of linguistic typology. In: Zlatkin-Troitschanskaia, O. (ed.). *Frontiers and Advances in Positive Learning in the Age of Information (PLATO)*, 207-235. Cham: Springer Nature Switzerland.
- Gabbard, R., Leaming, A., Liu, Q., Lei, W. & Guy, M. (2014). Uncovering the online information seeking behaviors of Chinese university students: A pilot study. *Journal of East Asian Libraries*, 2014(159),4.
- List, A., & Alexander, P. A. 2019. Toward an integrated framework of multiple text use. *Educ Psychol*, 54(1), 20-39.
- McNamara, D. S., Kintsch, E., Songer, N. B., & Kintsch, W. (1996). Are good texts always better? Interactions of text coherence, background knowledge, and levels of understanding in learning from text. *Cogn Instr*, 14(1), 1-43.
- Mehler, A., Hemati, W., Gleim, R. & Baumartz, D. (2018) VienNA. In *Forschungsinfrastrukturen und digitale Informationssysteme in der germanistischen Sprachwissenschaft*. Berlin: De Gruyter.
- Mehler, A., Hemati, W., Welke, P., Konca, M. & Uslu, T. (2020). Multiple texts as a limiting factor in online learning: quantifying dissimilarities of knowledge networks across languages. *Frontiers in Edu. (Digital Edu.)*, pp. 1–31.

- Molerov, D., Zlatkin-Troitschanskaia, O., Nagel, M.-T., Brückner, S., Schmidt, S., & Shavelson, R. (2020). Assessing university students' critical online reasoning ability: A conceptual and assessment framework with preliminary evidence. *Frontiers in Education*. <https://doi.org/10.3389/feduc.2020.577843>
- Rouet, J., Britt, M., & Potocki, A. (2019). Multiple-Text Comprehension. In J. Dunlosky & K. Rawson (eds.), *The Cambridge Handbook of Cognition and Education* (pp. 356-380). Cambridge: Cambridge University Press.

## **Bo6: The Role of the Narrative Framing and Latent Meaning Structures of Online Information used by Medical and Economics Students in their DOM-COR and GEN-COR**

Carla Schelle, Mita Banerjee, Jochen Roeper & Olga Zlatkin-Troitschanskaia

### **Abstract**

Students from various disciplines use the Internet sources and information embedded in narrative framings and latent meaning. In the B06 project, we investigate how students of medicine and economics (with and without teaching degrees) deal with such frames when selecting and using information for solving Internet-based tasks. Utilizing the given data, we perform an analysis of the students' utilization of sources and their text production in the form of written task responses. Both of these aspects are considered social practices, and are interpreted and reconstructed hermeneutically (Schelle et al., 2021). In pursuit of our objective, we have implemented an innovative mixed-method study approach that blends the analytical techniques of reconstructive hermeneutics for action regularity and narrative analysis (Banerjee et al., 2020) that is attuned to linguistic and narrative elements, such as metaphors. The students of economics and medicine are asked to solve generic (GEN-COR) tasks (e.g. exploring the health benefits of using e-bikes) as well as domain-specific (DOM-COR) tasks (e.g. on the founding of start-up companies) by finding credible Internet sources for task-solving. We use reconstructive hermeneutics and narrative analysis to examine the extent to which students recognize framings as well as latent or normative interpretations contained in the sources they used.

### **Aims and Research Questions**

To investigate student task-solving as a social practice, we draw on the Internet-based GEN- and DOM-COR tasks along with all digitally recorded data from the students' task-solving processes: the Internet sources visited or used, written responses, and log data (including search terms, etc.). These multimodal data document students' thinking processes in the Internet environment. Using these data, we explore how task solutions are produced situationally and interactively between students and the Internet environment. Through reconstructive analysis of the visible traces generated in situ by students solving GEN- und DOM-COR tasks in Internet spaces (log data, sources used, written texts), we gain insights into students' information processing and decision-making (e.g., students making use of certain sources while discarding others), which would otherwise not have become manifest. We focus on the following research questions:

Do students recognize the latent narrative framings and meaning structures, including normative implications, within online sources, they accessed and used?

How are narrative framings conveyed in the students' statements and how do they impact their argumentative structure?

How do narrative framings and meaning structures influence the COR-task-solving process (particularly the search phase and source selection)?

Are there meaningful differences regarding narrative impact between GEN- and DOM-COR tasks?

Are there meaningful differences regarding narrative impact between students from different domains (medicine/economics)?

### **Contribution to the FOR CORE**

Through a comparative analysis of selected cases involving students from economics teacher programs and medicine, and their performance on a GEN-COR task, we systematically reconstruct the situation and process of how these students interact with information on the Internet. This analysis provides valuable insights into the nature of students' engagement with online information in educational settings. The analyses of the students' answers show that students often follow, with little reflection, the

(latent) frames inherent in the Internet sources. For instance, a respondent's answer showed an unreflective adoption of the source's framing in attributing the health risk of e-bikes to certain social groups such as older and overweight people. Furthermore, the respondent also adopted further normative interpretations, including the framing of these groups as "sports grouch". By interweaving hermeneutic reconstruction and narratology, we break new methodological ground and show how this novel approach might also be useful for interaction analysis in digital university settings of teaching and learning. In addition to scoring students' responses within COR, this approach provides a comprehensive analysis of how students integrate arguments from online sources into their own argumentation.

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### **References**

- Banerjee, M. & Zlatkin-Troitschanskaia, O. (2021). The gap between knowledge and belief: Narrative, affect and students' deeper learning in higher education. *Studies in Higher Education*, 46 (10) <https://doi.org/10.1080/03075079.2021.1953330>.
- Banerjee, M., Zlatkin-Troitschanskaia, O., & Roeper, J. (2020). Narratives and their impact on students' information seeking and deeper learning in higher education economics and medicine. *Frontiers in Education*, 5 (570625), <https://doi.org/10.3389/educ.2020.570625>.
- Efferth, T., Banerjee, M. & Paul, N. W. (2017). Broken heart, tako-tsubo or stress cardiomyopathy? Metaphors, meanings and their medical impact. *Int. J. Cardiol.* 230, 262-268. doi: 10.1016/j.ijcard/2016.12.129.
- Schelle, C. (2021): Objektive Hermeneutik: Rekonstruktion der wechselseitigen Konstituierung von Gegenstand und Schüler\*innensubjekt als Fallstruktur. In A. Petrik, D. Jahr & C. Hempel (Hg.): *Methoden der qualitativen Politikunterrichtsforschung. Acht Perspektiven auf eine Politikunterrichtsstunde zum Thema Wahlen*. Wochenschau Verlag: Frankfurt/Main, 115-137.
- Schelle, C. Fritzsche, B. & Lehmann-Rommel, R. (2021). Falldarstellungen für eine komparative, praxeologische Seminararbeit. *Unterrichtssituationen aus Deutschland, Frankreich, Senegal und England*. Münster/New York: Waxmann.
- Thibodeau, P.H. & Boroditsky, L. (2011). Metaphors We Think With: The Role of Metaphor in Reasoning. *PLoS ONE* 6 (2), e16782. <https://doi.org/10.1371/journal.pone.0016782>.

## AREA C – Integrative Analyses

### Co7: Students' GEN-COR and DOM-COR Task-solving Processes and Strategies and their Development over the Course of a Degree Program in and across four Domains (Economics, Medicine, Physics, Sociology)

Sebastian Brückner, Verena Klose, Stefan Küchemann & Maruschka Weber

#### **Abstract**

Taking a behavioristic approach to modeling and empirically investigating the construct facets involved in students' responses to generic and domain-specific critical online reasoning (GEN- and DOM-COR) tasks can only allow deriving the educational inferences and consequences to a limited extent. An in-depth analysis of the task-solving process is needed to understand cognitive processes underlying information acquisition and processing and construction of a task response.

In this project, we intend to describe in detail the GEN- and DOM-COR task-solving strategies of students in four domains (economics, sociology, medicine, and physics) and to track the development of these strategies over the course of their studies using gaze data and verbal data collected during and after task completion within predefined online sources (Internet-like simulations) and in a real Internet environment.

First, we cooperate with the A and B project teams to define areas of interest (AoIs) by creating media and content-related narrative and linguistic features gathered from students' completion of GEN and DOM-COR tasks. We relate gaze and verbal data to these AoIs. Second, we identify students' task-solving strategies based on gaze data and verbal data related to these AoIs with high and low GEN-COR and DOM-COR performance scores (obtained from the A projects). We analyze the correlations among the identified task-solving strategies, the students' GEN- and DOM-COR performance scores in their respective domains, and the students' study progress. Additionally, we iteratively fine-tune the AoIs in cooperation with A and B project teams according to their new findings during the study progress.

#### **Aims and Research Questions**

Our research is focussing on the following hypotheses (H):

GEN- and DOM-COR task-solving in an Internet-like simulation:

- H1a: Students with high and low performance in GEN- and DOM-COR tasks differ in task-solving strategies of the COR facets (OIA, CIE, and REAS).
- H1b: Students' task-solving strategies develop and also explain high- and low-performance levels in GEN- and DOM-COR tasks according to: (a) Acclimation (1 basic level), (b) Competence (2 advanced level), and (c) Proficiency (3 proficient level).
- H2a: Students with higher levels of prior domain knowledge (Economics/Medicine students) differ in their task-solving strategies indicated by gaze data and verbal data in comparison to students with low levels of domain knowledge (comparison groups: Sociology/Physics).
- H2b: The described effects of (H2a) develop and become more pronounced as the DOM-COR levels develop along the examined study terms (comparison within domains).

GEN- and DOM-COR task-solving in the real internet:

- H3a: Students with high levels of domain-specific knowledge (Economics/Medicine) are more likely to select relevant and scientifically sound sources in corresponding DOM-COR tasks, measured by log data, than students with low levels of domain-specific knowledge (comparison groups: Sociology/Physics)

- H3b: Distinct differences between students from the four domains in terms of their log data become increasingly evident throughout their study programs:

Media- and content-related, narrative, and linguistic features:

H4: Media- and content-related, narrative, and linguistic features of the websites used by students when solving the COR tasks are associated with distinct web search and information evaluation strategies in students with high vs. low GEN- and DOM-COR performance.

**Contribution to the FOR CORE**

C07 contributes substantially to the understanding of students' GEN- and DOM-COR task-solving strategies and changes therein. Using the eye-tracking data, verbal data, and log data analyzed by A and C08 projects in our experimental studies, we identify significant aspects of the students' task-solving processes and successful task-solving strategies and compare the identified strategies across four domains. This will lead us to an explanation of high and low DOM- and GEN-COR performances. Thus, we develop a detailed basis for designing targeted instructional interventions, whereby we build on the tested technical-methodological prototypes developed at DFKI (during the 2<sup>nd</sup> research phase).

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- Brückner, S., Zlatkin-Troitschanskaia, O., Küchemann, S., Klein, P., & Kuhn, J. (2020). Changes in students' understanding of and visual attention on digitally represented graphs across two domains in higher education: A postreplication study. *Frontiers in Psychology, 11*(2090). <https://doi.org/10.3389/fpsyg.2020.02090>
- Kumari, N., Ruf, V., Mukhametov, S., Schmidt, A., Kuhn, J., & Küchemann, S. (2021). Mobile eye-tracking data analysis using object detection via YOLO v4. *Sensors, 21*(22), 7668. Klein, P., Küchemann, S., Brückner, S., Zlatkin-Troitschanskaia, O., & Kuhn, J. (2019). Student understanding of graph slope and area under a curve: A replication study comparing first-year physics and economics students. *Physical Review Physics Education Research, 15*, 020116.
- Ruf, V., Horrer, A., Berndt, M., Hofer, S. I., Fischer, F., Fischer, M. R., Zottmann, J., Kuhn, J., & Küchemann, S. (2023). A Literature Review Comparing Experts' and Non-Experts' Visual Processing of Graphs during Problem-Solving and Learning. *Education Sciences, 13*(2), 216. Molerov, D., Zlatkin-Troitschanskaia, O., Nagel, M.-T., Brückner, S., Schmidt, S., & Shavelson, R. (2020). Assessing university students' critical online reasoning ability: A conceptual and assessment framework with preliminary evidence. *Frontiers in Education. https://doi.org/10.3389/feduc.2020.577843*
- Nagel, M. T., Reichert-Schlax, J., Zlatkin-Troitschanskaia, O., Klose, V., Weber, M., & Roeper, J. (2021). The relationship between medical students' media use and learning progress. *Studies in Higher Education, 46*(10), 2063–2073.



- Roeper, J., Zlatkin-Troitschanskaia, O., Klose, V., Nagel, M. T., & Schlax, J. (2020). A new approach to analysing the development of domain-specific knowledge among undergraduate medical students using learning scores. *American Journal Of Biomedical Science & Research*, 7(4). <http://dx.doi.org/10.34297/AJBSR.2020.07.001166>
- Roeper, J., Reichert-Schlax, J., Zlatkin-Troitschanskaia, O., Klose, V., Weber, M., & Nagel, M. T. (2022). Patterns of domain-specific learning among medical undergraduate students in relation to confidence in their physiology knowledge: Insights from a pre-post study. *Frontiers in Psychology*, 12, 562211.
- Schmidt, S., Zlatkin-Troitschanskaia, O., Roeper, J., Klose, V., Weber, M., Bültmann, A.-K., & Brückner, S. (2020). Undergraduate students' critical online reasoning - process mining analysis. *Frontiers in Psychology*, 11, 576273. <https://doi.org/10.3389/fpsyg.2020.576273>
- Zlatkin-Troitschanskaia, O., Kuhn, C., Brückner, S., & Leighton, J. P. (2019). Evaluating a technology-based assessment (TBA) to measure teachers' action-related and reflective skills. *International Journal of Testing*, 19(2), 148–171. <https://doi.org/10.1080/15305058.2019.1586377>

## Co8: Integrating Student's Process and Textual Data for Measuring the Interdependency of GEN-COR and DOM-COR

Gianluca Romano, Daniel Baumartz, Hendrik Drachsler & Alexander Mehler

### **Abstract**

The state-of-the-art approach to assessing learning outcomes conceives assessment as a process of reasoning from the necessarily limited evidence of what students do to make claims about what they know and can do in the real world (Zieky 2014, p. 79). To this end, measurement experts design highly standardized scenarios and tasks to elicit desired behavior that serves as evidence for the targeted constructs (Mislevy et al., 2003). In contrast, the analysis of process and text data generated by students during their learning, understood as uninterrupted behavior, is considered a more authentic alternative. It collects observational data rather than data through indirect methods such as surveys (Greller & Drachsler, 2012). This process and text data form multimodal data (Mehler & Lücking, 2009; Drachsler & Goldhammer, 2020), which have the potential to create a more complete picture of critical online reasoning (COR) processes and can be analyzed by data science methods. The Co8 project addresses the overarching question, to what extent can data science methods be compared to state-of-the-art assessments to study COR processes.

### **Aims and Research Questions**

The Co8 project has three main objectives for advancing the field of educational research. First, Co8 provides an authentic digital assessment and learning environment in the AZURE cloud where students can behave as they do on their computers. Second, Co8 captures student activities by integrating multimodal textual and response process data in a research infrastructure called the Multimodal Learning Data Science System (MLDS). MLDS allows for examinations of students' process data (e.g., webpage scrolling, time spent) and textual data (e.g., websites processed, text written) in generic (GEN) and domain-specific (DOM) COR tasks. Third, Co8 analyzes and explores this multimodal data set to uncover latent relationships between text data processed or written by students and their behavioral response data (e.g., browsing histories, duration) while solving GEN- and DOM-COR tasks. Co8 investigates three research questions:

RQ 1: Is there a relation between the process data and textual data of students while performing GEN-DOM-COR tasks?

RQ 2: How can multimodal data be used to validate the research findings for individual research unit (FOR) projects?

RQ 3: Do text or process data reflect GEN- or DOM-COR related task-solving strategies?

### **Contribution to the FOR CORE**

Co8 provides an authentic digital assessment and learning environment to emulate a Windows PC using cloud-based services. This environment will be used for assessments in real Internet scenarios and related simulations. The GEN- and DOM-COR tasks will be implemented in close collaboration with the A- and B-projects. Co8 captures textual and process data of student task-solving activities in its MLDS research infrastructure to make it available for all FOR projects. It investigates the role and interaction of text and process data in successful vs. unsuccessful COR-task performances and how they are linked to students' domain knowledge and personal traits.

Co8 tests the usability of data science methods in the field of education. It identifies added values and limitations of such methods for processing multimodal text and process data generated in GEN- and DOM-COR assessments to contribute new insights and methods to educational science.

Co8 collaborates with all FOR projects to create and evaluate a unique big data set for GEN- and DOM-COR research and develops an infrastructure to analyze and explore this data. While it contributes data

science expertise to the FOR, it requires the expertise of educational scientists to customize and calibrate its methods.

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- Greller, W., & Drachsler, H. (2012). Translating learning into numbers. *Journal of Educational Technology & Society*, 15(3), 42–57. <https://www.jstor.org/stable/jeductechsoci.15.3.42>
- Mehler, A., & Lücking, A. (2009). A structural model of semiotic alignment: The classification of multimodal ensembles as a novel machine learning task. In *AFRICON 2009* (pp. 1-6). IEEE. <https://doi.org/10.1109/AFRCON.2009.5308098>
- Mislevy, R. J., Almond, R. G., & Lukas, J. F. (2003). A brief introduction to evidence-centered design. *ETS Research Report Series*, 2003(1), i-29. doi:10.1002/j.2333-8504.2003.tb01908.x
- Zieky, M. J. (2014). An introduction to the use of evidence-centered design in test development. *Psicología Educativa*, 20(2), 79-87. <https://doi.org/10.1016/j.pse.2014.11.003>