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Olga Zlatkin-Troitschanskaia, Dimitri Molerov & Miriam Toepper

Developing Students' Critical Online Reasoning in Higher Education (CORE):

Longitudinal Insights, AI-Related Challenges, and Implications for Future Research: CORE +

Johannes Gutenberg University Mainz
Goethe University Frankfurt
Leibniz Institute for Research and Information in Education (DIPF)
Ludwig-Maximilians-Universität München

Deutsche Forschungsgemeinschaft

CORE Working Papers on the DFG Research Unit "Critical Online Reasoning in Higher Education"

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Series Editors
Prof. Dr. Olga Zlatkin-Troitschanskaia
Johannes Gutenberg University Mainz
Faculty of Law, Management & Economics
Chair of Business and Economics Education
Jakob-Welder-Weg 9
D-55099 Mainz

Prof. Dr. Johannes Hartig
DIPF | Leibniz Institute for Research and Information in Education Frankfurt Department
Teacher and Teaching Quality
Head of Unit - Educational Measurement
Rostocker Straße 6
60323 Frankfurt am Main

Contact
core@uni-mainz.de

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Developing Students' Critical Online Reasoning in Higher Education (CORE): Longitudinal Insights, AI-Related Challenges, and Implications for Future Research: CORE +

Abstract

The CORE research unit "Critical Online Reasoning in Higher Education" (CORE), funded by the German Research Foundation (DFG) since 2023, brings together nine collaborative projects to investigate how students' COR skills develop longitudinally across four major disciplines (economics, medicine, social sciences, and physics) and to gain initial insights on how AI integration affects these processes. CORE examines both generic and domain-specific dimensions of COR, and the specific role of AI-driven tools in authentic academic learning and problem-solving contexts. By combining interdisciplinary expertise, CORE seeks to map COR developmental trajectories across disciplinary contexts, analyze how digital tools and AI-mediated learning environments support – or hinder – this development. The present report summarizes the theoretical foundations, research design, methodological innovations, and emerging findings from the first two project years, while outlining directions for future research.

Key Words

Critical Online Reasoning; Online Learning Environment; Digital Learning; Higher Education; Online Information Landscape; Critical Information Problems; Behavioral Data; Multimodal Text Data; Eye Tracking; Scenario-based Tests; Artificial Intelligence (AI)

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1. CORE Rationale

In an increasingly digitalized society, self-directed online learning has become central to higher education. To navigate through this complex information landscape effectively and responsibly, students require *Critical Online Reasoning* (COR) skills: the ability to strategically search for, critically evaluate, and synthesize high-quality information from diverse online sources (Molerov et al., 2020). Despite a growing number of initiatives to enhance students' digital skills in education, empirical research consistently shows that many students struggle to distinguish between trustworthy and misleading information (Weinburg et al., 2022; Zlatkin-Troitschanskaia et al., 2021b).

At the outset of the CORE research program, students reported that the Internet was their primary source of study-related information (Maurer et al., 2020; Grothaus et al., 2021). Previous fundings further demonstrated that students' COR-related skills are closely linked to their academic success (Weber, 2019; Elbright-Jones, 2024).

These challenges have intensified with the rapid advancement of generative AI technologies, such as ChatGPT. While (generative) AI tools provide unprecedented access to vast amounts of information, they often produce superficially plausible yet inaccurate content, thereby increasing the risks associated with uncritical reasoning (Mannuru et al., 2024; Romero-Rodríguez et al., 2023). As AI-powered tools become increasingly integrated into higher education (and civic life), fostering students' COR skills is increasingly intertwined with promoting AI literacy, which encompasses understanding the limitations, biases, and epistemic implications of algorithmically generated content (Pinski & Benlian, 2024; Zhang & Magerko, 2025).

The CORE research unit "Critical Online Reasoning in Higher Education", funded by the German Research Foundation (DFG) since 2023, brings together nine collaborative projects (see Figure 1) to investigate how students' COR skills develop longitudinally across four major disciplines (economics, medicine, social sciences, and physics) and to gain initial insights on how AI integration affects these processes. CORE examines both generic and domain-specific dimensions of COR, and the specific role of AI-driven tools in authentic academic learning and problem-solving contexts. By combining interdisciplinary expertise, CORE seeks to map COR developmental trajectories across disciplinary contexts, analyze how digital tools and AI-mediated learning environments support – or hinder – this development.

The present report summarizes the theoretical foundations, research design, methodological innovations, and emerging findings from the first two project years, while outlining directions for future research.

2. Conceptual Background and Research Questions

Critical Online Reasoning (COR) is conceptualized as a multidimensional skillset essential for effective, and evidence-based learning in digital information environments (Molerov et al., 2020). Building on established models such as *Information Problem Solving on the Internet* (Brand-Gruwel et al., 2009), *Multiple Source Comprehension* (Goldman & Brand-Gruwel, 2018), *Multi-Source, Multi-Modal Processing* (List & Alexander, 2018), and *Civic Online Reasoning* (Wineburg et al., 2016), the COR framework integrates cognitive and metacognitive processes for searching, selecting, evaluating, and synthesizing online information to make well-founded decisions.

The COR framework emphasizes four core facets (Molerov et al., 2020) (for AI-related adaptations, see Section 5):

1. *Online Information Acquisition*: Skills for strategic information search, requiring students to develop targeted search strategies and identify high-quality, relevant information from search engines or databases.
2. *Critical Information Evaluation*: Skills for systematically analyzing quality and relevance of sources based on appropriate indicators.
3. *Reasoning based on Evidence, Arguments, and Synthesis:* Skills for integrating multiple perspectives, weighting (conflicting) evidence, constructing coherent arguments, and drawing justified conclusions.
4. *Meta-Cognitive Activation:* Skills for monitoring and reflecting one's reasoning strategies and decision-making processes, and regulating one's approach as needed during the learning process.

A distinguishing feature of the COR framework is the differentiation between *generic* (GEN) COR skills, which are independent of specialized disciplinary knowledge, and *domain-specific* (DOM) COR skills, which rely on in-depth expertise and discipline-based reasoning (Zlatkin-Troitschanskaia et al., 2021a). COR tasks are designed to capture both dimensions across varying academic contexts.

For example, evaluating a study on vaccine effectiveness requires not only general critical thinking but also domain-specific medical knowledge, including established research methodologies, whereas addressing questions related to fiscal policy requires discipline-specific expertise in economic models (List, 2021). In combination with the Model of Domain Learning (Alexander, 2004), this approach enables a systematic examination of how COR skills develop across diverse knowledge domains and varying levels of expertise (Zlatkin-Troitschanskaia et al., 2021a).

Given the growing role of (generative) AI technologies in the learning and information landscape, the COR framework is being extended to incorporate skills related to strategic and reflective interacting with AI-tools and AI-generated content (e.g. AI-literacy; Gonsalves, 2023). These skills include the ability to formulate effective prompts, critically evaluate AI-generated content, and triangulate AI outputs with traditional sources (Federiakin et al., 2024).

The CORE research unit is organized into three main areas (see Figure 1).

AREA A investigates the longitudinal development of students GEN- and DOM-COR skills throughout their undergraduate studies in economics and medicine, with control comparisons in sociology and physics.

Area B examines the characteristics and quality of the online information (e.g., accuracy, linguistic features, narrative frames, and latent meaning structures) students engage with while completing COR tasks, and their influence on learning and performance.

Area C focuses on cognitive and metacognitive processes underlying COR task performance, using experimental designs and predictive analyses to model reasoning patterns.

An additional **working group** explicitly addresses **AI use**, exploring how students interact with AI tools, the effects on performance, and the implications for COR development.

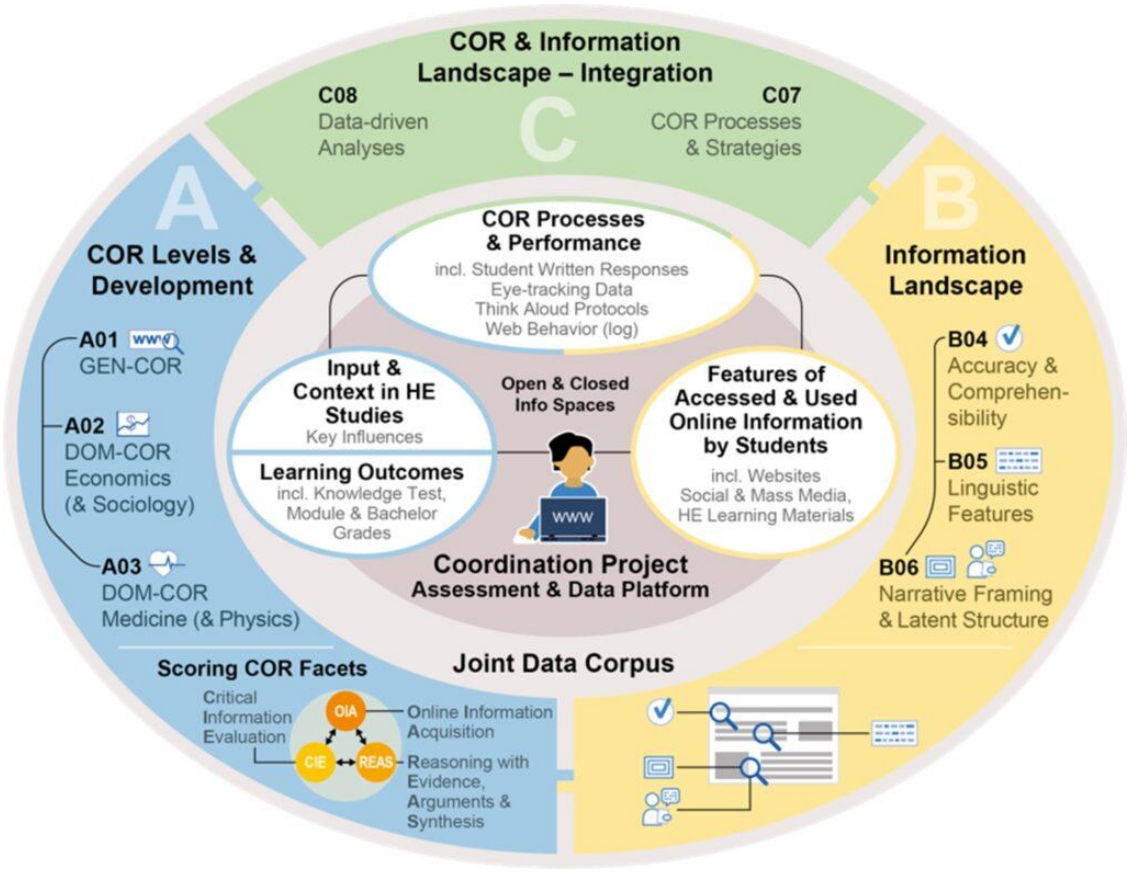

Figure 1. Research structure with 3 areas and 9 projects.

CORE investigates several major research questions across its three main areas.

In *Area A*, we examine whether GEN- and DOM-COR skills develop interdependently over time, how these skills relate to individual characteristics such as prior knowledge and intellectual abilities, and how contextual factors, including course attendance and academic experiences, influence their development. Additionally, CORE investigates the relationship between COR skills and overall student learning outcomes.

In *Area B*, key questions include identifying the defining features of high- and low-quality sources, such as comprehensibility, linguistic style, narrative patterns, and determining how these source characteristics relate to the students COR skills. This work aims to explore the extent to which students' reasoning depends on the quality and characteristics of the information environment.

In *Area C*, cognitive laboratory studies with eye-tracking and think-alouds are used to uncover students' strategies while completing COR tasks. We also examine whether integrating process data could reveal patterns in large-scale datasets that enable predictive insights into reasoning performance and learning outcomes.

In response to the increasing integration of (generative) AI in higher education, an additional *working group* within CORE was established to investigate students' interactions with AI tools and their effects on learning. Research questions address how does students' AI use, including both self-reported experience with AI chatbots, such as ChatGPT, in their academic studies and observed behaviors in COR assessments, relate to their reasoning strategies, COR task performance (e.g. quality of students' written responses) and learning outcomes (e.g. exams passed, grades), and, thereby providing early insights into the role of AI in shaping critical online reasoning.

3. Assessment Framework

CORE brings together nine projects, 55 researchers, and ten institutions, representing expertise from 15 disciplines – including educational measurement, economic and medical education, communication, information and computer sciences, and linguistics – and fosters close collaboration across three interconnected research areas (see Figure 1). The CORE research infrastructure combines large-scale competency assessments with fine-grained process data collection:

Area A focusses on the *longitudinal assessment* of students' GEN- and DOM-COR skills across four academic disciplines, using *large-scale, computer-based testing*.

Area B investigates the characteristics and quality of the online information sources selected and used by students during COR tasks, employing *a systematic combination of qualitative and quantitative text-based approaches*.

Area C examines students' cognitive and behavioral processes during COR task performance through *multimodal data collection methods, including log data, think-aloud protocols, and eye-tracking*.

COR skills are measured through authentic, computer-based performance assessments in *live* online environments. Students are given *unrestricted access to the Internet* to search for and evaluate information and construct evidence-based arguments. COR tasks simulate realistic decision-making scenarios, requiring students to independently navigate information, critically evaluate sources, and provide justified conclusions. Students search the live Internet to gather and evaluate information for tasks such as verifying a contested claim or making a domain-specific decision.

COR tasks are situated in both *generic and domain-specific contexts* and vary in complexity and cognitive demand. For instance, a GEN-COR task may ask students to evaluate the claim "Radio mast radiation is harmless to humans," while a domain-specific task may ask economics students to assess economic growth in relation to environmental sustainability, based on conflicting data. DOM-COR tasks are designed to assess the above-mentioned COR facets across three reasoning contexts (*fundamental, practical, transdisciplinary*) and three proficiency levels (*basic, advanced, proficient*; Alexander, 2004) and are aligned with curricular content. COR tasks were developed and validated through iterative) design cycles involving student feedback, expert reviews, and pilot testing (Nagel et al., 2022).

Building on the COR framework, the COR assessment in summer 2025 now explicitly incorporates AI-mediated reasoning. Students' interactions with AI tools have been recorded through log files, screen capture, and self-report questionnaires, allowing researchers to measure prompt construction, source triangulation, and critical evaluation of AI outputs (see Section 5). This approach situates COR in contemporary information landscapes where AI is increasingly present, ensuring ecological validity while preserving rigorous measurement of reasoning skills.

Students' responses are scored by trained raters using validated rubrics (Nagel et al., 2022; Hartig et al., 2025). Indicators include the number and quality of sources used, explicit reference to evaluation criteria, integration of multiple perspectives, and use of appropriate (disciplinary) arguments. Interrater reliability consistently exceeds α=0.80, confirming the robustness of performance scoring across tasks (Nagel et al., 2022; Hartig et al., 2025).

In addition to product data (written responses), process data from log files, including search queries, clickstreams, website navigation patterns, and time-on-task are analyzed to trace students' online reasoning behaviors (Schmidt et al., 2020). Think-aloud protocols and eye-tracking data further capture metacognitive regulation and strategic behaviors during task completion (Kunz et al., 2024). Together with performance data, these multimodal measures provide a comprehensive view of how students navigate both traditional and AI-enhanced online information environments.

4. Study Design

CORE employs a multi-cohort longitudinal design with a panel structure. Since 2023, undergraduate students have been tracked from their first semester through three years of study to capture individual growth trajectories and disciplinary differences in COR development.

The initial sample (t0: N=2,458; t1: N=2,869) was drawn from eight universities across four disciplines (see Figure 2). A stratified sampling procedure ensures balanced representation across disciplines and study progress. In each wave, approximately 470 students complete a three-hour assessment consisting of both GEN- and DOM-COR tasks (for an overview on COR samples, see Tables 1, 2, 3). In addition, students complete self-reflection questionnaires following each COR task.

In addition to performance measures, the study collects background data, cognitive ability tests (e.g., BEFKI, Schipolowski et al., 2015), reading comprehension skills, and domain-specific knowledge measures (e.g. economic knowledge test: WiWiKom, Zlatkin-Troitschanskaia et al., 2019). Sub-studies with eye-tracking and think-aloud protocols (N=88) provide detailed insights into students' attentional processes and reasoning strategies (Maur et al., 2025).

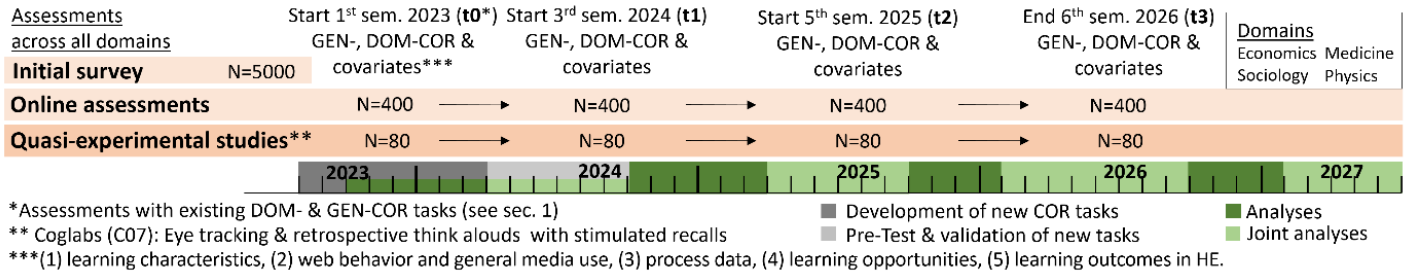

Figure 2. Longitudinal study design.

	Measurement point		
Assessments (completed)	T0	T1.1	T1.2
Full survey	2,458	2,098	871
COR assessment participants	473	471	
ChatGPT	-	-	225
Eyetracking	88	74	

Table 1. Participants across measurement points.

Descriptive Statistics

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Gender (1 = Female)	471	0	1	0.53	N/A
Age	471	15	57	20.17	3.025
High School GPA[a]	471	0.9	3.5	1.74	0.606
No prior university studies	471	0	1	0.80	N/A
No prior apprenticeship	471	0	1	0.85	N/A
Current Semester	471	1	1	1.00	0.000
Dom-COR (1 = EC)	471	0	1	0.57	N/A

a. German GPA grades: 1 = Very Good, 4 = Sufficient

Table 2. Sample descriptive statistics at t0 (winter 2023-24): socio-demographics.

Discipline	N	Percent
Total	471	100.00
Economics	173	36.73
Social Sciences	97	20.59
Medicine	137	29.09
Physics	64	13.59
DOM-COR Economics	270	57.32
DOM-COR Medicine	201	43.68
GEN-COR	471	100.00

Table 3. Sample descriptive statistics at t0: students' disciplines and tasks.

The collected data captures students' digital behaviors, including comprehensive log files, screen recordings that capture sequences of information navigation, as well as detailed analyses of selected sources, focusing on their type, structure, authorship, and citation practices, etc. (Scherer et al., 2025). This rich, multimodal dataset enables researchers to reconstruct students' research strategies, trace their decision-making processes, and identify potential barriers to learning.

This design enables the investigation of both longitudinal skills development and cross-sectional differences, while allowing detailed analysis of how AI-mediated information sources influence reasoning strategies. It also provides the foundation for examining individual differences in COR development, disciplinary variation, and the role of AI use, ensuring that CORE remains responsive to the rapidly evolving digital learning environment.

5. AI-Related Design Adaptations and Conceptual Foundations

The rapid rise of generative AI technologies, especially large language models (LLMs) such as ChatGPT and Google Gemini, has fundamentally altered the digital information ecosystem in which students operate, requiring appropriate adjustments to the study design (Federiakin et al., 2024). While CORE's initial assessments were designed to evaluate students' independent online reasoning without the assistance of AI (Nagel et al., 2022), initially, AI use was restricted during COR tasks to preserve the validity of skill assessments. However, with AI tools becoming integrated into mainstream search engines, productivity platforms, and academic workflows, and students increasingly relying on AI-generated content for academic tasks, a reorientation of initial COR assessment approach is necessary. The ubiquity of AI-assisted information access requires a conceptual reframing of COR as students no longer only evaluate static information from typically human-authored sources but also interact with algorithmically curated and dynamically generated content. This shift has profound implications for both the construct definition of COR and the methods used to assess and promote it.

From a theoretical perspective, the integration of AI into learning environments intersects with established digital literacy frameworks (e.g., Greene et al., 2014) that emphasize information literacy, media literacy, and critical thinking as essential skills for navigating digital contexts (e.g., Pinski & Benlian, 2024; Zhang & Magerko, 2025). However, AI introduces new demands beyond traditional literacy competencies (Gonsalves, 2024). Building on frameworks such as the European Digital Competence Framework (DigComp 2.2, Vuorikari et al., 2022) and the UNESCO Digital Literacy Global Framework (Law et al., 2018), we conceptualize AI literacy as an AI-specific COR subskill being defined as multidimensional extension of digital literacy that includes the ability to:

- *Prompt construction*: Ability to formulate effective and contextually appropriate prompts to obtain relevant outputs;
- *AI-output evaluation*: Capacity to critically evaluate chatbot responses with respect to accuracy, reliability and potential biases;
- *Source triangulation*: Comparing AI outputs with diverse, independently verified sources;
- *AI fundamentals*: Understanding the limitations (e.g. probabilistic nature), training data biases, and ethical implications of AI models;
- *AI integration*: Strategically integrating AI support into research, decision-making, and learning processes.

These AI-specific skills align closely with and expand upon the four facets of COR (strategic search, critical evaluation, synthesis and argumentation, and metacognitive regulation; see Section 2), while adding an explicit AI-mediated reasoning component.

To capture these emerging skills, since summer 2025, CORE has introduced AI-augmented assessment conditions in which students are allowed or even required to use AI tools during COR task completion. These quasi-experimental designs allow researchers to investigate how students adapt their reasoning strategies when AI-generated information becomes part of their workflow. AI-behavior is detected through log data, screen capture, and self-reflection questionnaire.

Preliminary analysis from a comparative study of students' performance on COR tasks with and without LLM access (N=225 participants from COR main sample) indicate that while AI access can improve efficiency and reduce surface-level search effort, it does not automatically enhance reasoning quality as manifested in students written responses (Molerov et al., 2025). In fact, overreliance on AI-outputs often appears to lead to reduced source diversity and weaker justification of claims. These findings echo broader concerns about automation bias and the erosion of evaluative reasoning in AI-assisted environments (e.g., Bashkirova & Krpan, 2024).

6. Major Findings and Outcomes

Analyses from the first two years of data collection (2023-24 and 2024-25) reveal key insights:

- *Area A*: Cross-sectional and longitudinal growth in students' COR skills became evident, particularly in their ability to construct more nuanced, well-reasoned, evidence-based arguments in domain-specific tasks (e.g., Zlatkin-Troitschanskaia et al., 2025).
- *Area B*: The data reveal persistent weaknesses in the evaluation of source credibility (Scherer et al., 2025). Many students continue to rely on easily accessible but less reliable or poorly contextualized sources, underscoring the need for explicit instruction in evidence quality assessment (Schelle et al., 2025a). Notable domain-specific differences have emerged: Medical students demonstrate a higher reliance on peer-reviewed literature and professional research databases or highly specialized, domain-specific repositories, while economics and social sciences students more frequently consult journalistic or open web sources (Schelle et al., 2025b). These disciplinary patterns highlight the importance of tailoring instruction and assessment to domain-specific epistemic practices.
- *Area C*: Process data, including log file analyses, eye-tracking metrics, and think-aloud protocols, show that students often prioritize efficiency over systematic source evaluation and cross-source validation, engaging in rapid information skimming rather than deep source interrogation (Maur et al., 2025). Eye-tracking shows minimal attention to source credibility markers. While these behaviors may reflect real-world digital practices, they also limit students' capacity for critical reasoning in high-stakes or ambiguous contexts.

The integration of AI into CORE's assessment designs (see Section 5) has produced initial insights into how students navigate an AI-rich information environment and indicates varying AI use patterns (Molerov et al., 2025). Based on the preliminary results, we classify students' AI use as strategic (integrated with evaluation) or overreliant (used uncritically as the sole information source). These patterns are correlated with COR performance outcomes (Molerov et al., 2025). Strategic AI users who critically interrogate AI-generated content and integrate it with multiple human-authored sources, perform above average, demonstrating improved synthesis and argumentation in their written COR responses. In contrast, students who overly rely on AI and treat AI responses as authoritative often display weaker source diversity, less robust (accurate) justification, and greater susceptibility to automation bias (Molerov et al., 2025). These preliminary findings align with broader debates in AI literacy research, suggesting that AI's educational value depends on students' metacognitive regulation and their understanding of AI systems (e.g., Fan et al., 2025), and raising important questions about how to scaffold AI integration in digital learning without undermining critical thinking (Gonsalves, 2024).

These early results highlight the need for a *dual* focus in higher education: strengthening traditional information evaluation and online reasoning skills, while cultivating critical AI literacy as a skillset that enables students to interpret, question, and strategically use AI-generated information. This integrated approach positions AI not as a substitute for critical reasoning, but emphasizes its role as a tool that requires informed and reflective engagement. Such an understanding can foster responsible and thoughtful use of AI, both within and beyond the higher education context.

7. Conclusions and Implications for Future Work

The CORE research program offers the first large-scale, longitudinal analysis of Critical Online Reasoning (COR) in digital and AI-augmented information environments. Considering AI-mediated learning contexts, the COR framework is being expanded to include AI literacy skills, encompassing prompt formulation, critical analysis of AI outputs, triangulation with independent sources, and reflection on AI limitations and biases (see Section 5). This integration aligns COR with contemporary digital literacy frameworks, such as DigComp 2.2 and UNESCO's Digital Literacy guidelines, situating AI use as a critical component of reasoning competence. By extending established frameworks of digital and information literacy to include AI-mediated reasoning, CORE advances a future-oriented understanding of how students acquire, evaluate, and synthesize knowledge in higher education.

CORE makes a substantive contribution to the evolving field of digital learning and online reasoning by addressing a critical gap in the literature: the longitudinal and interdisciplinary analysis of COR in live digital learning contexts (Zlatkin-Troitschanskaia et al., 2021b). While prior studies have established the importance of source evaluation, multiple-source integration, and civic reasoning in digital environments (Goldman & Brand-Gruwel, 2018; List & Alexander, 2018; Wineburg et al., 2016; 2022), few have systematically examined how these skills develop over time and interact with domain-specific knowledge and AI-mediated practices.

The study highlights both promise and challenges in fostering students' COR development. While students generally show improvement over time, key gaps persist, particularly in evaluating source quality and well-founded argumentation (see Section 6). AI-tools further complicate this picture by introducing new affordances and risks (see Section 5).

The CORE research contributes to a growing body of evidence that digital literacy alone is insufficient (Osborne et al., 2022; Zlatkin-Troitschanskaia et al., 2021b). Students must learn to reason critically in fluid, complex, and AI-mediated information spaces (Romero-Rodríguez, et al, 2023; Gonsalves, 2023). By combining rigorous assessment design with longitudinal tracking, this project offers scalable models for both COR evaluation and instructional support.

Theoretically, this study extends existing models such as the Internet-based Information Problem Solving (Brand-Gruwel et al., 2009; Goldman & Brand-Gruwel, 2018) and Civic Online Reasoning (Wineburg et al., 2016) by integrating domain-specificity and critical thinking (Alexander, 2004; List, 2021) with AI-related skills (Gonsalves, 2023). The inclusion of prompt engineering, AI-evaluation, and triangulation reflects an updated conception of what it means to reason critically online in the rapidly evolving AI-enhanced digital tools (Federiakin et al., 2024). In this way, CORE contributes to digital literacy research by proposing a multidimensional model of AI-augmented COR that integrates cognitive, metacognitive, disciplinary, and sociotechnical dimensions of reasoning. This model emphasizes that digital literacy is no longer limited to searching and evaluating static web content but must also address dynamically generated, algorithmically curated information streams.

The cross-disciplinary perspective (covering four major disciplines) further advances theory-building by identifying both shared and domain-specific COR patterns, responding to calls in the literature for domain-sensitive digital reasoning frameworks (Alexander, 2004).

Methodologically, CORE breaks new ground and demonstrates the value of combining large-scale authentic, open-internet performance assessments with fine-grained process data (including log files, screen recordings, eye-tracking, think-alouds). This multimodal approach enhances validity and allows for triangulated insights into students' reasoning strategies in real digital settings, corroborating and extending findings from controlled lab studies (List et al., 2016; Stadtler et al., 2020) to more ecologically valid, naturalistic learning settings. The use of open-ended tasks and real-time web browsing environments addresses long-standing criticisms of over-reliance on self-reports or closed tasks in digital literacy research (Zlatkin-Troitschanskaia et al., 2021b). The introduction of AI-inclusive assessment conditions represents a pioneering step toward measuring how students adapt their reasoning processes in hybrid human - machine information ecosystems (see Section 6).

Empirically, the project's longitudinal design allows researchers to model developmental trajectories in COR across multiple years, enabling analysis of individual differences and instructional effects over time – an aspect largely absent in previous cross-sectional studies (Zlatkin-Troitschanskaia et al., 2021b). Furthermore, the integration of AI use behavior into performance data provides early empirical evidence on how generative tools are shaping students' reasoning processes, complementing emerging work in this area (e.g., Yamamoto, 2024).

Practically, this work provides actionable insights for higher education and supports curriculum development by identifying persistent bottlenecks in students' reasoning processes. It offers validated, scalable models for COR scaffolding that can be embedded into higher education teaching practices across disciplines. In this way, it responds to increasing demands for digital and AI-literacy as core educational outcomes (Knoth et al., 2024; Osborne et al., 2022).

Taking together, CORE bridges theoretical, methodological, and practical perspectives of educational research on digital learning and critical reasoning. It contributes to a growing scholarly consensus that fostering sophisticated online reasoning is not merely a digital literacy issue but central to academic and civic life in the 21st century (Goldman & Brand-Gruwel, 2018; Wineburg et al., 2016) By situating COR in the context of real-world student behavior, domain expertise, and technological transformation, this study lays foundational groundwork for future research and instructional practice.

Key implications include developing dynamic assessments that can adapt to students' AI-tool use and digital environments, and designing COR instruction across disciplines, with emphasis on critical reasoning, source analysis, and AI-literacy. Moving forward, CORE research needs to further develop a conceptual framework for AI-augmented critical online reasoning that integrates perspectives from cognitive science, digital literacy, and human-AI-interaction research. This framework should emphasize the interplay between human judgment and algorithmic mediation, positioning students as active decision-makers rather than passive consumers of AI content. Consequently, future iterations of COR assessments need to adopt dynamic, technology-responsive design principles, ensuring that tasks reflect the evolving realities of AI-driven learning environments.

The integration of AI carries also important implications for curriculum design and instructional practice. Curricula need to evolve to explicitly integrate AI literacy, focusing not only on technical

skills but also on epistemic awareness, ethical reasoning, and reflective judgment (Gonsalves, 2024). Instructional models should promote algorithmic transparency awareness, i.e. an understanding of how AI systems produce outputs and the potential biases they encode, and teach students to evaluate AI-generated information with the same rigor as traditional sources. This aligns with a shift in higher education toward critical AI literacy, which combines computational thinking with ethical reasoning, reflective judgment, and civic engagement (Pinski & Benlian, 2024; Zhang & Magerko, 2025; Knoth et al., 2024; Caulfield & Wineburg, 2023).

Against this background, future research in CORE needs to address three directions:

(1) *Expanding its longitudinal models* to examine how AI use shapes students' developmental trajectories in COR across disciplines and whether AI-supported reasoning leads to durable learning gains.

(2) *Conducting intervention studies* that embed structured AI evaluation tasks and adaptive feedback into coursework to explicitly teach students how to critically interrogate AI outputs, e.g., through structured evaluation rubrics, guided prompts, or metacognitive scaffolding.

(3) *Developing next-generation adaptive assessment designs* that dynamically adapt task difficulty and modality based on students' reasoning behavior, creating a more authentic, personalized testing experience. This includes *leveraging multimodal analytics* to provide individualized profiles of students' reasoning strengths and weaknesses.

By embedding AI into both the theoretical and methodological core of its research program, CORE will provide a future-ready framework for digital competence in higher education that reflects the complex interplay between human reasoning and AI systems. As generative AI reshapes professional and academic practice, higher education must prepare learners not only to consume information critically but also to question algorithmic authority, integrate diverse sources, and maintain intellectual agency. This approach will ensure that Critical Online Reasoning (COR) remains a relevant and robust construct, equipping students not only to navigate the current digital landscape but also to thrive in an era where AI will increasingly shape knowledge production, decision-making, and academic practice. Consequently, CORE's research agenda will continue to evolve alongside emerging technologies, ensuring that critical reasoning remains a central pillar of higher education in the age of AI.

8. CORE+: Advancing Critical Online Reasoning in AI-Driven Higher Education and Early Career Phases

8.1 From CORE Research Phase 1 to CORE+: Insights and Emerging Challenges

In its 1st funding phase, the CORE research unit established a robust theoretical and methodological foundation for investigating *Critical Online Reasoning (COR),* defined as the ability to search, evaluate, and integrate information from diverse online sources in authentic academic settings (Molerov et al., 2020). Unlike traditional approaches to information literacy, which typically separate information search from evaluation and use, CORE adopted an integrative perspective, capturing all three components simultaneously and in authentic task settings (Nagel et al., 2022; Kunz et al., 2024). This comprehensive approach allowed for the identification of reasoning strategies in real-world contexts, rather than relying solely on artificial test settings.

The methodological design of CORE is distinguished by its multimodal data collection (Schmidt et al., 2020). Students solved complex reasoning tasks that required them to gather and synthesize online information, while their behavior was continuously recorded. The resulting rich dataset included log files, screen recordings, and navigation sequences that documented every search query, time allocation, and source selection. This behaviorial data was complemented by eye-tracking to capture students' visual attention and think-aloud protocols to gain insights into their cognitive strategies (Kunz et al., 2024). Additionally, each source students selected and used was systematically analyzed for its type (e.g., news article, academic paper, blog), authorship, structure, accuracy, etc. (Scherer et al., 2025). This approach enabled researchers to reconstruct not only students' final task performance (written responses) but also the entire information processing and decision-making process underlying their reasoning strategies they took to arrive at them (Schmidt et al., 2020; Maur et al., 2025).

These investigations revealed several key findings. COR emerged as a multidimensional construct consisting of generic (GEN) reasoning skills, which can be transferred across disciplines (Schelle et al., 2025a, b), and domain-specific (DOM) skills that are closely tied to disciplinary knowledge (Zlatkin-Troitschanskaia et al., 2025). Longitudinal and cross-sectional studies demonstrated that these skills develop at different rates depending on disciplinary context, thus highlighting striking differences in students' reasoning approaches across disciplines (see Section 6). For instance, medical students often demonstrated strengths in evaluating evidence quality, likely drawing on their training in evidence-based medicine to prioritize peer-reviewed studies or institutional guidelines (Schelle et al., 2025, Touzos et al. 2024). In contrast, economics students were often efficient searchers who quickly identified relevant (e.g.) statistical evidence, but they frequently over-relied on surface-level credibility cues, such as website design or brand familiarity, without systematically verifying the reliability of the content (Maur et al., 2025). Economic students displayed a stronger tendency to use narrative-driven resources, and often underestimated the need for cross-verifying claims with empirical studies, while social science students were more likely to consult a wide variety of perspectives (Schelle et al., 2025). Across disciplines, CORE research uncovered persistent challenges in evaluating online content. Many students struggled to critically assess the credibility of information, frequently relying on heuristics such as author name recognition or institutional affiliation rather than systematically comparing multiple sources (Maur et al., 2025).

Analyses of expert performance offered a useful benchmark (Nagel et al., 2025). Domain experts, such as experienced economics educators, demonstrated a more strategic and systematic approach to reasoning tasks. They were quicker to triangulate evidence across multiple sources, showed greater scepticism toward seemingly authoritative content, and frequently evaluated the origins of data before using it, leading to more robust conclusions. The comparisons between novices and domain experts underscored the developmental nature of COR skills and the gap between novice and expert reasoning, suggesting that such skills can and should be systematically trained (Nagel et al., 2024; 2025).

The preliminary findings across different cohorts from the 1st phase indicate that COR is predictive of academic outcomes. Students with higher reasoning scores tended to perform better in written assignments or examinations (Molerov et al., 2025). For instance, in economics, students with higher COR skills were more adept at interpreting complex policy data and engaging in evidence-based argumentation, skills directly transferable to professional roles in consultancy and policymaking (Nagel et al., 2025).

However, the rapid integration of generative AI tools into the information landscape fundamentally changes the skills required to reason effectively online (Gonsalves, 2024). Systems like ChatGPT, Bard, or domain-specific AI assistants no longer merely provide links to information but produce polished, synthesized responses that obscure their underlying sources and may contain subtle inaccuracies. This shift challenges students' ability to trace evidence, assess quality, and understand potential algorithmic biases. AI also introduces new literacy demands: students must learn to craft effective prompts, critically evaluate the epistemic status of AI-generated outputs, and critically reflect on probabilistic text generation, and how algorithmic systems influence their understanding. This rapid evolution of the digital information environment necessitates a conceptual expansion of COR theory, adjustments to its measurement, and the development of targeted interventions that address reasoning in AI-mediated environments (see Section 5).

These shifts highlight the urgency of CORE+: a 2nd phase of research aimed at developing a comprehensive framework for reasoning in AI-augmented learning and professional contexts.

8.2 From CORE to CORE+: An Expanded Research Agenda

Building on the achievements of the 1st phase, CORE+ will adopt a forward-looking perspective that situates critical reasoning within a rapidly evolving digital ecosystem. The rise of AI has created both opportunities and challenges for this research. Traditional search-based reasoning is increasingly replaced by zero-click or one-click search formats, where AI tools generate responses that appear polished and authoritative, yet lack transparent attribution. This shift undermines many of the cues students relied upon for source evaluation and requires an expansion of reasoning skills to include prompt literacy, AI tool comparison, and a heightened awareness of the limitations of automated content generation (see Section 5). CORE+ will respond to these developments with several innovations, and to investigate how AI reshapes traditional reasoning tasks.

The transition from CORE to CORE+ can be summarized as a systematic progression in three keyways (see Table 4):

1. *Theoretical advancement*: The project will refine the COR framework to explicitly account for reasoning processes in AI-mediated environments, integrating concepts from AI literacy, critical thinking, and epistemic cognition (see Section 5), resulting in an AI-integrated COR model.
2. *Technological integration*: The next-generation assessments will include AI-supported scoring and feedback systems, capturing data from both human - AI interactions (e.g., prompts and responses) and traditional process measures.
3. *Longitudinal expansion*: While the 1st phase focused on undergraduate students, CORE+ extends its longitudinal tracking into *graduate education and early professional practice*. For instance, medical students will be followed into their clinical internships (practical year (PJ)), while teacher education students will be observed during their practical training (*Referendariat*). This extension will reveal how reasoning skills transfer from university to professional environments.

CORE Phase 1 (2023–2027)	AI-Driven Contextual Challenges	CORE+ Innovations (2027–2031)
Validated COR framework (GEN/DOM differentiation; three reasoning contexts)	AI reshapes reasoning contexts (e.g., zero-click results, opacity of source provenance)	A revised, AI-integrated COR model including AI literacy and epistemic evaluation
Open-Internet assessments across four disciplines	Existing COR assessments lack validity for AI-assisted reasoning	Adaptive assessments with AI-supported scoring, feedback and dynamic difficulty
Multimodal behavioral and cognitive process data (logs, eye-tracking, think-alouds)	New data types to capture AI interaction dynamics: prompts, generated text etc.	Integration of AI-interaction data: prompts, AI system outputs
Novice-expert comparisons highlight reasoning gaps	Limited understanding of AI influence on reasoning strategy	Systematic analysis of AI-mediated reasoning strategies
Field and lab interventions in development	Need for scalable training for critical AI literacy	Domain-specific interventions with explainable AI (XAI);
Focus on fundamental higher education (undergraduate phase)	Growing demand for cross-sector AI competence	Expanded longitudinal panel from student stages into early professional practice

Table 4. Condensed overview of transition from CORE to CORE+.

8.3 Research Questions and Hypotheses

Considering the findings and insights from the 1st research phase, CORE+ seeks to answer a set of interrelated *research questions* that reflect the evolving demands:

(1) Concerning the adaptation of COR theory: how should the COR construct be reconceptualized to capture reasoning in AI-mediated information ecosystem/learning environment?

(2) Addressing the skills required for reflective and critical AI use, including both transferable reasoning strategies and domain-specific expertise: Which cognitive, metacognitive, and ethical skills are needed to critically engage with AI-generated content?

(3) Investigating how these skills can be measured reliably and validly, particularly in contexts where AI systems partially mediate information search and synthesis?

(4) Exploring, how do reasoning strategies evolve from undergraduate education into professional roles, and how do they differ between disciplines?

(5) Identifying and evaluating instructional intervention designs that can effectively foster critical reasoning skills in a hybrid information environment of human- and AI-generated content and transfer them into professional practice.

These questions will be operationalized through *superordinate hypotheses* distributed across the research unit's three areas:

1. *Valid measurement of COR in AI-supported settings*: COR is a multidimensional construct with empirically distinct facets that remain valid in AI contexts.
2. *Development of COR and its predictors:* COR skills develop systematically over time, with domain-specific acceleration patterns during graduate study and professional training.

3. *Impact of COR on learning and professional success*: strong COR skills predict not only academic achievement but also success in professional contexts.
4. *AI-supported information landscapes and reasoning:* AI-mediated tasks reveal new forms of reasoning and introduce risks (e.g. of over-trust), requiring updated evaluation strategies.
5. *Reasoning strategies across domains:* Graduate students and trainees/early professionals display distinct domain-specific reasoning strategies that can inform tailored interventions.
6. *Effectiveness of targeted interventions:* Interventions that explicitly train COR in AI contexts lead to measurable improvements in reasoning strategies and task performance.

8.4 Research Design and Methodological Innovations in CORE+

The 2nd research phase aims to deepen the integration of *theory development, field assessments, and experimental studies*. CORE+ will expand the *longitudinal multi-cohort student panel* study established in the 1st phase, which will follow participants from early undergraduate study through graduate programs and into professional placements, incorporating AI use into the task environment. This design enables researchers to examine the sustainability and transferability of COR skills across educational and professional transitions.

AI-adapted COR assessments will capture interactions with AI tools in authentic settings, i.e. reasoning scenarios with the option to consult AI tools, allowing researchers to capture prompts, AI-generated responses, and subsequent decisions. This approach integrates traditional process measures such as screen recordings with AI interaction data. These rich datasets will allow researchers to model how students adapt to AI-supported environments and to identify strategies associated with high-quality reasoning in hybrid information spaces. For instance, in a redesigned economics task, students will evaluate government spending proposals using a combination of official statistics and AI-generated policy briefs. By tracing which sources students consult, how they evaluate AI outputs, and how they synthesize evidence into an argument, researchers can pinpoint reasoning bottlenecks unique to AI-supported environments.

Complementary laboratory studies will serve as testbeds for new interventions, such as embedding "*explainable AI*" features that highlight uncertainty or source origins. These interventions will be designed to make reasoning processes transparent, encourage metacognitive reflection, and strengthen students' capacity to critically evaluate AI outputs. Pilot studies will explore both domain-general modules, which teach transferable reasoning principles, and domain-specific variations tailored to disciplinary needs. For instance, such studies will test whether transparency tools improve reasoning quality and support epistemic awareness in AI-meditated contexts.

8.5 Contribution and Broader Impact

CORE+ aims to provide an updated, empirically validated model of online reasoning in AI-driven environments. This model will advance theoretical understanding of how critical reasoning develops, how it interacts with AI, and which personal and contextual factors shape its growth. Beyond theoretical contributions, by systematically documenting how reasoning evolves across disciplines and professional transitions, CORE+ aims to produce diagnostic tools for assessing reasoning skills and to design evidence-based instructional interventions for universities and professional training programs that strengthen students' ability to navigate digital information ecosystems responsibly.

By extending its research focus beyond undergraduate study into early professional phases, CORE+ positions itself at the intersection of higher education research, digital literacy, and workforce readiness. The findings will inform policymakers, curriculum designers, and educational technologists, offering practical insights into how higher education can prepare students and graduates for a knowledge society increasingly shaped by AI systems, algorithmic content curation, and evolving standards of academic and professional integrity. In this way, CORE+ will help universities prepare students not only to succeed academically but also to navigate future professional roles responsibly and critically.

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.

Brand-Gruwel, S., Wopereis, I., & Walraven, A. (2009). A descriptive model of information problem solving while using internet. *Computers & Education*, 53(4), 1207–1217.

Bashkirova A., & Krpan D. (2024). Confirmation bias in AI-assisted decision-making: AI triage recommendations congruent with expert judgments increase psychologist trust and recommendation acceptance. *Computers in Human Behavior: Artificial Humans (2)*1. https://doi.org/10.1016/j.chbah.2024.100066.

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. *Front. Comput. Sci.*, 6. https://doi.org/10.3389/fcomp.2024.1366934

Braunheim, D. (2024). Effects of Regular Media Use of Young Professionals on Their Online Source Selection During a Situated Digital Performance Assessment. In O. Zlatkin-Troitschanskaia, M.-T. Nagel, V. Klose, & A. Mehler (Eds.), Students', Graduates' and Young Professionals' Critical Use of Online Information (pp. 47-67). Springer.

Caulfield, M., & Wineburg, S. (2023). Verified: How to think straight, get duped less, and make better decisions about what to believe online. University of Chicago Press.

Fan, Y., Tang, L., Le, H., Shen, K., Tan, S., Zhao, Y., Shen, Y., Xinyu, L., & Gašević, D. (2025). Beware of metacognitive laziness: Effects of generative artificial intelligence on learning motivation, processes, and performance. *British Journal of Educational Technology*, *56*(2), 489-530. https://doi.org/10.1111/bjet.13544

Federiakin, D., Molerov, D., Zlatkin-Troitschanskaia, O., & Maur, A. (2024, November). Prompt engineering as a new 21st century skill. In Frontiers in Education (Vol. 9, p. 1366434). Frontiers Media SA.

Goldman, S., Lawless, K., Gomez, K., Braasch, J., MacLeod, S., & Manning, F. (2010). Literacy in the digital world: Comprehending and learning from multiple sources. In M. G. McKeown & L. Kucan (Eds.), *Bringing reading reasearch to life* (p. 257–284). Guilford Publications.

Goldman, S. R., & Brand-Gruwel, S. (2018). Learning from multiple sources in a digital society. In F. Fischer, C. E. Hmelo-Silver, S. R. Goldman, & P. Reimann (Eds.), *International handbook of the learning sciences* (pp. 68–95). Routledge. https://doi.org/10.4324/9781315617572

Gonsalves, C. (2024). Generative AI's Impact on Critical Thinking: Revisiting Bloom's Taxonomy. *Journal of Marketing Education*, 1, 1–16. https://doi.org/10.1177/02734753241305980

Greene, J. A., Yu, S. B., & Copeland, D. Z. (2014). Measuring critical components of digital literacy and their relationships with learning. *Computers & Education*, 76, 55–

69. https://doi.org/10.1016/j.compedu.2014.03.008

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

Hahnel, C., Jung, A. J. & Goldhammer, F. (2023). Theory matters: An example of deriving process indicators from log data to assess decision-making processes in web search tasks. *European Journal of Psychological Assessment*, *39*(4), 271-279. doi: 10.1027/1015-5759/a000776HYPERLINK "https://econtent.hogrefe.com/doi/10.1027/1015-5759/a000776"

Knoth, N., Tolzin, A., Janson, A., & Leimeister, J. M. (2024). AI literacy and its implications for prompt engineering strategies. *Computers and Education: Artificial Intelligence*, *6*, 100225. https://doi.org/10.1016/j.caeai.2024.100225

Köhler, C. & Hartig, J. (2024). ChatGPT in higher education: Measurement instruments to assess student knowledge, usage, and attitude. *Contemporary Educational Technology*, *16*(4), ep528. doi: 10.30935/cedtech/15144HYPERLINK "https://www.cedtech.net/article/chatgpt-in-higher-education-measurement-instruments-to-assess-student-knowledge-usage-and-attitude-15144"

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

Law, N., Woo, D., de la Torre, J., & Wong, G. (2018). *A global framework of reference on digital literacy skills for indicator 4.4.2*. UNESCO Institute for Statistics.

List, A., Grossnickle, E. M., & Alexander, P. A. (2016). Undergraduate students' justifications for source selection in a digital academic context. *Journal of Educational Computing Research*, *54*(1), 22–61.

List, A., & Alexander, P. A. (2018). Toward an Integrated Framework of Multiple Text Use. *Educational Psychologist*, *54*(1), 20–39. https://doi.org/10.1080/00461520.2018.1505514

List, A., & Alexander, P. A. (2018b). Corroborating students' self-reports of source evaluation. Behaviour & Information Technology, 37(3), 198–216. https://doi.org/10.1080/0144929X.2018.1430849

List, J. A. (2021). Enhancing critical thinking skill formation: Getting fast thinkers to slow down. *The Journal of Economic Education*, *53*(1), 100–108. https://doi.org/10.1080/00220485.2021.2004282

Mannuru, N. R. , Mannuru, A. and Lund, B. (2024). Large Language Models (LLMs) as a Tool to Facilitate Information Seeking Behavior. *InfoScience Trends, 1*(2), 34–42. https://doi:10.61186/ist.202401.01.15

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

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*. https://doi.org/10.3389/feduc.2020.577843

Mutanga, M. B., Msane, J., Mndaweni, T. N., Hlongwane, B. B., & Ngcobo, N. Z. (2025). Exploring the Impact of LLM Prompting on Students' Learning. *Trends in Higher Education*, 4(3), 31. https://doi.org/10.3390/higheredu4030031

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.* https://doi.org/10.3389/feduc.2020.565062

Nagel, M. T., Zlatkin-Troitschanskaia, O., & Fischer, J. (2022, November). Validation of newly developed

tasks for the assessment of generic Critical Online Reasoning (COR) of university students and graduates. In *Frontiers in Education* (Vol. 7, p. 914857). Frontiers Media SA.

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/

Pinski, M., & Alexander Benlian, A. (2024). AI literacy for users – A comprehensive review and future research directions of learning methods, components, and effects. Computers in Human Behavior: Artificial Humans (2)1. https://doi.org/10.1016/j.chbah.2024.100062

Romero-Rodríguez, J. M., Ramírez-Montoya, M. S., Buenestado-Fernández, M., & Lara-Lara, F. (2023). Use of ChatGPT at university as a tool for complex thinking: Students' perceived usefulness. *Journal of New Approaches in Educational Research*, *12*(2), 323–339. https://doi.org/10.7821/naer.2023.7.1458

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

Stadtler, M., & Bromme, R. (2007). Dealing with multiple documents on the WWW: The role of metacognition in the formation of documents models. *International Journal of Computer-Supported Collaborative Learning*, *2*(2), 191–210.

Stadtler, M., Scharrer, L., & Bromme, R. (2020). How relevance affects understanding of conflicts between multiple documents: An eye-tracking study. *Reading Research Quarterly*, *55*(4), 625–641.

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* (pp. 67–95). Springer.

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The digital competence framework for citizens – With new examples of knowledge, skills and attitudes* (EUR 31006 EN). Publications Office of the European Union. https://doi:10.2760/115376

Wineburg, S., McGrew, S., Breakstone, J., & Ortega, T. (2016). *Evaluating information: The cornerstone of civic online reasoning*. Stanford Digital Repository.

Wineburg, S., Breakstone, J., McGrew, S., Smith, M. D., & Ortega, T. (2022). Lateral reading on the open Internet: A district-wide field study in high school government classes. *Journal of Educational Psychology, 114*(5), 893–909. https://doi.org/10.1037/edu0000740

Yamamoto, Y. (2024). Suggestive answers strategy in human-chatbot interaction: a route to engaged critical decision making. *Frontiers in Psychology*, *15*, 1382234. https://doi.org/10.3389/fpsyg.2024.1382234

Zhang, C., & Magerko, B. (2025). Generative AI Literacy: A Comprehensive Framework for Literacy and Responsible Use. *ArXiv*, abs/2504.19038. https://doi.org/10.48550/arXiv.2504.19038.

Zlatkin-Troitschanskaia, O., Shavelson, R. J., Schmidt, S., & Beck, K. (2019). On the complementarity of holistic and analytic approaches to performance assessment scoring. *British Journal of Educational Psychology*, *89*(3), 468–484.

Zlatkin-Troitschanskaia, O., Hartig, J., & Goldhammer, F. (2021a). Progressions in learning in the age of (mis)information (PLATO) – advances in Higher education Learning research. *Studies in Higher Education.* doi: 10.1080/03075079.2021.1953338

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*, doi: 10.1080/03075079.2021.1953336