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

Annual Newsletter
December 2024 / January 2025

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Welcome!

Dear colleagues, we are very pleased to share with you our annual CORE newsletter.
In this first edition, you will find a brief overview of the research group (FOR) and its coordination project as well as an overview of the key results from last year in all eight CORE projects. Here you can see the progress we have made in this group.
We hope you enjoy this newsletter and would like to thank you all for your support and collaboration during this challenging project.

Looking back at 2024

- Three of our *over 25 young researchers* in CORE successfully completed their dissertations. We would like to congratulate Dr. Anika Kohmer (Project C07), Dr. Alice Laufer (Project B04) and Dr. Denis Federiakin (Project A02) and look forward to the completion of many more doctoral degrees in 2025.
- In addition to the 3rd international CORE meeting, our project was present at many renowned national and international conferences. We offered CORE sessions and symposia, including AERA 2024, WERA/BERA 2024, and GEBF 2024.
- Numerous exciting CORE publications have been prepared and some published. For updates, please visit our home-page: https://core.uni-mainz.de/

Overview of the Research Unit CORE

The interdisciplinary research unit "Critical Online Reasoning in Higher Education" (**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 online information landscape, e.g. the Internet, to acquire crucial knowledge, complete course-related tasks, and study successfully.

CORE is an international **group of 65 researchers from 16 disciplines** including a strong community of young researchers (PhD Candidates & Postdocs) with well-established collaborative working structures and methods for interdisciplinary research.

List of Abbreviations

COR: Critical Online Reasoning
OIA: Online Information Acquisition
CIE: Critical Information Evaluation
REAS: Evidence-based Synthesis and Argumentation
OIL: Online Information Landscape
GEN: Generic
DOM: Domain-specific
OIS: Open Information Space
CIS: Closed Information Space

Research Focus:

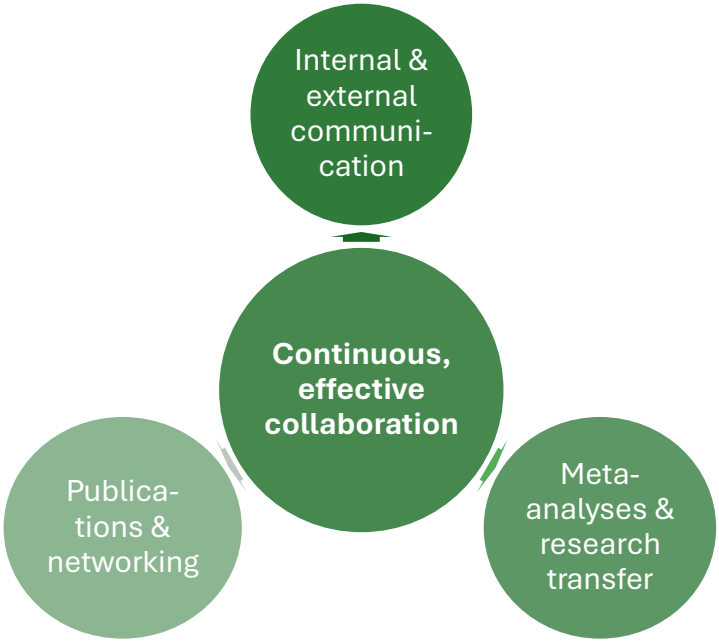
(1) **COR skills of university students in economics and medicine** (including social sciences and physics as comparison disciplines) and their development over the course of academic study.

(2) **Characteristics of the online sources and content university students select and use for learning** on course-related topics, including accuracy and comprehensibility, media and linguistic features, narrative frames, and latent meaning structures, and how they influence how students use information sources in higher education.

(3) **Relationship** between (1) the level and development of students' COR skills, (2) the features of the online information landscapes students use for their learning, and students' success in higher education.

The Coordination Project (CP)

The CP ensures **continuous, effective collaboration** among all FOR participants and all national and international partners through **targeted communication and information management structures** and **activities** that support the advancement as well as alignment of conceptual and methodological collaboration within and across the CORE projects.
The Steering Committee and the Research Advisory Board are also supported by the CP in all management and coordination activities in the FOR.



- The CP has implemented **internal and external digital communication** as well as – together with the C08 project - the **assessment platform** for all FOR projects (based on the Azure Lab platform previously used in the BRIDGE project).
- The CP organizes support for young researchers in CORE (YORE) to promote professional development as well as gender and minority equality.
- To promote the national and international visibility of the FOR research, the CP prepares und 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 prestigious conferences, and the annual publication of CORE working papers.
- For on-going international research, exchange and transfer, CORE is also present on established scholarly social media such as ResearchGate and LinkedIn – please visit us at https://www.linkedin.com/company/coreunimainz

CORE Project A01

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

Website: https://core.uni-mainz.de/a01/

Summary

Name of the test instruments used:

GEN-COR OIS & CIS tasks

Domain focused: General, everyday online information problems

Assessed competences: Generic COR

Target group: Undergraduate and graduate students

Test type: Generic scenario-based digital performance assessment tasks

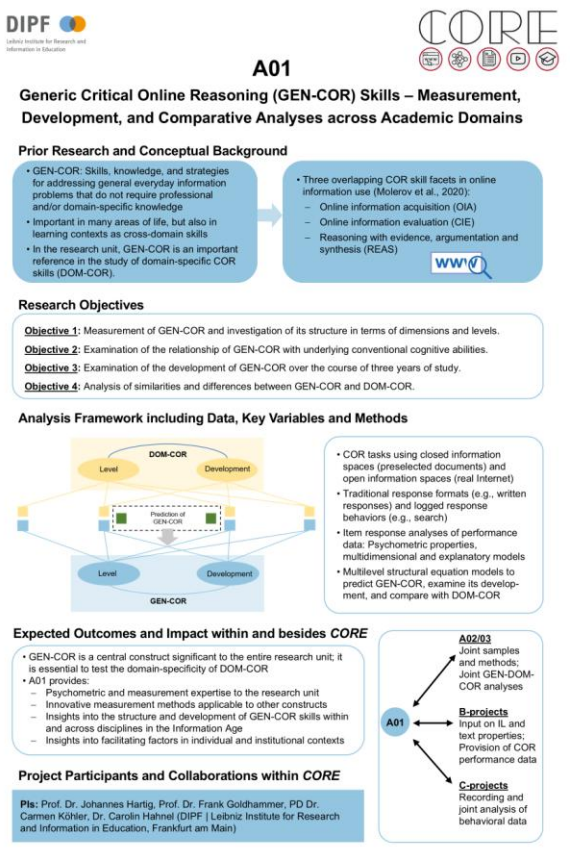
Assessment framework: Each task is constructed to assess the three COR facets: Online Information Acquisition skills [OIA], Critical Information Evaluation skills [CIE], and Reasoning based on Evidence, Argumentation and Synthesis skills [REAS].

Modality: Online-assessment with closed (Closed Information space, CIS) / unrestricted (Open information space, OIS) Internet access.
Each task presents an overarching initial scenario with prompts addressing all three COR facets.

Duration: 25 minutes per task

Test setup: Digital assessment platform

General test purpose: Objective, performance-based and reliable assessment of students' GEN-COR levels and development thereof and online media use.



CORE Project A01

Application scenarios: Students of economics and medicine in German higher education institutions. Their COR skills in longitudinal or cross-sectional study design are assessed. Suitable for formative and summative assessments.

Not suitable for: Children

Note for practical use: Currently 7 OIS tasks and 3 CIS Tasks are developed and being tested.

OIS task topics	CIS task topics
Cell phone tower	Cell phone tower
Green sauce	Green sauce
Heat stick	Heat stick
Tetra Pak recycling	Tetra Pak recycling
Handwriting and personality	
Speed writing	
Zoos and species conservation	

Related work:

Goldhammer, F., Hahnel, C., Kroehne, U., & Zehner, F. (2021). From byproduct to design factor: On validating the interpretation of process indicators based on log data. *Large-Scale Assessments in Education*, *9*(1), Article 1. https://doi.org/10.1186/s40536-021-00113-5

Hahnel, C., Eichmann, B., & Goldhammer, F. (2020). Evaluation of Online Information in University Students: Development and Scaling of the Screening Instrument EVON. *Frontiers in Psychology*, *11*, 1–16. https://doi.org/10.3389/fpsyg.2020.562128

Hahnel, C., Goldhammer, F., Kröhne, U., & Naumann, J. (2018). The role of reading skills in the evaluation of online information gathered from search engine environments. *Computers in Human Behavior*, *78*, 223–234. https://doi.org/10.1016/j.chb.2017.10.004

CORE Project A01

Hahnel, C., Kroehne, U., & Goldhammer, F. (2023). Rule-based process indicators of information processing explain performance differences in PIAAC web search tasks. *Large-Scale Assessments in Education*, *11*(16), Article 16. https://doi.org/10.1186/s40536-023-00169-5

Hahnel, C., Kroehne, U., Goldhammer, F., Schoor, C., Mahlow, N., & Artelt, C. (2019). Validating process variables of sourcing in an assessment of multiple document comprehension. *British Journal of Educational Psychology*, *89*, 524–537. https://doi.org/10.1111/bjep.12278

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

Projects:

DiFA - Digital Formative Assessment; https://tba.dipf.de/en/projects/difa-digital-formative-assessment-3?set_language=en

PISA 2025 „Learning in the Digital World"; https://www.dipf.de/de/forschung/projekte/pisa-ldw-erfassen-von-kompetenzen-fuer-das-lernen-in-der-digitalen-welt

ROSE – Reflective online search education; https://www.diag.psy.ruhr-uni-bochum.de/diag/forschung/dfg-rose.html.de

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

CORE Project A02
Development of Students' Domain-Specific
Critical Online Reasoning (DOM-COR) Skills in Economics

Website: https://core.uni-mainz.de/a02/

Summary

Name of the test instruments used: DOM-COR OIS & CIS Tasks

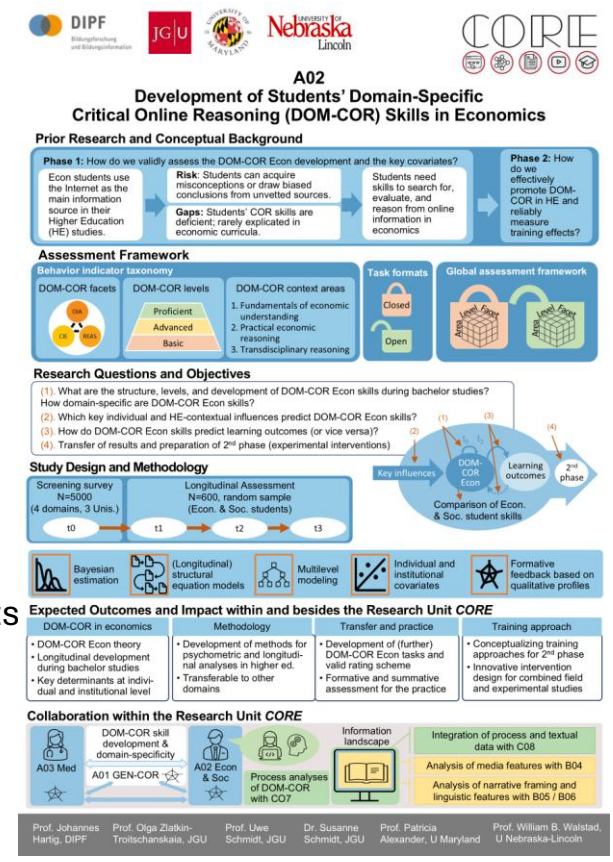
Domain focused: Economics and sociology

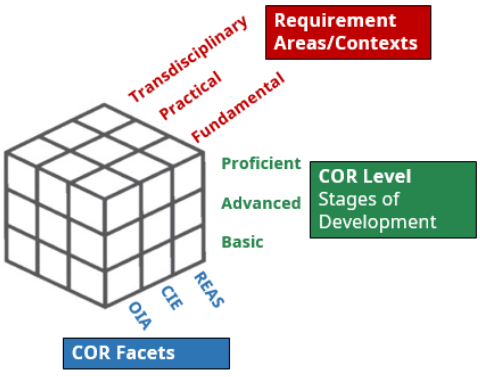
Assessed competences: Economic domain-specific Critical Online Reasoning

Target group: Undergraduate and graduate students

Test type: Study-related, scenario-based digital performance assessment tasks

Assessment framework: Each task is constructed so as to assess the three COR facets (OIS, CIE, REAS); three requirement contexts (Fundamental, Practical, Transdisciplinary) and three levels of COR competence (Basic, Advanced, Proficient)





Modality: Online-assessment with closed (closed information space, CIS) / unrestricted (open information space, OIS) Internet access. Each task presents an overarching initial scenario and, in line with the three requirement areas, the tasks are subdivided into three subtasks, each of which covers one application context (Fundamental, Practical, Transdisciplinary) and the three COR facets.

CORE Project A02

Duration: 25 minutes per sub-task

Test setup: Digital assessment platform

General test purpose: Objective, performance-based and reliable assessment of students' DOM-COR levels and development thereof and online media use

Application scenarios: Assessment of economic students' COR skills in German higher education institutions in longitudinal or cross-sectional study design. Suitable for formative and summative assessments.

Not suitable for: Other groups of persons

Note for practical use: Currently 7 OIS tasks and 3 CIS Tasks are developed and validated.

OIS task topics	CIS task topics
Windpark	Windpark
Startup	Startup
Nudging	Nudging
Pilot Strike	Pilot Strike
Tuition fees	
Retirement provision	
Economic growth	

Previous Projects:

Critical Online Reasoning Assessment (CORA)

https://www.plato.uni-mainz.de/cora/

Practical educational processes in law and teacher training and medicine using digital media (BRIDGE)

https://eng.bridge.uni-mainz.de/

CORE Project A02

Related work (selection):

Braunheim, D., Martin de los Santos Kleinz, L. & Trierweiler, L. (2024). Differences in source selection and their effect on the quality of written statements during a critical online reasoning performance assessment. Frontiers in Computer Science. 6,doi: 10.3389/fcomp.2024.1366934

Kunz, A.-K., Zlatkin-Troitschanskaia, O., Schmidt, S., Nagel, M.-T., & Brückner, S. (2024). Investigation of Students' Use of Online Information in Higher Education Using Eye Tracking. Smart Learning Environments, 11(44), doi: 10.1186/s40561-024-00333-6

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. doi: 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*. doi: 10.3389/feduc.2022.914857

Schmidt, S., Zlatkin-Troitschanskaia, O., & Shavelson, R. J. (2023). Modeling and measuring domain-specific quantitative reasoning in higher education business and economics. *Frontline Learning Research, 11*(1), 40-56, doi: 10.14786/flr.v11i1.885

Zlatkin-Troitschanskaia, O., Nagel, M.-T., Klose, V., & Mehler, A. (Eds.) (2024). *Students', Graduates' and Young Professionals' Critical Use of Online Information – Digital Performance Assessment and Training within and across Domains*. Springer. doi: 10.1007/978-3-031-69510-0

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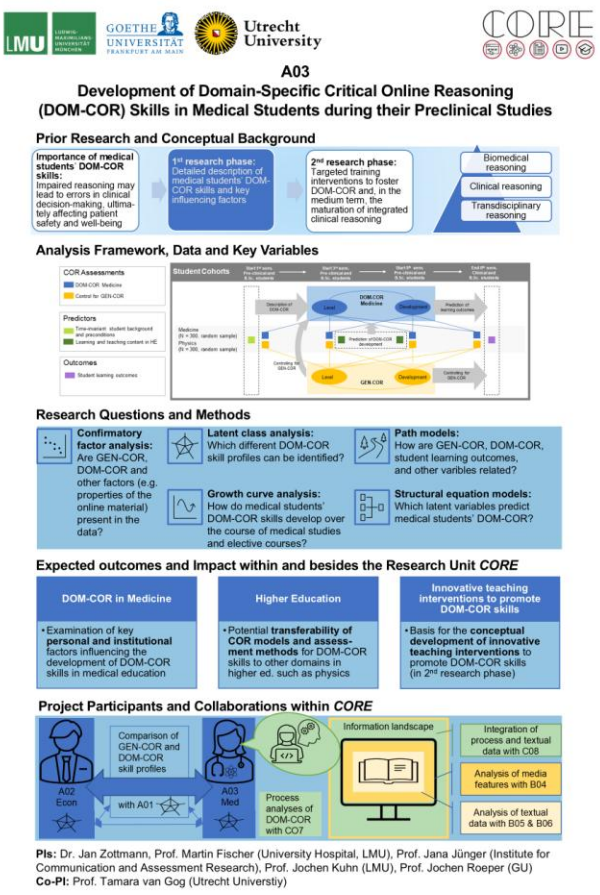
CORE Project A03

Development of Domain-Specific Critical Online Reasoning (DOM-COR) Skills in Medical Students during their Preclinical Studies

Website: https://core.uni-mainz.de/a03/



Summary

Name of the test instruments used: DOM-COR OIS & CIS tasks

Domains focused: Medicine and physics

Assessed skills: Medical DOM-COR skills

Target group: Undergraduate and graduate students

Test type: Study-related, scenario-based digital performance assessment tasks

Assessment framework: Each task is constructed in such a way to assess the three COR skill facets (OIA, CIE, REAS), three reasoning contexts (fundamental scientific, practical clinical, transdisciplinary reasoning), and three levels of COR development (basic, advanced, proficient).

Modality: Online-assessment with closed internet access (closed information space = CIS) and unrestricted internet access (open information space = OIS). Each DOM-COR task presents an overarching initial scenario and is divided into three sub-tasks, each of which covers one reasoning context and the three COR skill facets.

Duration: 25-30 minutes per sub-task

Test setup: Digital assessment platform

General test purpose: Objective, reliable, performance-based assessment of students' (development of) medical DOM-COR skills

CORE Project A03

Application scenarios: Assessment of medical students' DOM-COR skills in cross-sectional as well as longitudinal study designs. Suitable for summative assessments (and potentially also for formative assessments).

Note for practical use: Currently, 7 OIS tasks and 4 CIS tasks have been developed and implemented.

DOM-COR task topics	Available formats
Auge [Eye]	OIS + CIS
Mittelohr [Middle ear]	OIS + CIS
Kreislauf [Circulation]	OIS + CIS
Atmung [Respiration]	OIS + CIS
Schilddrüse [Thyroid gland]	OIS
Osteoporose [Osteoporosis]	OIS
Epilepsie [Epilepsy]	OIS

Related work:

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

Kiesewetter, J., Sailer, M., Jung, V., Schönberger, R., Bauer, E., Zottmann, J. M., Hege, I., Zimmermann, H., Fischer, F., & Fischer, M. R. (2020). Learning clinical reasoning: How virtual patient case format and prior knowledge interact. *BMC Medical Education*, *20*, Article 73. https://doi.org/10.1186/s12909-020-1987-y

CORE Project A03

Schmidt, F. M., Zottmann, J. M., Sailer, M., Fischer, M. R., & Berndt, M. (2021). Statistical Literacy and Scientific Reasoning & Argumentation in physicians. *GMS Journal for Medical Education, 38*(4), Article Doc77. https://doi.org/10.3205/zma001473

Weidenbusch, M., Lenzer, B., Sailer, M., Strobel, C., Kunisch, R., Kiesewetter, J., Fischer, M. R., & Zottmann, J. M. (2019). Can clinical case discussions foster clinical reasoning skills in undergraduate medical education? A randomised controlled trial. *BMJ Open, 9*(9). https://doi.org/10.1136/bmjopen-2018-025973

Previous projects:

REASON (International Doctoral School)
https://www.en.mcls.uni-muenchen.de/study_programs/reason/index.html

ForschenLernen – Scientific Reasoning and Argumentation

https://www.lmu-klinikum.de/institut-dam/forschung/forschungsprojekte/forschenlernen-1-wissenschaftliches-argumentieren/77f77672fcae4f72

KOMPARE – Competencies of Argumentation based on Evidence

https://www.lmu-klinikum.de/institut-dam/forschung/forschungsprojekte/kompare-kompetentes-argumentieren-mit-evidenzen/599619bc44013fe8

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CORE Project B04

Analysis of the Accuracy and Comprehensibility of Media Content Used in University Learning Settings in Medicine and Economics

Summary

Name of the test instruments used: Codebook to operationalize information landscape characteristics

Domain focused: GEN- and DOM-COR in economics and medicine

Assessed constructs: Characteristics of websites used by students when solving the COR tasks

Competencies to which our analyses contribute: OIA, CIE, REAS

Target group: All websites indicated by the participants as relevant to the solution of the respective COR-task

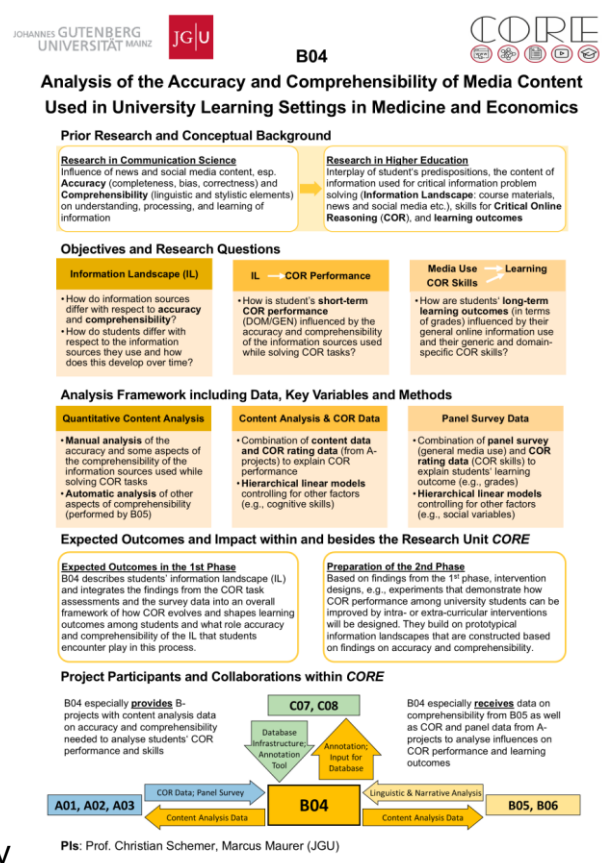
Method: Quantitative content analysis

Duration: The analysis takes place after each COR assessment wave until all websites used by students are coded. The coding process starts as soon as the websites are completely integrated into the coding tool. It usually is completed within 3 months.

Test setup: A team of 4-7 trained human coders uses the codebook to code the websites. Reliability of the coders is measured. Reliability coefficients were satisfactory and ranged from perfect reliability 1 to 0.802.

General test purpose: Description of the information landscape that students navigate and use while solving COR tasks.

Website: https://core.uni-mainz.de/b04/



CORE Project B04

Modality: The codebook consists of two parts. The first part focuses on general characteristics of the website, such as date, genre, visual elements, and how relevant these are for solving the COR task at hand. The second part specifically addresses the content of the website, which is broken down into four dimensions: *completeness, accuracy, balance, and comprehensibility.*
The *completeness* of relevant information is measured by comparing a list of key facts required for the task with information found on the website. This list was developed in collaboration with the COR task developers. The communication of uncertainty is examined to determine if the website acknowledges that the information it presents may not be definitive.
The *correctness* of the relevant information is assessed using the same list as for completeness, along with an analysis of the coherence of the information found on the website.
The *positioning* of the website in relation to its featured information is examined to determine if the information is presented in a biased or balanced manner. The website's reasoning for this positioning is also considered along with the occurrence and type of evidence which supports the information.
The *comprehensibility* of the website is evaluated using three categories: the objectivity of the language used, the use of statistics or case studies to present information, and the use of metaphors.

Not suitable for: The results of the content analysis serve as an indicator for further examination of the information landscape, e.g. the quality of websites. The content analysis itself is not a rating (e.g. credibility rating) of the respective website but rather a description of its various features.

Note for practical use: The examination of how the students' information use influences COR performance and learning outcomes provides a basis for the conceptual development of instructional interventions, e.g. using Internet-like simulations, to effectively foster COR skills. When combined with our other CORE projects, the results provide an in-depth understanding of the beneficial and detrimental roles of various online information sources for higher education learning among students in medicine and economics.

CORE Project B04

Related work:

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*, 5, 565062. https://doi.org/10.3389/feduc.2020.565062

Maurer, M., Jost, P., Haßler, J., & Kruschinski, S. (2019). Auf den Spuren der Lügenpresse. Zur Richtigkeit und Ausgewogenheit der Medienberichterstattung in der „Flüchtlingskrise". *Publizistik, 64*(1), 15-35.

Maurer, M., Jost, P., & Haßler, J. (2024). Grenzen der Perspektivenvielfalt–Wie deutsche Nachrichtenmedien über den Ukraine-Krieg berichtet haben. *Krieg der Narrative: Russland, die Ukraine und der Westen*, 149.

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: A Blessing or a Curse?* (pp. 197-208). Wiesbaden: Springer.

Maurer, M., Schemer, C., Zlatkin-Troitschanskaia, O., & Jitomirski, J. (2019). Positive and negative media effects on university students' learning: preliminary findings and a research program. In O. Zlatkin-Troitschanskaia (Ed.). *Frontiers and Advances in Positive Learning in the age of Information (PLATO)* (pp. 109-119). Cham: Springer.

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CORE Project B05

Modeling the Information Landscape (IL) for Assessing and Analyzing Critical Online Reasoning (DOM-COR and GEN-COR)

Summary

Name of the test instruments used: List of linguistic features; Hjelmslev machine

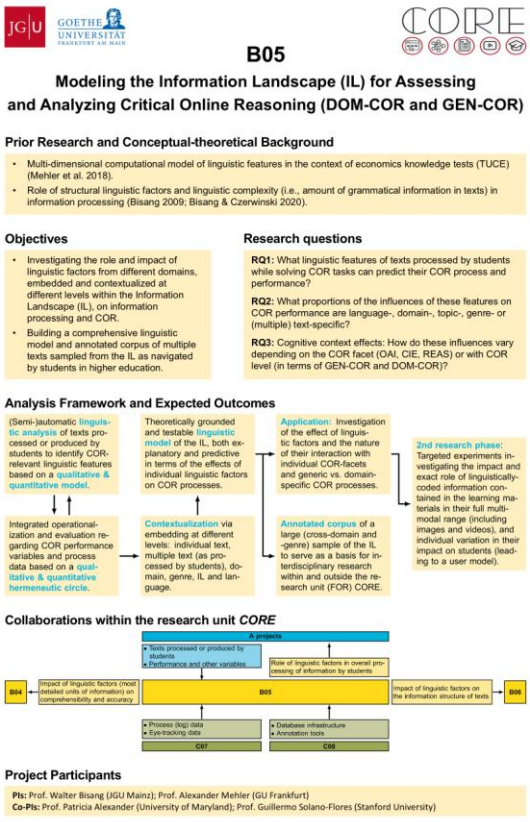
Domain focused: GEN-COR and DOM-COR in economics, medicine, sociology and physics

Assessed competences: Predictions of students' GEN- and DOM-COR performance based on linguistic features and vice versa; primarily focused on performance in the REAS facet, but also in the OIA and CIE facets

Focus of analysis: Texts used for the COR tasks, texts produced by students, multiple texts used by students online, connected texts found in the web information landscape

Type of analysis: Qualitative analysis of text characteristics combined with computational analysis and machine learning

Website: https://core.uni-mainz.de/b05/



Analysis setup: Manual/semi-automatic/automatic annotation and modeling of linguistic features after each COR assessment wave; systematic generation and evaluation of text-based features in research on COR by means of the newly developed Hjelmslev machine

General analysis purpose: Predictions of students' REAS performance based on linguistic features

Not suitable for: The developed text model is not an assessment, but rather serves to identify text characteristics to predict students' REAS performance.

CORE Project B05

Systemic COR Prediction Model	
Goal	The goal is to develop a systemic COR prediction model that interrelates various prediction functions based on linguistic features and incorporates interactions between student COR performance variables and linguistic features hypothesized to contribute to COR-related interpretation (e.g., the linguistic manifestation of truth status, the type and degree of coercion, and semantic relations between text segments).
Approach	The project originates from the collaboration between linguistics and computational linguistics, integrating qualitative and quantitative approaches. Based on the linguistic features of texts, it develops a systemic COR prediction model that integrates different prediction functions (e.g., from student responses to performance scores, from the texts used to student responses, or from written responses to student language scores) into a single predictive network model. This is achieved through an integrated model that explores the interdependencies, transitivities, and network behaviors of several dependent and independent variables (e.g., web information landscapes, language proficiency, and the complexity of written texts). Morpho-syntactic, lexical, syntactic, and semantic features are considered in conjunction with features related to the logical structure and cohesion of texts. From a qualitative perspective, grammatical features whose semantics affect text interpretation take precedence (e.g., mood/modality, the semantics of clause combining, etc.).
Outcome	A classifier network in terms of a systemic synergetic prediction network.

CORE Project B05

Hjelmslev machine	
Goal	Developing a Hjelmslev machine for the systematic generation and evaluation of text-based features in research on COR.
Approach	The project involves the development of a new type of machine, the output models of which are designed for the representation of texts in CORE. This so-called Hjelmslev machine is based on cascaded priors, which provide the machine with linguistic knowledge to generate syntagms and paradigms based on a set of fundamental text relations. These relations enable the quantification of input texts modeled by the machine. The simultaneously and automatically generated (by the Hjelmslev machine) and linguistically controlled text models satisfy certain optimality criteria. This approach allows for the systematic comparison and extension of linguistic COR research. Furthermore, it enables single texts, text corpora, and multiple texts to be automatically represented in terms of a large set of features from several text representation domains.
Outcome	Implementation and testing of Hjelmslev machines.

An atlas of linguistic COR relevant features	
Goal	Specifying the role of a large set of linguistic features in the context-sensitive prediction of COR variables
Approach	Based on a series of linguistic levels (morphology, syntax, semantics) and experiments covering a range of linguistic artifacts (e.g., information landscapes, written texts, multiple documents), as well as the distinction between DOM- and GEN-COR and the domains considered (e.g., economy, medicine), the project specifies in detail, for a large set of features, their functions in relation to each context, the features with which they interact, and the feature clusters they form on this basis. In this way, an atlas of COR-relevant features and feature clusters is created, contrasting the web information landscape with a landscape of features that represent it. This includes modeling the relevant grammatical features in terms of their semantics for COR tasks.
Outcome	Linguistic COR feature Atlas (LiCORA)

CORE Project B05

Interpretation Model of Linguistic COR Assessments	
Goal	Developing a metamodel of multiple text understanding that integrates various existing models in a single cognitive architecture while covering the specifics of the CORE research group.
Approach	Developing a model that maps common models for understanding multiple documents into a unifying cognitive architecture in a way that highlights the specifics of CORE. To this end, we capture the range of textual aggregates relevant to CORE (texts, multiple texts, the texts used, written texts, search queries, search results, prompts, prompting results, etc.) and link them in a unified text representation model. The resulting meta-model will serve to explain COR by providing a terminology that makes seemingly disparate phenomena theoretically accessible from an integrating perspective.
Outcome	A mapping of COR processes to a selected cognitive architecture

Related work:

Mehler, A., Bagci, M., Schrottenbacher, P., Henlein, A., Konca, M., Abrami, G., Bönisch, K., Stoeckel, M., Spiekermann C., & Engel, J. (2024). Towards New Data Spaces for the Study of Multiple Documents with Va.Si.Li-Lab: A Conceptual Analysis. In: *Students', Graduates' and Young Professionals' Critical Use of Online Information: Digital Performance Assessment and Training within and across Domains, 259–303*. Ed. by Zlatkin-Troitschanskaia, O., Nagel, M.-T., Klose, V. & Mehler, A. Springer Nature Switzerland.

Konca, M., Mehler, A., Lücking A., & Baumartz, D. (2024). Visualizing Domain-specific and Generic Critical Online Reasoning Related Structures of Online Texts: A Hybrid Approach. In: *Students', Graduates' and Young Professionals' Critical Use of Online Information: Digital Performance Assessment and Training within and across Domains, 195–239*. Ed. by Zlatkin-Troitschanskaia, O., Nagel, M.-T., Klose, V. & Mehler, A. Springer Nature Switzerland.

CORE Project B05

Zlatkin-Troitschanskaia, O., Nagel, M.-T., Klose, V. & Mehler, A. (Eds.) (2024). Students', Graduates' and Young Professionals' Critical Use of Online Information: Digital Performance Assessment and Training within and across Domains. Springer Cham.

Previous Project:

Berufspraktische Bildungsprozesse im Recht- und Lehramtsreferendariat sowie der Medizin unter Nutzung digitaler Medien (BRIDGE). 2020 – 2023. Funded by BMBF (01JD1906B).

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CORE Project B06

The Role of Narrative Framing and Latent Meaning Structures of Online Information Used by Medical and Economics Students in their COR

Website: https://core.uni-mainz.de/b06

Summary

Name of the test instruments used: GEN- (Heatpen, Radio Tower) and DOM-COR (Nudging) tasks

Domain focused: Economics (-Education), Medicine

Assessed competences: Reflection on narratives and latent meaning found in online sources used by students when solving the COR tasks relating to the three facets of COR.

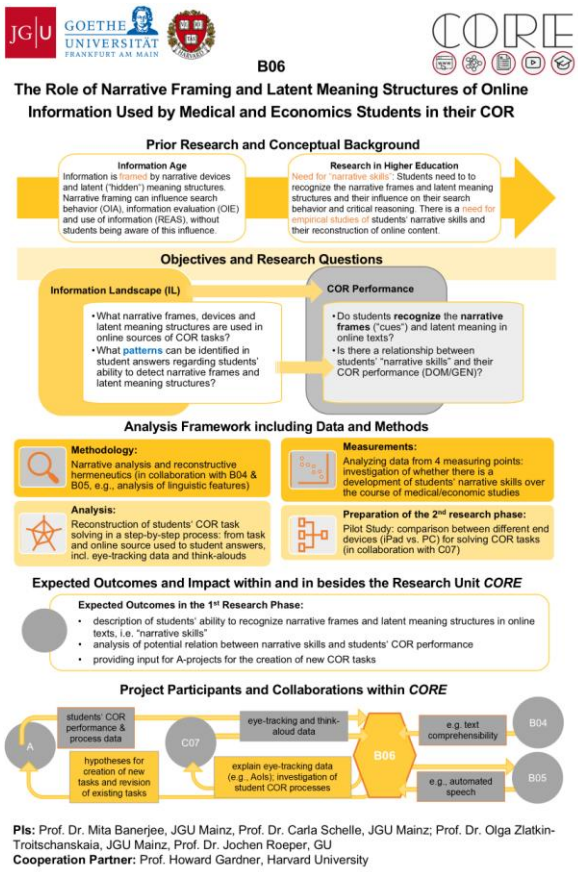
Target group: Students in higher education (primary focus on participants of eye tracking; project C0))

General purpose: Describing and analyzing the use/adoption of website content and its latent narrative frames and meaning structures (e.g. normative assumptions) in students written responses to the tasks. Students' (domain/topic-elated) self-positioning, argumentative style and structure, and (domain-related) language use are also described and analysed.

Goals: Detailed qualitative analysis of information use/adoption from website content into written responses

Analysis: Intraindividual analysis of responses by the same students for different COR tasks; interindividual analysis of responses by students from different domains on the same task

Theory: Narratology and theory of narrative framing; latent meaning and rule-based social behavior;; objective hermeneutics; domain-specific habitus (through language); boundary objects



PIs: Prof. Dr. Mita Banerjee, JGU Mainz, Prof. Dr. Carla Schelle, JGU Mainz; Prof. Dr. Olga Zlatkin-Troitschanskaia, JGU Mainz, Prof. Dr. Jochen Roeper, GU
Cooperation Partner: Prof. Howard Gardner, Harvard University

CORE Project B06

Product: Qualitative reconstruction of specific website elements (identified narrative frames and latent meaning structures) and the varying adaptation of those elements within student responses to different COR tasks

Application scenarios: Website use; textual analysis

Documents: Written responses, websites used, logfiles (e.g. search terms used), COR tasks

Not suitable for: Large scale assessment

Cooperations: Methodological integration; linguistic analysis of student responses

Note for practical use: Sensibility for language in both websites used and written responses

Previous Project:

Berufspraktische Bildungsprozesse im Recht- und Lehramtsreferendariat sowie der Medizin unter Nutzung digitaler Medien (BRIDGE). 2020 – 2023. Funded by BMBF (01JD1906A).

Related Work:

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/feduc.2020.570625

Banerjee, M., Zlatkin-Troitschanskaia, O., & Schelle, C. (2024). The Role of Narrative Framings and Latent Meaning Structures in Online Information Processing of Young Professionals –Potentials for an Innovative Mixed Methods Approach. In O. Zlatkin-Troitschanskaia, M.-T. Nagel, V. Klose, & A. Mehler. (Eds.). Students', Graduates' and Young Professionals' Critical Use of Online Information – Digital Performance Assessment and Training within and across Domains (pp. 241-258). Springer.

CORE Project B06

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

Touzos, A. A., Laufer, A., Banerjee, M., & Zlatkin-Troitschanskaia, O. (2024). The Role of Website Narratives in Young Professionals' Critical Online Reasoning. In O. Zlatkin-Troitschanskaia, M.-T. Nagel, V. Klose, & A. Mehler. (Eds.). Students', Graduates' and Young Professionals' Critical Use of Online Information – Digital Performance Assessment and Training within and across Domains (pp. 67-94). Springer.

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CORE Project C07

GEN- and DOM-COR Task-Solving Strategies and their Development over the Course of a Degree Program

Website: https://core.uni-mainz.de/c07/

Summary

Name of the test instruments used:
- t0: OIS tasks: GEN-COR: Funkmast, DOM-COR Medicine: Mittelohr; DOM-COR Economics: Nudging

- t1 CIS tasks: GEN-COR: Tetrapak, DOM-COR Medicine: Kreislauf, DOM-COR Economics: StartUp

Domain focused: GEN-COR and DOM-COR in economics, medicine, sociology and physics

Assessed competences: OIA, CIE, REAS

Target group:
t0: first semester, all four domains, 20 students per domain

t1: third semester, all four domains, 20 students per domain

Modality: COR tasks processing in one lab session

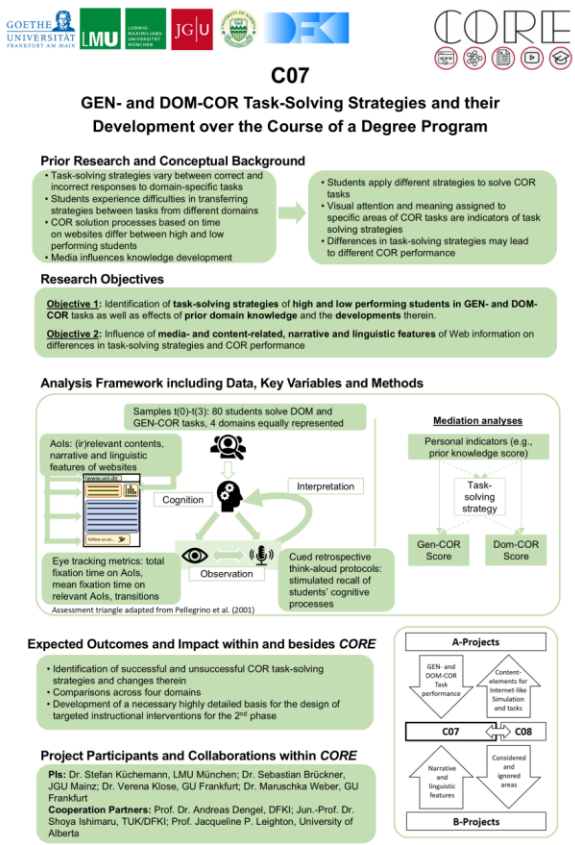
Duration: 3h per session (t0, t1…) in eye-tracking lab

Test setup: Eye-tracking (during COR task soliving), RTA (verbal data for selected excerpts of COR task processing (10 min) directly after tasks)

General test purpose: Insights into fine-grained process data on websites (eye-tracking) and corresponding think aloud data (verbal data)

Application scenarios: In lab studies: COR-task 1, RTA1, COR-task 2, RTA2 (each student received one GEN-COR and one DOM-COR task)

Not suitable for: Large scale studies; in OIS tasks raw data is hardly suitable for analysis (requires highly complex data preparation)



CORE Project C07

Note for practical use: Eye-tracking data reveals word by word resolution of students reading processes, raw eye-tracking data only accessible via specific tobii software (licence required), immense data amount; needs focus on specific research questions

Previous Projects:

Critical Online Reasoning Assessment (CORA)

https://www.plato.uni-mainz.de/cora/

Practical educational processes in law and teacher training and medicine using digital media (BRIDGE)

https://eng.bridge.uni-mainz.de/

Related work:

Kunz, A.-K., Zlatkin-Troitschanskaia, O., Schmidt, S. Nagel, M.-T., & Brückner, S. (2024). Investigation of students' use of online information in higher education using eye tracking. *Smart Learning Environments, 11*(44). https://doi.org/10.1186/s40561-024-00333-6

Klose, V., Kohmer, A., Demmer, I., Jochen, R. & Weber, M. (2024). Domain-Specific Critical Online Reasoning of Medical Students in Final Year of Studies (2024). In O. Zlatkin-Troitschanskaia, M.-T. Nagel, V. Klose & A. Mehler (Eds.), Students', Graduates' and Young Professionals' Critical Use of Online Information (pp. 135-150). Springer Cham. https://doi.org/10.1007/978-3-031-69510-0

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CORE Project C07

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. https://doi.org/10.1080/03075079.2021.1953334

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*. https://doi.org/10.3389/fpsyg.2020.576273

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CORE Project C08

Integrating Students' Process and Textual Data for Measuring the Interdependency of GEN- and DOM-COR

Website: https://core.uni-mainz.de/c08/

C08

Integrating Students' Process and Textual Data for Measuring the Interdependency of GEN- and DOM-COR

Prior Research and Conceptual Background

The state-of-the-art approach to assessing learning outcomes: *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.

Analyzing process and multimodal text data generated by students during their learning is considered as *uninterrupted behavior and thus a more authentic* alternative to the state-of-the-art.

Response process and text data together *form multimodal data ensembles, that have the potential to create a more complete picture of COR* processes and can be analysed by data science methods.

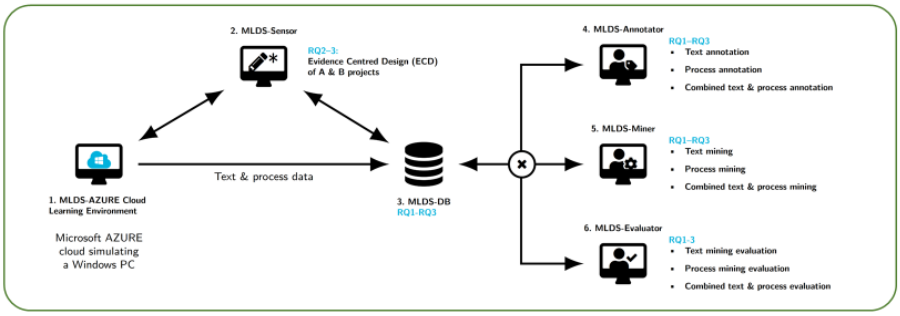
With the increasing use of data science in education, the question arises *to what extent data-driven approaches can be compared to state-of-the-art assessments and whether they represent a new measurement instrument* to investigae cognitive and meta-cognitive facets of COR.

Objectives and Research Questions

O1: Provide an ***authentic digital assessment and learning environment*** in the AZURE cloud where students can behave as they would on their Windows PCs.
O2: Capture students' activities by **integrating response process and text data in a research infrastructure** called *Multimodal Learning Data Science System*.
O3: Analyze and explore multimodal data for all projects in the research unit.

RQ1: Is there a **relation between the process data and textual** data of students **while performing COR tasks**?
RQ2: How can the **multimodal data be used to validate the research findings** of the individual projects?
RQ3: Do **text or process data reflect GEN- or DOM-COR** related **task-solving strategies**?

Research Infrastructure including Data and Methods



Expected Outcomes and Impact within and besides the Research Unit *CORE*

- Providing an authentic digital assessment and learning environment for tracking of multimodal data to investigate COR
- Support for individual A-projects in delivering authentic COR scenarios
- Development of a data infrastructure to annotate and analyze process and textual data of COR performance
- Identification of successful and unsuccessful task-solving strategies and changes therein beyond the scope of individual projects in the research unit

Principal Investigators

Dr. Hendrik Drachsler, Prof. of Computer Science, Goethe University Frankfurt a. M. & Leibniz DIPF, Germany
Dr. Alexander Mehler, Prof. of Computer Science, Goethe University Frankfurt a. M., Germany

CORE Project C08

MLDS-DB for CORE-relevant Linguistic and Process Data	
Goal	A database model and its implementation by a multimodal database management system that allows storage, management and searching of all CORE-relevant linguistic and process data
Approach	The project collects diverse primary and secondary textual data, utilizing the UIMA Database Interface for integration with various text annotation tools. It combines document-oriented, graph, and relational databases to manage different data types effectively. The TILLA infrastructure will be customized for capturing multimodal process data in the AZURE cloud, leveraging the OpenLAIR repository for selecting relevant process indicators. This unified system will facilitate data aggregation, exchange, and analysis across CORE projects.
Outcome	A multimodal database management system for multimodal text and process data.

Interleaving of Text and Process Data in the MLDS-DB	
Goal	Interleaving text and process data by means of a multimodal database.
Approach	Multimodal texts are structured across various levels, leading to complex graph structures when multiple levels interact. Student information processing and cognitive processes evolve over time, with varying attention to text segments that organize primary and secondary data. A model for multimodal ensembles captures the relationships and temporal ordering between textual and behavioral data. This model allows for the temporal structuring of textual data based on cognitive processes while linking behavioral data to relevant textual information. By contextualizing both data types, this approach facilitates the integration of behavioral and textual data, laying the groundwork for effective multimodal data mining.
Outcome	A data model for multimodal data types and ensembles in the form of contextualized data structures that can be queried using MLDS-DB.

CORE Project C08

MLDS-Sensor for Critical COR Task-solving Activities	
Goal	Definition of specific sensors by the CORE projects to measure key events according to Evidence-Centered Design
Approach	Building on insights from previous projects, a new Evidenced-Centered Design process will be implemented to define sensors that capture critical task-solving activities in assessments. This approach aims to significantly enhance both the quantity and quality of sensors compared to earlier initiatives. The planning phase will utilize established methods and indicator repositories to ensure comprehensive data collection. The sensors will track various user interactions, such as mouse and keyboard activities, and will save visited websites and their content. Additionally, the collected data will be integrated into a cloud-based system for efficient management and analysis.
Outcome	Each A-project has specified key events for their COR tasks, and those are integrated in the AZURE cloud and the MLDS-DB

Process Data Annotation	
Goal	Further developing and adapting existing annotation frameworks for CORE-relevant process and Web-based data
Approach	A review of existing annotation tools for process data will assess their suitability for the CORE projects, focusing on tools like DISCO, ChronoViz, RepoVizz, and the Visual Inspection Tool (VIT). The VIT is particularly beneficial for annotating multimodal data and supports various learning tasks through a customizable sensor set, aligning with the multidisciplinary nature of CORE. It enables researchers to triangulate multimodal data from different sources, segment data into time intervals with annotations, and download annotated datasets for analysis. Adjustments will be made to the VIT as needed to meet the specific requirements of the CORE projects.
Outcome	An annotation tool for the process data of the CORE projects.

CORE Project C08

Linguistic Annotator	
Goal	Further developing, adapting or making reusable of existing annotation frameworks for COR-relevant textual and web-based data.
Approach	A review of existing annotation frameworks will assess their suitability for the annotation needs of various projects. This includes tools for classifying topic-related content at different levels, such as single words, text segments, and entire texts. The focus will be on annotating entity structures, syntactic and propositional structures, as well as temporal, spatial, rhetorical, and argument structures. Additionally, tools will be developed for annotating online information sources, eliminating boilerplate content, and ranking the trustworthiness of web pages. This comprehensive approach will enhance the accessibility of linguistic content for detailed annotation, facilitating inter- and intratextual analysis across projects.
Outcome	A toolbox of text annotation tools

Annotation Framework for Integrating Text & Process Data	
Goal	A generalized method to annotate combined multimodal text and process data generated by the FOR.
Approach	The development of a generalized graph-theoretic representation format aims to facilitate the integrated management of text and process data within the CORE projects. Instead of creating multiple specialized data structures, this approach will utilize a generalized graph class to accommodate the diverse requirements of handling multimodal data. By incorporating multilayer and multiplex networks, the goal is to enable the annotation, classification, and linking of multimodal text and process data, thereby expanding the modeling base for the projects. These annotations will also contribute to the multimodal mining tools, enhancing data analysis capabilities.
Outcome	An annotation tool for the integrated annotation of multimodal data.

CORE Project C08

A Framework for Graph Class-oriented Annotation	
Goal	Closing the gap between existing annotation tools and the requirements of the CORE projects that go beyond what can be achieved by adapting these tools
Approach	The development of annotation software will focus on addressing various linguistic structures, including metaphorical and narrative text forms. To streamline this process and reduce development efforts, a generic module will be added to existing annotation tools, allowing for the mapping of generalized graph classes instead of specific structures. This approach involves identifying relevant graph classes and ensuring that the annotation model accommodates them through scripts that translate abstract graph models into user-friendly formats. Users will interact with a tailored interface that simplifies the annotation of different graph types, enhancing the tool's usability while maintaining consistent application logic.
Outcome	A toolbox of annotation tools for graph classes generically developed to meet the requirements of the CORE projects.

Active Learning	
Goal	Accelerating and extending the semi-automatic annotation of COR data.
Approach	Active Learning (AL) is a supervised learning method that enhances classifier accuracy by incorporating expert judgments while minimizing their annotation effort. It allows machine learning (ML) to focus on data points that are challenging to assess by querying human experts for their outputs. This approach aims to improve performance, particularly in complex tasks related to multimodal data. By utilizing AL, the annotation process can be expedited, and ML tools for text and process mining can be refined. Additionally, error analysis and expert feedback will be integrated to address areas where AL does not yield improvements, ensuring continuous evaluation and enhancement of project outcomes.
Outcome	An active learning system for improving the processing of COR data

CORE Project C08

Text Mining	
Goal	Implementing, testing, and applying a generic framework for the exploratory study of textual data in the FOR using ML methods.
Approach	The development and implementation of machine learning (ML) methods will focus on the exploratory analysis of linguistic and symbolic data within the FOR projects. This includes training neural networks for tasks such as recognizing, classifying, and mining novel data types. Key research objectives involve handling diverse linguistic resolutions, scaling methods for heterogeneous and small datasets, and addressing multiple target variables. The approach will explore automatic enrichment of data for in-depth experimentation and validation, fine-tuning transformer models for shallow semantic analysis, and employing multimodal computing methods. Additionally, the framework will investigate biases in NLP models and analyze various text structures, enhancing ML results through genre and domain classifications.
Outcome	A process mining tool adapted and developed in the FOR.

MLDS-Disseminator	
Goal	Publication of research outcomes and data according to the FAIR Principles.
Approach	C08's dissemination strategy consists of four steps. First, it will train the CORE projects to utilize the MLDS-DB and associated tools, fostering cross-project studies and collaborations. Second, it aims to publish scientific findings at various conferences and in high-impact open access journals. Third, the developed source code will be released under an open-source license in a public GitLab repository, allowing external use of C08's infrastructure. Finally, C08 will publish its collected data in accordance with FAIR principles through the DIPF Research Data Center, ensuring that anonymized data is accessible for research purposes.

CORE Project C08

Outcome	Training of CORE projects in using MLDS, open-access publication, code sharing via GitHub, and publication of research data in accordance with the FAIR principles.

Combined Text and Process Mining	
Goal	Implementing, testing, and applying a generic framework for the combined study of multimodal textual and response process data in the FOR.
Approach	The integration of text and process mining aims to achieve three research goals: enhancing text mining with process data, improving process mining through text data, and modeling multimodal and crossmodal ensembles. This approach explores novel data types that arise from combining textual and process data, potentially explaining variations in target variables. For instance, it investigates how specific linguistic features and medial configurations influence cognitive processes, leading to identifiable text patterns associated with cognitive strategies and student performance. The focus on integrated mining facilitates the development of methods for recognizing dependencies between different modalities, ultimately clarifying the relationship between linguistic and behavioral information in cognitive processes.
Outcome	A combined text and process mining tool for the detection of cross- and multimodal ensembles and for the study of their influence on GEN- and DOM-COR.

CORE Project C08

MLDS-Evaluator in Cooperation with CORE projects	
Goal	Interactive evaluation of methods and hypotheses testing in close cooperation with CORE projects.
Approach	C08 enhances data processing capabilities beyond what individual CORE projects can achieve, enabling validation of their study results that would otherwise be inaccessible. Its infrastructure allows for testing relationships between features across different modalities, addressing limitations faced by individual projects. This collaboration can spark new hypotheses and foster partnerships that enhance research outcomes. Acting as a central data hub, C08 gains access to all COR data, facilitating method development based on its multimodal database. By evaluating its instruments in cooperation with CORE projects, C08 aims to bridge the gap between educational sciences and data science, advancing multimodal machine learning and contributing to digital humanities tailored for educational research.
Outcome	Cooperative evaluation; hypothesis development and testing.

Related Work:

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CORE Project C08

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Hildebrand, J., Hemati, W., & Mehler, A. (2020). Recognizing sentence-level logical document structures with the help of context-free grammars. Proceedings of the 12th Language Resources and Evaluation Conference, 5282–5290. https://aclanthology.org/2020.lrec-1.650

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Konca, M., Mehler, A., Baumartz, D., & Hemati, W. (2021). From distinguishability to informativity. Language and Text: Data, Models, Information and Applications, 356, John Benjamins. 145-162. https://doi.org/10.1075/cilt.356.10kon

CORE Project C08

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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. In: *Frontiers in Education*. https://doi.org/10.3389/feduc.2020.562670, pp.1-31.

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Imprint

Annual Newsletter on the DFG Research Unit "Critical Online Reasoning in Higher Education"

The CORE Annual Newsletters announces information 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 Newsletter 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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