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The relation between critical online reasoning skills of first-semester university students and their epistemological beliefs

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Abstract The ability to competently research and critically evaluate online information is essential for students, yet many struggle to identify reliable sources. Prior research has identified links between students' Epistemological Beliefs (EBs) and their engagement with critical thinking, as well as their ability to evaluate arguments and information. This study examines the relation of EBs, students' self-reported critical online reasoning (COR) skills, and domain-specific Internet-specific EBs during online search. We conducted an online survey of first-year students ($N=1939$) of economics, medicine, sociology, and physics at eight German universities at the beginning of the winter term 2023/2024. Our multi-group regression analysis revealed that EBs predict COR skills and Internet-specific EBs across all the domains analyzed. Further analysis identified domain-specific differences in the

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interplay between the EBs and COR skills, which have far-reaching implications for further research and practice.

Keywords Critical online reasoning · Epistemological beliefs · Higher education

Zusammenhänge zwischen kritischem Online-Denken von StudienanfängerInnen in Deutschland und ihren epistemologischen Überzeugungen

Zusammenfassung Die Fähigkeit, Online-Informationen kompetent zu recherchieren und kritisch zu hinterfragen, ist für Studierende unerlässlich. Mehrere Studien zeigen Zusammenhänge zwischen den epistemologischen Überzeugungen (EÜs) von Studierenden und ihren Fähigkeiten des kritischen Denkens und Argumentierens sowie kritischer Bewertung von Informationen. Diese Studie untersucht den Zusammenhang von EÜs, selbstberichteten Fähigkeiten der Studierenden zum kritischen Online-Denken (COR) sowie fachspezifischen Überzeugungen bei der Internet-Recherche in einer Online-Umfrage unter $N = 1939$ Studienanfängern der Fächer Ökonomie, Medizin, Soziologie und Physik an acht Universitäten zu Beginn des Wintersemesters 2023/2024. Eine Multigruppen-Regressionsanalyse ergab, dass die EÜs die COR Fähigkeiten und Überzeugungen zum Internet in allen vier Domänen vorhersagen. Weitere Analysen ergaben domänenspezifische Unterschiede beim Zusammenspiel zwischen den EÜs und kritischem Online-Denken, die weitreichende Implikationen für weitere Forschung und Praxis haben.

Schlüsselwörter Kritisches Online-Denken · Epistemologische Überzeugungen · Hochschulbildung

1 Introduction

The ever-increasing digitalization and pervasive accessibility to information on the Internet have significantly transformed how we acquire knowledge, making it an indispensable aspect of everyday life (Grothaus et al. 2021). Using online information effectively and appropriately has become a crucial 21st century skill (Osborne et al. 2022). Students who use the Internet daily for personal and educational purposes must be able to competently research and evaluate online information and discern its credibility and accuracy, to ensure academic success (McGrew et al. 2018; Weber et al. 2018).

Despite the (sometimes fiercely debated) claim that the current generation of students are ‘digital natives’, i.e. having grown up with digital technologies, research indicates that it is erroneous to assume that they are inherently proficient in using the Internet as a source for information for self-directed learning (McGrew et al. 2019; Wineburg et al. 2018). They frequently lack the required skills to identify credible information online and critically evaluate its content. Furthermore, their capacity for critical reflection in online research appears to be limited, as habitual research

practices and excessive reliance on non-objective criteria such as popular search engines may lead to an unreflective consumption of information that encourages passive use rather than critical enquiry (Bhatt and MacKenzie 2019; Breakstone et al. 2021).

When critically evaluating and selecting online information, Epistemological Beliefs (EBs)—which include one's assumptions about the nature of knowledge and the process of knowledge acquisition—are relevant dispositions, as they constitute a component of critical thinking and influence one's approach to evaluating information (Hofer and Pintrich 1997; Klopp and Stark 2016). Students' beliefs about knowledge are a significant predictor of their willingness to engage in critical thinking and evaluate arguments (Mason et al. 2010a, b; Zlatkin-Troitschanskaia et al. 2020). Different dimensions of EBs can positively or negatively affect the appropriate processing of online information and critical thinking skills (Bråten and Strømsø 2006; Kammerer et al. 2021; Küçükaydın et al. 2023; Rott 2021). At the same time, there is a still open question in current research as to whether general EBs are prerequisites for students' acquisition of critical thinking (Hyytinen et al. 2014) and reasoning skills (Rosman et al. 2018), especially in online contexts, or whether appropriate EBs are an outcome of adept reasoning skills (Hotulainen and Telivuo 2014; Kerwer and Rosman 2020).

Berndt et al. (2021) reported the significance of EBs for scientific reasoning and argumentation skills including evidence evaluation. This effect differed between the study domains of economics, medicine and sociology. While the relationships between the Critical Online Reasoning (COR) skills, which comprise the ability to search for, critically evaluate, and reason with online information (Molero et al. 2020), the general EBs (Klopp et al. 2023) and Internet-specific EBs, which play an important role in online academic information searching (Chiu et al. 2013), have already been investigated in graduates in the domains of economics and medicine (Nagel et al. 2024), there is no insight into the interplay of these skills in students at the beginning of their studies in these domains. Our study addresses this research desideratum and investigates to what extent general EBs predict both Internet-specific EBs and students' COR skills. This is achieved by means of a multiple regression model, testing whether general EBs directly (and indirectly via Internet-specific EBs) predict COR skills from the beginning of their studies and whether such effect may vary across four major study domains of economics, sociology, medicine, and physics (Bråten and Strømsø 2005; Hendriks et al. 2020; Klopp and Stark 2022a).

As prior research indicates, EBs may serve as reference points for COR process, e.g., when students decide to start or refine an online search, to critically evaluate found information, or to use these information to answer a question at hand (Molero et al. 2020). The findings on the significance of the role that EBs play in shaping (freshman) students' skills in learning with online information, as well as possible differences between study domains, are necessary to better understand the development of these skills during the course of study and thus to be able to effectively promote them in educational practice (Osborne et al. 2022).

2 Theoretical background and research questions

COR comprises the essential skills for effective online learning, including critical thinking, problem-solving, and making proficient use of online information (Molerov et al. 2020). COR is strongly based on process and phase models of online information use (Brand-Gruwel et al. 2009; Huang et al. 2019; Walraven et al. 2009; Whitelock-Wainwright et al. 2020). These models are supplemented with research on web credibility (Fogg et al. 2003; Metzger 2007), multiple source use and multiple document comprehension (Braasch and Bråten 2017; Braasch et al. 2018) and expanded to include a critical thinking component (Fischer et al. 2014; Walton 2006) in modeling students' information use in self-directed learning (Oser and Biedermann 2019). The COR construct encompasses four skill facets (Molerov et al. 2020):

- Online Information Acquisition (OIA), which involves effective use of search engines and finding trustworthy sources;
- Critical Information Evaluation (CIE), which necessitates the ability to discern reliable and unreliable sources, information, and arguments;
- Reasoning using Evidence, Argumentation, and Synthesis (REAS); and
- Meta-cognitive Activation (MCA), which regulates the COR process.

Based on prior research with graduates (Nagel et al. 2024), Internet-specific EBs were also included in our study when investigating the relation between EBs and COR skills. Given that the information of different quality is presented online and is usually not (didactically) prepared for learning, students must make a specific effort to evaluate the relevance and accuracy of the information (compared to traditional learning materials) (Bråten 2008; Bråten et al. 2005). During this process, EBs have been shown to influence students' planning and engagement with information, as well as their metacognitive regulation and monitoring (Schommer-Aikins and Hutter 2002). These factors are critical in distinguishing effective and successful learners (Cho et al. 2017; Zimmerman 2002). Mason et al. (2010a, 2011) have also demonstrated that EBs are context-dependent, including those that are specific to the Internet, as outlined in the Theory of Integrated Domains in Epistemology (TIDE) (Muis et al. 2006). To capture the Internet-specific EBs, Chiu et al. (2013) developed a corresponding scale based on Hofer and Pintrich's (1997) 4-dimensional model:

- *Justification for Internet-based knowledge* describes skills and beliefs regarding Internet search behavior and information evaluation.
- *Source of Internet-based knowledge* describes the belief that there are various sources of reliable quality on the Internet.
- *Simplicity of Internet-based knowledge* describes the belief that the Internet provides information that is easy to understand and specific.
- *Certainty of Internet-based knowledge* describes the belief that the Internet provides accurate expert statements that alleviate difficulties and offer correct answers for subject-related topics.

In this study, we utilized the students' self-evaluation of their COR skills and Internet-specific EBs to establish an initial baseline. These self-perceptions are crucial

in shaping search behavior and the readiness to engage with in-depth online research (Paulhus and Vazire 2007; Zhou 2014; Zlatkin-Troitschanskaia et al. 2021).

This paper employs the definition of EBs as individual assumptions about the validity of claims or knowledge and the processes of knowledge acquisition (Hofer and Pintrich 1997; Klopp et al. 2023). The particular focus lies on the justification approach to EBs (Klopp and Stark 2016). In this approach, EBs describe individual assumptions about the sources of knowledge, e.g., authority or direct experience, assumptions about the criteria for justifying the validity of knowledge claims (Pieschl and Sivyer 2021; Schommer 1990), and assumptions about the nature of knowledge, e.g., whether it is certain or evolving. A framework to measure general EBs comes from Klopp et al. (2023), and consists of the following six dimensions:

- *Personal Justification* (Greene et al. 2010) describes the belief that scientific knowledge consists merely of the personal opinion of scientists and also entails the belief that scientific authorities disseminate their own opinion as a scientific fact.
- *Justification by Authority* describes the tendency to trust scientific authorities like scientists or other sources like textbooks. It also entails the tendency to trust knowledge claims that originate from a specific scientific source, e.g., a particular scientist or scientific domain.
- *Justification by Multiple Sources* describes the belief that there must be multiple sources to corroborate a knowledge claim, like a scientific theory, and that it is necessary to check multiple sources in the verification process of a knowledge claim.
- *Justification by the Scientific Community* refers to the belief that the scientific community must recognize a scientific theory to count as valid knowledge. These beliefs refer to the nature of knowledge, in particular, the conditions that must hold for valid scientific knowledge.
- The following two kinds of beliefs target the process of knowledge acquisition: *Certainty of Knowledge* concerns the belief that scientists can reach the final truth and that knowledge may hold forever, whereas
- *Reflexive Nature of Knowledge* refers to the belief that knowledge may be revised depending on new insights and that new experiences may alter the current knowledge base.

EBs can influence cognitive processes, learning strategies, and research behavior, and they play a crucial role in how individuals interpret, evaluate, and integrate information (Feinkohl et al. 2016). For instance, EBs can affect how the trustworthiness of sources is assessed and how individuals distinguish between reliable and unreliable information and arguments (Zlatkin-Troitschanskaia et al. 2020). They can also influence how individuals perceive the availability, comprehensibility, and accuracy of knowledge found on the Internet (Barzilai and Zohar 2012).

Recent studies (Binali et al. 2021; Bråten et al. 2016) emphasize that online environments, characterized by information abundance, require strong skills in critical evaluation and selection. However, the specific cognitive processes involved in solving ambiguous information problems in online environments remain insufficiently understood (Goldman and Brand-Gruwel 2018). While recent studies have advanced

our understanding of metacognitive accuracy in online reasoning (Dunn et al. 2021) and highlighted the role of EBs in evaluating digital information (Bråten et al. 2016; Kiili et al. 2022), a comprehensive investigation into how these underlying beliefs predict students' competencies in COR and Internet-specific EBs is still lacking. Against this research background, our first research question (RQ) is:

RQ1 Which dimensions of EBs are relevant predictors of students' (self-rated) COR skills? (RQ1a) and for students' Internet-specific EBs? (RQ1b)?

The TIDE framework proposed that EBs vary in their degree of domain-specificity (Muis et al. 2006) and thus can be examined from both general and domain-specific perspectives (Buehl and Alexander 2001; Hofer 2006). According to Muis et al. (2006), general EBs are shaped early in life through diverse, non-academic experiences, whereas domain-specific EBs develop later within academic contexts and disciplinary socialization. In line with the TIDE framework, and given that our participants are first-semester students it can be assumed that they have not yet developed robust domain-specific EBs (Buehl et al. 2002; Owen 2011).

Since general EBs serve as a foundation for more context-dependent beliefs (Buehl and Alexander 2005), these beliefs about cross-domain scientific knowledge represent the starting point of our investigation. By examining the predictive power of general EBs—which tend to be relatively stable (Sandoval 2014)—for both COR skills and Internet-specific EBs, we aim to understand the extent to which underlying beliefs predict behavior and reasoning in online settings.

Previous research has identified associations between students' EBs and their critical thinking during information searches (Dandotkar et al. 2022; Huang 2020; Rott 2021; Zlatkin-Troitschanskaia et al. 2020). There is also evidence that EBs influence students' problem-solving skills (Shin and Song 2016). Among trainee teachers (Küçükaydın and Ayaz 2024) and students of science and mathematics (Yang et al. 2019), EBs were significant predictors of scientific reasoning. In studies with students from the humanities and social sciences, relationships between EBs and critical thinking skills were similarly observed (Chan et al. 2011; Feinkohl et al. 2016; Mansouri and Hamzaoui 2023). Additionally, students from a range of disciplines including the humanities, social sciences, and natural and applied sciences have been shown to differ in how EBs influence their search strategies, evaluation of information, and recognition of authoritative sources (Whitmire 2003, 2004). In studies with students from medicine, social science, and economics, specific dimensions of EBs also predicted scientific thinking and reasoning, particularly regarding the evaluation of evidence (Berndt et al. 2021).

Given that our sample consists of first-semester students who have not yet undergone extensive academic training in their respective disciplines, we expect only minor differences in the predictive role of EBs across the four domains (economics, medicine, sociology, physics). Nonetheless, as the domain-specific nature of EBs and their interaction, especially in the context of online information processing, has not yet been sufficiently examined (Hofer 2006), our second research question is:

RQ2 Are there domain-specific differences in the role of EBs as predictors for (self-rated) COR skills (RQ2a) and Internet-specific EBs (RQ2b)?

Our study investigates freshman students' COR skills, EBs and Internet-specific EBs in the domains of medicine, economics, sociology, and physics. The selection of these four domains is firstly in accordance with previous research (Berndt et al. 2021; Nagel et al. 2024), that indicates that students in these domains differ in their attitudes, beliefs, learning strategies and in their approach to COR. Secondly, this selection ensures a broad representation of different types of higher education programs and student populations. These disciplines encompass a sizable and heterogeneous student body, characterized by a wide spectrum of educational backgrounds and learning prerequisites. Thirdly, these programs embody distinctly different archetypes of academic pursuits. For instance, in medicine, students focus on the acquisition of practice-oriented knowledge to diagnose and treat immediate problems in specific patient encounters. In contrast, economic and sociology students often solve problems with broader systemic implications, that involves more abstract theoretical thinking.

3 Methods

3.1 Study design and instruments

The data presented in this article were obtained from the initial survey of first-year students conducted at the beginning of the winter semester (2023/24). The 15-minute survey was advertised to students in the introductory courses in various German universities and was made available via the online survey tool Unipark. Participants were able to complete the survey either on-site or later. Participation was voluntary, and a monetary incentive was provided.

Two scales were utilized to measure the dependent variables: To assess COR skills, the scale developed and tested in previous studies (Kohmer et al. 2025; Nagel et al. 2024) was used here: students were asked to evaluate their abilities in Internet research in comparison to the skills of other Internet users on a school grading scale, ranging from 1 (indicating very good proficiency) to 5 (indicating very poor proficiency). The COR facets (see Sect. 2) were assessed using five single-item indicators: The OIA facet was represented by the capacity to utilize search engines to identify dependable sources of information (*Acquisition of Online Information*). The CIE facet was assessed using two indicators: The ability to distinguish between reliable and non-reliable *sources* (*Critical Evaluation of Sources*) and the ability to distinguish reliable from non-reliable *information* (*Critical Evaluation of Information*). The fourth indicator, *Critical Identification of Arguments*, which assesses the ability to distinguish fact-based arguments from assertions, represents the REAS facet of the COR construct. For example, this item (English translation) reads: "Please rate your ability, compared to other Internet users, on a school grading scale from 1 [very good] to 5 [very poor]: the ability to reliably distinguish fact-based arguments from claims (such as opinions)." Since the introduction of the COR construct, the online information landscape has undergone a significant transformation, and generative AI systems have become indispensable (Abbas et al. 2024). Thus, the ability to work effectively with ChatGPT or comparable generative AI systems (*Informative Use*

Generative AI), has been incorporated as a novel specification of the COR concept (Federiakin et al. 2024).

The Internet-specific EB scale originally developed by Chiu et al. (2013) was adapted and translated into German to precisely capture beliefs about knowledge and skills in the context of subject-related online information search and evaluation. This scale with high action and self-reference encompasses four 3-item scales (see Sect. 2). Its selection was predicated on its direct address of the perception of online information, incorporating availability, comprehensibility, and correctness, which are closely associated with the emphasis on COR process. Participants were asked to indicate the extent to which each of the items applied to them on a scale of 1 (does not apply at all) to 4 (fully applies). For instance, one item from the *Justification for Internet-based knowledge* subscale (our translation) reads as follows: “When I search the Internet for discipline-specific information, I compare information from various sources to evaluate the trustworthiness of what I find online.” The scales included in our study and the corresponding Cronbach’s α coefficients based on our sample are: *Justification for Internet-based knowledge*: $\alpha=0.63$, *Source of Internet-based knowledge*: $\alpha=0.69$, *Simplicity of Internet-based knowledge*: $\alpha=0.69$ and *Certainty of Internet-based knowledge*: $\alpha=0.62$.

The independent variable of general EBs according to the framework presented above (see Sect. 2) was measured with a particular focus on beliefs about cross-domain scientific knowledge in the six dimensions with 3-item scales by Klopp et al. (2023) on a 6-point Likert scale. Participants completed the scales by reading statements about scientific knowledge and indicating their level of agreement using response options ranging from “strongly disagree” (1) to “strongly agree” (6). For example, one item from the *Reflexive Nature of Knowledge* subscale reads: “The evaluation of knowledge changes with new findings.” The internal consistency of the scales, measured by Cronbach’s α based on our sample, is as follows: *Personal Justification*: $\alpha=0.81$, *Justification by Authority*: $\alpha=0.75$, *Justification by Multiple Sources*: $\alpha=0.75$, *Justification by the Scientific Community*: $\alpha=0.60$, *Certainty of Knowledge*: $\alpha=0.75$, and *Reflexive Nature of Knowledge*: $\alpha=0.83$.

3.2 Sample

Of the original 2165 students surveyed in the first term, all cases with missing values in the dependent and independent variables were excluded, resulting in a total of 1939 participants (881 female 13 non-binary) with a mean age of 19.91 years ($SD=2.42$) included in the following analyses. The students were distributed across four academic domains: 820 in economics, 405 in sociology, 514 in medicine, and 200 in physics. The mean grade of the university entrance qualification varied by domain, with economics students having a mean grade of 1.94 ($SD=0.58$), sociology students 2.11 ($SD=0.60$), medicine students 1.39 ($SD=0.47$), and physics students 1.78 ($SD=0.66$). Lower grades in the German university entrance qualification (‘Abitur’), typically indicate a higher overall academic performance, with 1 being the best and 4 being the lowest grade possible.

3.3 Statistical analysis

To analyze the predictive power of EBs on COR skills and Internet-specific EBs (RQ1a and b), we used a multivariate regression approach implemented in a multiple-group structural equation model, in which a group represents one of the four domains. The model's predictors were the six EB dimensions; COR skills and Internet-specific EBs were dependent variables. We start by investigating the full sample, i.e., all domains together. Afterward, we use the multiple-group regression model to investigate the predictor of COR skills and Internet-specific EBs in each group. Because some variables had non-normal distributions, we used the MLM estimator (Finney and DiStefano 2013), which provides classic robust standard errors.

To compare the regression coefficients between the groups (RQ2a and b), we used the Wald test with the following strategy: First, we conducted a Wald test to test the equality of the regression coefficients for a certain combination of independent and dependent variables over all domains. Second, we tested the equality of the regression coefficients for a certain combination of independent and dependent variables between two domains for all possible pairwise combinations.

All calculations were done in R (version 4.0.2; R Core team 2020) using the packages lavaan (version 0.6-17; Rosseel 2012) and ltm (version 1.2-0; Rizopoulos 2006).

4 Results

In this section, we report the findings for each research question (RQ) separately. We begin with the results related to COR skills, addressing RQ1a followed by RQ2a. Then, we report the results on Internet-specific EBs, addressing RQ1b and RQ2b. For RQ1a and RQ1b, we first present the regression model for the full sample, i.e., across all domains, followed by the regression results for each domain.

4.1 Predictive power of EBs for COR skills (RQ1a)

The regression results for the full sample (see Table A.1) indicate that beliefs in *Personal Justification* and *Justification by the Scientific Community* predict *Critical Evaluation of Sources*. Furthermore, *Personal Justification* and *Justification by Authority* predict *Critical Evaluation of Information* and *Critical Identification of Arguments*. Finally, *Reflexive Nature of Knowledge* predicts *Informative Use Generative AI*. Overall, however, the explained variance is low, likely due to the single-item measurement of the COR skills. An exception is *Informative Use Generative AI*, which shows approximately 10% of the explained variance, with *Reflexive Nature of Knowledge* as the sole significant predictor.

A more differentiated picture emerges in the domain-specific regressions (see Tables A.2 and 1). *Personal Justification* strongly predicts *Critical Identification of Arguments* in sociology, *Critical Evaluation of Sources* in medicine and physics, and *Informative Use Generative AI* in physics. Similarly, *Justification by Authority* predicts *Critical Evaluation of Information* in economics, strongly predicts *Acquisition*

Table 1 Overview of significant predictions of COR skills by EBs.

	Whole sample	Economics	Sociology	Medicine	Physics
AOI	–	–	JA++	–	–
CES	PJ+ JC–	–	JC—	PJ++ JA++	PJ++ JS—
CEI	PJ+ JA+	JA+	–	–	–
CIA	PJ+ JA+	–	PJ++	JA++	–
IUG	RN++	–	–	RN++	PJ++ RN++

EBs: *PJ* Personal Justification, *JA* Justification by Authority, *JS* Justification by Multiple Sources, *JC* Justification by the Scientific Community, *CK* Certainty of Knowledge, *RN* Reflexive Nature of Knowledge; COR skills: *AOI* Acquisition of Online Information, *CES* Critical Evaluation of Sources, *CEI* Critical Evaluation of Information, *CIA* Critical Identification of Arguments, *IUG* Informative Use Generative AI. Note: “++” indicates an effect size greater than 0.1.

of *Online Information* in sociology and *Critical Evaluation of Sources* and *Critical Identification of Arguments* in medicine. In contrast, *Justification by Multiple Sources* is a strong negative predictor of *Critical Evaluation of Sources* in physics, and *Justification by the Scientific Community* negatively predicts the same outcome in sociology. *Reflexive Nature of Knowledge* strongly predicts *Informative Use Generative AI* in both medicine and physics. For the explained variance in each domain, we see the same picture as for the full sample.

4.2 Domain differences in predictors of COR skills (RQ2a)

The overall Wald test indicates significant domain differences in the regression of *Informative Use Generative AI* on *Personal Justification*, particularly between economics, sociology, medicine, and physics. The pairwise Wald tests support these findings and reveal additional domain differences in the prediction of *Critical Evaluation of Sources* (see Table A.3). Specifically, *Personal Justification* predicts *Critical Evaluation of Sources* in physics, but not in economics. *Justification by Authority* is a significant predictor in medicine but not economics and sociology. *Justification by Multiple Sources* is a significant predictor in physics, but not in the other domains. *Reflexive Nature of Knowledge* showed significantly different coefficients for *Critical Evaluation of Sources* between economics and medicine or physics, but it was not a significant predictor in either domain. Finally, for *Informative Use Generative AI*, differences in the predictive power of *Justification by Authority* (between economics and medicine) and *Justification by Multiple Sources* (between sociology and physics) were also observed. However, these predictors were not significant.

4.3 Predictors of internet-specific EBs (RQ1b)

For the full sample (see Table A.1), beliefs in *Personal Justification* negatively predict *Justification of Internet-based Knowledge* and *Sources of Internet-based Knowledge*. *Justification by Authority* predicts *Certainty of Internet-based Knowledge*,

Table 2 Overview of significant predictions of Internet-specific EBs by EBs.

	Whole sample	Economics	Sociology	Medicine	Physics
JIK	PJ– JS++ CK+ RN+	JS++	JS++	JS+ RN+	JS+ RN++
SOK	PJ– RN+	RN+	–	RN++	–
SIK	JS+ CK+ RN+	CK+ RN+	JS++	RN++	–
CIK	JA+ JS+ CK+ RN+	JS+ CK+	JA+	JS+ RN++	–

EBs: *PJ* Personal Justification, *JA* Justification by Authority, *JS* Justification by Multiple Sources, *JC* Justification by the Scientific Community, *CK* Certainty of Knowledge, *RN* Reflexive Nature of Knowledge; Internet-specific EBs: *JIK* Justification of Internet-based Knowledge, *SOK* Sources of Internet-based Knowledge, *SIK* Simplicity of Internet-based Knowledge, *CIK* Certainty of Internet-based Knowledge. Note: “++” indicates an effect size greater than 0.1.

while *Justification by Multiple Sources* predicts *Justification*, *Simplicity*, and *Certainty of Internet-based Knowledge*. *Certainty of Knowledge* is a predictor of all three aforementioned dimensions. *Reflexive Nature of Knowledge* significantly predicts all Internet-specific EB dimensions. The highest explained variance of about 30% is observed for *Justification of Internet-based Knowledge*, and around 10% for other dimensions.

Domain-specific analyses provide a more detailed picture (see Table A.2, for an overview, Table 2). Notably, *Justification by Authority* is a significant predictor of *Certainty of Internet-based Knowledge* only in sociology. *Justification by Multiple Sources* predicts *Justification of Internet-based Knowledge* in all domains, *Simplicity* in sociology, and *Certainty* in economics and medicine. In economics, *Certainty of Knowledge* predicts both *Simplicity* and *Certainty of Internet-based Knowledge*, and *Reflexive Nature of Knowledge* predicts *Sources* and *Certainty*. In medicine, *Reflexive Nature of Knowledge* predicts all Internet-specific EB dimensions; in physics, it only predicts *Justification of Internet-based Knowledge*.

With respect to explained variance, *Justification of Internet-based Knowledge* shows lower variance in medicine (about 23%) and much higher variance at about 47% in physics compared to the full sample. *Sources of Internet-based Knowledge* shows slightly higher variance at about 15% in economics and similar levels in other domains. *Simplicity* and *Certainty of Internet-based Knowledge* show slightly higher variance in economics and sociology, while medicine and physics mirror the full sample.

4.4 Domain differences in predictors of internet-specific EBs (RQ2b)

The overall Wald test indicates significant differences between the domains in the regression of *Sources of Internet-based Knowledge* on *Reflexive Nature of Knowl-*

edge. The pairwise tests (see Table A.3) show that this EB dimension is a significant predictor in economics and medicine, but not in sociology and physics. The overall Wald test also indicates domain-specific differences in the regression of *Simplicity of Internet-based Knowledge* on *Justification by Multiple Sources*. The pairwise comparisons show that this EB dimension significantly predicts *Simplicity of Internet-based Knowledge* only in sociology.

Additional pairwise Wald tests indicate differences in the regression of *Justification of Internet-based Knowledge* on *Justification by Multiple Sources* between sociology and medicine. Both regression coefficients are significant, indicating different predictive strengths. Significant differences were also observed in the regression of *Certainty of Internet-based Knowledge* on *Reflexive Nature of Knowledge* between medicine and physics, with significance only in medicine but not physics. The additional correlation tables for the full sample and all domains can be found in the appendix (see Tables A.4, A.5, A.6, A.7 and A.8).

5 Conclusion

5.1 Discussion

The objective of RQ1a was to determine which dimensions of general EBs are relevant predictors of self-reported COR skills in the full sample. The findings of the cross-domain evaluation indicate a link between four dimensions of EBs and four distinct facets of COR skills. Remarkably, there are no relations between the EB dimensions *Certainty of Knowledge* and *Justification by Multiple Sources* and the COR skills. For instance, the results suggest that students who tend to believe that scientists only express personal opinions and not objective facts (*Personal Justification*) rate their own ability to distinguish reliable from unreliable sources, information and arguments lower. This is in line with Berndt et al. (2021), where *Personal Justification* negatively predicts evidence evaluation and conclusion drawing. Students who see no difference between scientific evidence and personal opinion may find no basis for judging reliability (Bromme and Gierth 2021) or have no need to critically evaluate as they deem critical thinking to be pointless in that circumstance (Greene et al. 2018): “all assertions are opinions, knowledge is uncertain, and thus critical thinking is useless” (p. 1085).

Such generalized distrust of scientists may, paradoxically, undermine students’ self-efficacy in deciding what is credible. First-semester students can be seen as novices as they are in the early stages of acquiring the conventions and practices of academic disciplines (Greene et al. 2018), i.e., they may not have learned about scientific inquiry or peer review (Klopp and Stark 2016). Without this knowledge, they might think it’s impossible to discern reliable from unreliable science, and so they might underestimate their ability to distinguish trustworthy sources, information, and arguments. Engagement with scientific consensus-building processes and peer review procedures during their study period is therefore of significant relevance to strengthen trust in science and at the same time to promote the utilization of critical evaluation skills (Osborne et al. 2022).

Our analysis revealed no significant relations in the EBs related to the competent use of search engines for identifying reliable sources. One potential explanation might be that the students perceive their *Acquisition of Online Information* skills as purely technical, highly routinized action, failing to recognize the role of EBs such as the evaluation of source quality when searching and navigating online, as observed by Huang (2020) or Whitmire (2003).

RQ1b explored which dimensions of general EBs are relevant predictors of students' Internet-specific EBs in the full sample. The cross-domain analysis shows that five dimensions of general EBs serve as predictors of the four dimensions of Internet-specific EBs. There were no correlations between the EB dimension *Justification by the Scientific Community* and the Internet-specific EBs.

Our results indicate that the more sophisticated general EBs (Schommer 1990) as the awareness that knowledge is evolving (*Reflexive Nature of Knowledge*) and appreciation of various sources (*Justification by Multiple Sources*) are positively related to three or four Internet-specific EB dimensions. This finding is in line with prior research regarding critical evaluation of texts (Feinkohl et al. 2016), critical thinking (Muis et al. 2021) and online search behavior (Ulyshen et al. 2015). Therefore, such beliefs can motivate students to continually seek out new information and integrate it into their existing knowledge base. It can also encourage students to prioritize the credibility of sources and the diversity of perspectives.

Despite the fact that the belief in *Certainty of Knowledge* may initially appear to be 'naïve', this EB is shown to be a positive predictor for three of the four Internet-specific EB dimensions. Students—especially those who are novices—who adhere to this belief demonstrate higher levels of confidence in their capacity to locate comprehensible and accurate information online. This finding is also in line with previous research (Dong et al. 2014; Kammerer and Gerjets 2012).

Among the EB dimensions, *Justification by the Scientific Community* was the only one not significantly predicting any of the Internet-specific EBs for the full sample. Klopp et al. (2023) propose a potential explanation for this finding that the concept of a scientific community is not taught explicitly in schools and that students are only introduced to this concept implicitly during the initial stages of academic development. In addition, the low internal consistency may have attenuated the relation between *Justification by the Scientific Community* and Internet-specific EBs. Thus, it is unclear if the missing relation between *Justification by the Scientific Community* is caused by the aforementioned factors or is an artifact of the low internal consistency.

RQ2a and RQ2b were employed to examine the effect of EBs on COR skills and Internet-specific EBs for domain-specific differences. The discrepancies in the predictive efficacy of EB dimensions across domains indicate that the impact of these beliefs on COR skills may be domain-dependent, despite the non-specific nature of the scales and the students' entry stage in their academic careers.

Our study revealed significant differences between the four domains. Such marked differences among first-term students in the early stages of their studies were not anticipated (Buehl et al. 2002), yet the data demonstrates domain-dependency among the novices. The scales were designed to measure general EBs about scientific knowledge. However, their predictive power varied by domain, suggesting that these

general beliefs may interact with early domain-specific experiences or expectations. This indicates that general EBs of even freshman students are not completely divorced from the context of the domain in which they are applied and the observed differences may be attributable to the divergent conceptions of science that were evoked among the students in the survey (see also Klopp and Stark 2022b; Porsch and Bromme 2010). In line with the TIDE model, general EBs interact with contextual cues, that may lead even first-term students to contextualize their general EBs in domains they study—possibly influenced by prior schooling and informal learning experiences—stronger than expected (Muis et al. 2006). It is also conceivable that students with particularly distinctive EBs that have manifested during their school years may opt to pursue specific academic domains (Horrer et al. 2024).

5.2 Study limitations and further research

Regarding RQ1, the partially low variance explanation suggests that general EBs may be related to COR skills, but other factors such as information processing style (Schemer et al. 2008) also play a prominent role (Schmidt et al. 2020). Single-item measurement may only capture the variability of students' COR skills to a limited extent, however, the relatively high variance explanation of over 10% in some cases for single items is noteworthy. General EBs as independent variables may not fully align with the relatively narrowly measured facets of the COR skills, potentially contributing to the partially low variance in explanations. The relatively low variance explained by the general EBs indicates that the Internet-specific EBs, as context-specific EBs, are a different cognitive disposition than general EBs. This finding underlines the importance of measuring and promoting both the general and context-specific EBs in education and learning.

An additional significant limitation is that all constructs are based on self-reported data. Discrepancies between reported and observed behavior have already been documented in the context of EBs and COR skills (Limón 2006; Nagel et al. 2024). Thus, further research is needed to investigate the extent to which the results of this research can be replicated when COR skills are assessed using objective measures (e.g., recording students' actual processing of information problems on the Internet; Nagel et al. 2024). This can help determine other key metrics, including search strategy, navigating between results, and queries (Nagel et al. 2020; Schmidt et al. 2020).

Moreover, the study's choice of EBs as antecedents of COR skills and Internet-specific EBs was theoretically motivated (see Sect. 1) and implied using a regression analysis. As the study's design is cross-sectional, a definitive answer cannot be given whether EBs causally affect COR skills and Internet-specific EBs. To investigate this question on the causal effects of EBs, a longitudinal and/or experimental study design is needed.

Regarding RQ2, to investigate whether the EBs predictors vary across the domains, the results suggest that certain dimensions of the EBs can serve as indicators of COR skills and Internet-specific EBs, with notable differences across the domains. In the context of the TIDE framework it should be investigated to what extent domain-specific differences in effects of general EBs remain stable or are

revised over the course of studies in the domains. Insights into the development of general and context-specific EBs and their relation to COR skills over time may shed light onto the still pressing research question whether EBs drive successful reasoning processes in online contexts (as emphasized in some theories on critical thinking development; Greene and Yu 2016) or are the results of adept reasoning skills (in the age of misinformation; see Osborne et al. 2022).

5.3 Implications

Despite these limitations, this study, which is based on a large student sample from the four major study domains, provides evidence on the still under-researched relationship between general EBs, Internet-specific EBs and critical reasoning skills in online learning contexts. Moreover, this study obtained insight on the baseline of these crucial cognitive dispositions and (self-rated) behaviors of the beginning students in higher education and the differences in these construct relations between different domains. In this respect, the results of this study, in particular on the domain-specificity vs. generality of these dispositions and their relations are not only relevant for further development of such established theoretical frameworks like the TIDE model, but also crucial for fostering of such student learning dispositions in educational practice.

While the overall results on the relationships between the EBs and COR skills indicate similar patterns to those found in previous research on the relationships with critical thinking and related constructs such as argumentative skills (Berndt et al. 2021; Muis et al. 2021), firstly, new insights were identified with regard to the relationship to the specific facets of COR such as searching, evaluating, and selecting information in online settings. Secondly, domain-specific differences were revealed that may be attributed to the quite various learning contexts in online settings, such as the specifics of online research in the domains. For example, while professional databases such as Amboss and PubMed have been established in medical studies, such curated platforms do not exist in economics, so that the vast majority of economic students use general search engines such as Google to search for learning information (Nagel et al. 2024). This implies that COR skills should be specifically promoted in domains where there are no such specialized platforms. Thirdly, the finding that such differences are already evident at the beginning of the academic study is also a new insight that has far-reaching practical implications, namely that the promotion of these dispositions should start at the very beginning in higher educational practice.

Overall, the presented findings collectively indicate the necessity of theory-integrative conceptualizing COR, Internet-specific and general EBs as multi-layered, deeply woven constructs how students process information and how they view knowledge in online learning settings today, and for which both the specific study context and domain must be considered when promoting them. This theoretical understanding is the necessary basis for fostering the development of these dispositions in higher education. For instance, the promotion of sophisticated general as well as Internet-specific EBs at the beginning of academic studies, may help students to evaluate online information critically and select high-quality sources for

their learning. The revealed relations indicate that these dispositions need to be fostered explicitly and in conjunction to each other. Prior intervention studies have also demonstrated that students who received explicit instruction on both critical thinking (Tiruneh et al. 2016) and EBs (Rosman et al. 2018) exhibited improvements in all assessments, indicating a positive synergy.

6 Appendix

Table A.1 Regression for the whole sample.

AOI	CES			CEI			CIA			IUG			JIK			SOK			SIK			CIK					
	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p			
PJ	0.028	0.025	0.269	0.056	0.025	0.024	0.054	0.024	0.024	0.079	0.025	0.001	-0.012	0.030	0.700	-0.033	0.012	0.005	-0.026	0.013	0.050	-0.006	0.014	0.666	-0.017	0.013	0.198
JA	0.042	0.026	0.113	0.035	0.025	0.174	0.082	0.025	0.001	0.079	0.026	0.002	-0.002	0.033	0.943	0.008	0.014	0.548	0.026	0.015	0.078	-0.010	0.016	0.523	0.035	0.015	0.021
JS	-0.022	0.029	0.461	-0.007	0.029	0.812	-0.013	0.029	0.648	0.010	0.029	0.716	0.030	0.036	0.401	0.118	0.014	0.000	0.020	0.017	0.217	0.048	0.018	0.007	0.050	0.016	0.001
JC	-0.007	0.025	0.780	-0.049	0.025	0.046	-0.021	0.024	0.375	-0.009	0.024	0.725	-0.026	0.030	0.388	-0.001	0.012	0.906	0.011	0.014	0.423	0.002	0.014	0.895	-0.019	0.013	0.162
CK	-0.032	0.019	0.094	-0.025	0.020	0.215	-0.029	0.019	0.118	-0.017	0.020	0.397	0.001	0.025	0.953	0.019	0.010	0.045	0.020	0.012	0.102	0.038	0.012	0.001	0.037	0.012	0.001
RN	-0.009	0.034	0.786	-0.001	0.032	0.977	0.008	0.033	0.811	0.013	0.033	0.683	0.170	0.038	0.000	0.040	0.016	0.012	0.070	0.017	0.000	0.061	0.018	0.001	0.042	0.017	0.012
ρ^2	0.02		0.026			0.032			0.035			0.098			0.308			0.094			0.098			0.109			

EBs: PJ Personal Justification, JA Justification by Authority, JS Justification by Multiple Sources, JC Justification by the Scientific Community, CK Certainty of Knowledge, RN Reflexive Nature of Knowledge, COR skills: AOI Acquisition of Online Information, CES Critical Evaluation of Sources, CEI Critical Evaluation of Information, CIA Critical Identification of Arguments, IUG Informative Use Generative AI, Internet-specific EBs: JIK Justification of Internet-based Knowledge, SOK Sources of Internet-based Knowledge, SIK Simplicity of Internet-based Knowledge, CIK Certainty of Internet-based Knowledge

Table A.2 Regression results for each domain.

	AOI			CES			CEI			CIA			IUG			JIK			SOK			SIK			CIK			
	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p				
1	PJ	0.009	0.043	0.834	0.001	0.042	0.987	0.047	0.042	0.262	0.053	0.041	0.190	-0.016	0.044	0.710	-0.032	0.018	0.074	-0.017	0.018	0.370	-0.020	0.021	0.334	-0.017	0.020	0.400
	JA	0.031	0.041	0.445	0.016	0.039	0.675	0.093	0.039	0.017	0.038	0.041	0.348	0.072	0.047	0.129	0.005	0.020	0.800	0.043	0.023	0.062	0.008	0.021	0.717	0.023	0.021	0.278
	JS	0.005	0.048	0.923	0.019	0.046	0.686	-0.030	0.047	0.528	0.029	0.046	0.528	-0.018	0.051	0.720	0.124	0.022	0.000	0.001	0.022	0.982	0.005	0.026	0.845	0.047	0.023	0.044
	JC	0.020	0.041	0.631	-0.006	0.042	0.880	0.011	0.040	0.783	0.007	0.039	0.849	-0.010	0.048	0.832	-0.011	0.019	0.569	-0.011	0.020	0.597	-0.008	0.021	0.700	-0.026	0.021	0.217
	CK	-0.026	0.034	0.450	-0.022	0.035	0.519	-0.035	0.033	0.292	-0.046	0.036	0.198	0.029	0.040	0.458	0.018	0.017	0.286	0.039	0.020	0.056	0.051	0.020	0.012	0.044	0.019	0.017
2	RN	-0.034	0.054	0.523	-0.077	0.051	0.135	-0.027	0.051	0.596	0.033	0.051	0.523	0.104	0.054	0.054	0.025	0.024	0.308	0.090	0.024	0.000	0.083	0.027	0.002	0.028	0.025	0.264
	R^2	0.012		0.025			0.034			0.045			0.077			0.318			0.151			0.139			0.167			
	PJ	0.013	0.047	0.784	0.061	0.050	0.224	0.048	0.044	0.269	0.105	0.049	0.033	-0.093	0.067	0.163	-0.029	0.023	0.221	-0.045	0.026	0.086	0.017	0.029	0.559	-0.037	0.028	0.189
	JA	0.107	0.051	0.035	-0.055	0.051	0.279	0.060	0.048	0.215	0.081	0.050	0.104	-0.040	0.066	0.547	0.022	0.029	0.446	0.012	0.028	0.667	-0.009	0.034	0.799	0.063	0.032	0.048
	JS	-0.050	0.065	0.449	0.060	0.067	0.366	0.001	0.057	0.981	-0.015	0.061	0.800	0.149	0.076	0.052	0.162	0.029	0.000	0.012	0.031	0.699	0.140	0.036	0.000	0.036	0.030	0.227
	JC	-0.087	0.052	0.098	-0.125	0.051	0.015	-0.042	0.049	0.382	-0.049	0.049	0.313	0.041	0.061	0.499	0.001	0.024	0.957	0.039	0.029	0.180	0.027	0.032	0.396	0.019	0.027	0.478
	CK	-0.038	0.042	0.364	-0.002	0.043	0.966	-0.014	0.036	0.692	-0.016	0.040	0.686	-0.028	0.050	0.584	-0.004	0.021	0.839	0.005	0.024	0.853	0.008	0.023	0.734	0.011	0.024	0.652
	RN	-0.015	0.063	0.808	-0.003	0.065	0.962	-0.019	0.064	0.768	0.015	0.064	0.815	0.070	0.088	0.430	0.027	0.034	0.425	0.035	0.033	0.275	0.002	0.034	0.952	0.050	0.035	0.149
	R^2	0.055		0.058			0.052			0.044			0.163			0.315			0.088			0.136			0.122			

Table A.2 (Continued)

		AOI			CES			CEI			CIA			IUG			JIK			SOK			SIK			CIK		
		β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p			
3	PJ	0.061	0.048	0.201	0.118	0.048	0.013	0.032	0.046	0.484	0.062	0.048	0.202	-0.035	0.059	0.549	-0.044	0.027	0.106	-0.032	0.028	0.255	-0.010	0.029	0.733	0.018	0.028	0.514
	JA	0.047	0.051	0.355	0.141	0.050	0.005	0.070	0.054	0.195	0.134	0.052	0.010	-0.116	0.066	0.079	-0.008	0.027	0.768	0.027	0.029	0.344	-0.030	0.032	0.356	0.029	0.031	0.341
	JS	-0.054	0.053	0.302	-0.023	0.049	0.643	0.049	0.050	0.331	0.021	0.050	0.674	0.081	0.072	0.265	0.079	0.028	0.004	0.048	0.034	0.158	0.069	0.037	0.060	0.072	0.031	0.020
	JC	0.043	0.049	0.377	-0.054	0.046	0.244	-0.064	0.048	0.181	0.035	0.049	0.470	-0.027	0.058	0.641	0.016	0.024	0.521	0.027	0.028	0.338	-0.014	0.027	0.618	-0.039	0.027	0.145
4	CK	-0.058	0.037	0.113	-0.023	0.035	0.522	-0.033	0.036	0.365	-0.006	0.038	0.879	0.032	0.048	0.504	0.032	0.017	0.065	-0.010	0.023	0.652	0.010	0.022	0.648	0.033	0.021	0.124
	RN	0.028	0.076	0.717	0.088	0.061	0.148	0.103	0.068	0.129	0.037	0.067	0.587	0.206	0.084	0.014	0.074	0.036	0.040	0.136	0.037	0.000	0.123	0.040	0.002	0.106	0.035	0.002
	R ²	0.038			0.041			0.047			0.052		0.119			0.23			0.098			0.095			0.099			
	PJ	0.032	0.083	0.697	0.163	0.068	0.016	0.078	0.068	0.246	0.109	0.066	0.097	0.253	0.099	0.011	0.003	0.029	0.906	-0.009	0.049	0.852	-0.003	0.050	0.958	-0.089	0.053	0.091
	JA	-0.099	0.102	0.330	0.030	0.093	0.747	0.068	0.081	0.405	0.079	0.093	0.400	0.114	0.113	0.314	0.018	0.045	0.693	-0.050	0.054	0.348	-0.064	0.060	0.291	0.005	0.058	0.935
	JS	-0.030	0.072	0.678	-0.218	0.086	0.012	-0.052	0.089	0.560	-0.030	0.083	0.721	-0.183	0.123	0.137	0.089	0.041	0.029	0.043	0.062	0.491	0.010	0.052	0.846	0.087	0.050	0.086
	JC	-0.059	0.054	0.274	-0.021	0.062	0.730	-0.004	0.058	0.951	-0.046	0.066	0.488	-0.130	0.080	0.106	-0.003	0.026	0.916	-0.029	0.045	0.514	0.029	0.042	0.491	-0.031	0.039	0.429
	CK	0.024	0.048	0.617	-0.030	0.053	0.567	0.010	0.049	0.834	0.019	0.051	0.717	-0.062	0.070	0.379	0.016	0.025	0.513	0.010	0.033	0.774	0.033	0.033	0.314	0.025	0.033	0.463
	RN	-0.020	0.111	0.859	0.221	0.130	0.089	0.041	0.117	0.725	-0.107	0.120	0.374	0.337	0.153	0.028	0.122	0.054	0.025	-0.112	0.085	0.186	-0.025	0.077	0.746	-0.042	0.065	0.515
	R ²	0.085			0.108			0.08			0.117		0.162			0.467			0.082			0.101			0.108			

1: economics, 2: sociology, 3: medicine, 4: physics

EBs: PJ Personal Justification, JA Justification by Authority, JS Justification by Multiple Sources, JC Justification by the Scientific Community, CK Certainty of Knowledge, RN Reflexive Nature of Knowledge, COR skills: AOI Acquisition of Online Information, CES Critical Evaluation of Sources, CEI Critical Evaluation of Information, CIA Critical Identification of Arguments, IUG Informative Use Generative AI, Internet-specific EBs: JIK Justification of Internet-based Knowledge, SOK Sources of Internet-based Knowledge, SIK Simplicity of Internet-based Knowledge, CIK Certainty of Internet-based Knowledge

Table A.3 Overall and pairwise Wald tests.

	χ^2	<i>df</i>	<i>p</i>
<i>1. Step: Overall Wald tests</i>			
IUG on PJ	8.768	3	0.033
SOK on RN	9.385	3	0.025
SIK on JS	9.976	3	0.019
<i>2. Step: Pairwise Wald tests</i>			
CES on PJ between economics and physics	4.139	1	0.042
CES on JA between economics and medicine	3.857	1	0.050
CES on JA between sociology and medicine	7.460	1	0.006
CES on JS between economics and physics	5.835	1	0.016
CES on JS between sociology and physics	6.505	1	0.011
CES on JS between medicine and physics	3.889	1	0.049
CES on RN between economics and medicine	4.280	1	0.039
CES on RN between economics and physics	4.554	1	0.033
IUG on PJ between economics and physics	6.145	1	0.013
IUG on PJ between sociology and physics	8.369	1	0.004
IUG on PJ between medicine and physics	6.232	1	0.013
IUG on JA between economics and medicine	5.341	1	0.021
IUG on JS between sociology and physics	5.240	1	0.022
JIK on JS between sociology and medicine	4.262	1	0.039
SOK on RN between economics and physics	5.246	1	0.022
SOK on RN between sociology and medicine	4.123	1	0.042
SOK on RN between medicine and physics	7.176	1	0.007
SIK on JS between economics and sociology	9.132	1	0.003
SIK on JS between sociology and physics	4.141	1	0.042
SIK on RN between sociology and medicine	5.239	1	0.022
CIK on RN between medicine and physics	4.046	1	0.044

EBs: *PJ* Personal Justification, *JA* Justification by Authority, *JS* Justification by Multiple Sources, *JC* Justification by the Scientific Community, *CK* Certainty of Knowledge, *RN* Reflexive Nature of Knowledge; COR skills: *AOI* Acquisition of Online Information, *CES* Critical Evaluation of Sources, *CEI* Critical Evaluation of Information, *CIA* Critical Identification of Arguments, *IUG* Informative Use Generative AI; Internet-specific EBs: *JIK* Justification of Internet-based Knowledge, *SOK* Sources of Internet-based Knowledge, *SIK* Simplicity of Internet-based Knowledge, *CIK* Certainty of Internet-based Knowledge

Table A.4 Mean and correlation table for the whole sample.

	M	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1. PJ	2.41	1.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. JA	4.22	0.87	-0.129***	-	-	-	-	-	-	-	-	-	-	-	-	-
3. JS	4.86	0.95	-0.186***	0.067**	-	-	-	-	-	-	-	-	-	-	-	-
4. JC	3.83	0.96	0.075**	0.165***	0.179***	-	-	-	-	-	-	-	-	-	-	-
5. CK	4.24	1.14	-0.024	0.222***	0.077**	0.102***	-	-	-	-	-	-	-	-	-	-
6. RN	5.04	0.91	-0.308***	0.233***	0.543***	0.101***	0.153***	-	-	-	-	-	-	-	-	-
7. AOI	2.01	0.97	0.043	0.01	-0.058*	-0.023	-0.039	-0.054*	-	-	-	-	-	-	-	-
8. CES	2.12	0.97	0.074**	-0.005	-0.056*	-0.057*	-0.033	-0.058*	0.556***	-	-	-	-	-	-	-
9. CEI	2.11	0.95	0.072**	0.039	-0.062**	-0.027	-0.031	-0.052*	0.537***	0.565***	-	-	-	-	-	-
10. CIA	2.06	0.98	0.104***	0.032	-0.045*	-0.005	-0.016	-0.051*	0.493***	0.516***	0.528***	-	-	-	-	-
11. IUG	3.00	1.22	-0.104***	0.037	0.104***	-0.029	0.021	0.16***	0.113***	0.138***	0.113***	0.108***	-	-	-	-
12. JIK	3.09	0.56	-0.193***	0.113***	0.364***	0.091***	0.09***	0.331***	-0.134***	-0.115***	-0.134***	-0.141***	0.037	-	-	-
13. SOK	2.91	0.56	-0.084***	0.115***	0.156***	0.078**	0.09***	0.206***	-0.04	-0.049*	-0.035	-0.048*	-0.045*	0.206***	-	-
14. SIK	2.96	0.57	-0.071**	0.058*	0.187***	0.06**	0.104***	0.204***	-0.053*	-0.058*	-0.044	-0.079***	-0.035	0.236***	0.56***	-
15. CIK	2.98	0.55	-0.092***	0.126***	0.187***	0.039	0.12***	0.205***	-0.057*	-0.094***	-0.087***	-0.08***	-0.011	0.253***	0.497***	0.524***

EBs: *PJ* Personal Justification, *JA* Justification by Authority, *JS* Justification by Multiple Sources, *JC* Justification by the Scientific Community, *CK* Certainty of Knowledge, *RN* Reflexive Nature of Knowledge; COR skills: *AOI* Acquisition of Online Information, *CES* Critical Evaluation of Sources, *CEI* Critical Evaluation of Information, *CIA* Critical Identification of Arguments, *IUG* Informative Use Generative AI; Internet-specific EBs: *JIK* Justification of Internet-based Knowledge, *SOK* Sources of Internet-based Knowledge, *SIK* Simplicity of Internet-based Knowledge, *CIK* Certainty of Internet-based Knowledge

Table A.5 Mean and correlation table for economics.

	M	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1. PJ	2.66	1.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. JA	4.16	0.90	-0.081*	-	-	-	-	-	-	-	-	-	-	-	-	-
3. JS	4.70	1.0	-0.247***	0.123***	-	-	-	-	-	-	-	-	-	-	-	-
4. JC	3.78	0.92	0.138***	0.144***	0.148***	-	-	-	-	-	-	-	-	-	-	-
5. CK	4.26	1.09	-0.033	0.288***	0.157***	0.133***	-	-	-	-	-	-	-	-	-	-
6. RN	4.80	0.99	-0.298***	0.238***	0.595***	0.101**	0.261***	-	-	-	-	-	-	-	-	-
7. AOI	2.04	1.02	0.022	0.013	-0.028	0.01	-0.027	-0.042	-	-	-	-	-	-	-	-
8. CES	2.12	0.99	0.037	-0.017	-0.053	-0.016	-0.041	-0.094**	0.593***	-	-	-	-	-	-	-
9. CEI	2.15	1.01	0.089*	0.04	-0.09*	0.008	-0.04	-0.087*	0.573***	0.605***	-	-	-	-	-	-
10. CIA	2.13	1.03	0.089*	0.003	-0.022	0.01	-0.046	-0.027	0.52***	0.539***	0.593***	-	-	-	-	-
11. IUG	2.76	1.16	-0.086*	0.086*	0.065	-0.011	0.069*	0.12**	0.263***	0.255***	0.191***	0.216***	-	-	-	-
12. JIK	3.02	0.58	-0.21***	0.129***	0.38***	0.052	0.113**	0.332***	-0.053	-0.079*	-0.12**	-0.129***	0.064	-	-	-
13. SOK	2.91	0.55	-0.088*	0.172***	0.186***	0.05	0.16***	0.268***	-0.053	-0.04	-0.016	-0.039	-0.029	0.275***	-	-
14. SIK	2.97	0.57	-0.114**	0.119**	0.188***	0.041	0.159***	0.261***	-0.057	-0.04	-0.047	-0.094**	-0.017	0.332***	0.571***	-
15. CIK	2.98	0.55	-0.117**	0.137***	0.223***	0.024	0.149***	0.234***	-0.041	-0.083*	-0.089*	-0.063	0.015	0.38***	0.491***	0.528***

EBs: *PJ* Personal Justification, *JA* Justification by Authority, *JS* Justification by Multiple Sources, *JC* Justification by the Scientific Community, *CK* Certainty of Knowledge, *RN* Reflexive Nature of Knowledge; COR skills: *AOI* Acquisition of Online Information, *CES* Critical Evaluation of Sources, *CEI* Critical Evaluation of Information, *CIA* Critical Identification of Arguments, *IUG* Informative Use Generative AI; Internet-specific EBs: *JIK* Justification of Internet-based Knowledge, *SOK* Sources of Internet-based Knowledge, *SIK* Simplicity of Internet-based Knowledge, *CIK* Certainty of Internet-based Knowledge

Table A.6 Mean and correlation table for sociology.

	M	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1. PJ	2.43	1.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. JA	4.15	0.88	-0.094	-	-	-	-	-	-	-	-	-	-	-	-	-
3. JS	4.94	0.91	-0.106*	0.11*	-	-	-	-	-	-	-	-	-	-	-	-
4. JC	3.79	0.92	0.091	0.204***	0.152**	-	-	-	-	-	-	-	-	-	-	-
5. CK	4.09	1.12	0.027	0.127*	0.089	0.113*	-	-	-	-	-	-	-	-	-	-
6. RN	5.08	0.94	-0.288***	0.303***	0.555***	0.08	0.125*	-	-	-	-	-	-	-	-	-
7. AOI	2.09	0.96	0.023	0.051	-0.094	-0.094	-0.036	-0.06	-	-	-	-	-	-	-	-
8. CES	2.27	0.97	0.053	-0.087	-0.003	-0.137**	-0.01	-0.04	0.484***	-	-	-	-	-	-	-
9. CEI	2.13	0.86	0.036	0.05	-0.023	-0.05	-0.021	-0.014	0.495***	0.487***	-	-	-	-	-	-
10. CIA	2.1	0.91	0.115*	0.036	-0.058	-0.044	-0.008	-0.051	0.45***	0.465***	0.459***	-	-	-	-	-
11. IUG	3.28	1.21	-0.173***	0.033	0.178***	0.007	-0.038	0.19***	0.021	0.076	0.101*	0.074	-	-	-	-
12. JIK	3.04	0.53	-0.136**	0.164**	0.407***	0.1*	0.05	0.345***	-0.168**	-0.113*	-0.093	-0.116*	0.046	-	-	-
13. SOK	2.77	0.5	-0.075	0.08	0.124*	0.11*	0.052	0.134**	-0.089	-0.005	-0.086	-0.003	-0.019	0.185***	-	-
14. SIK	2.8	0.55	0.014	0.027	0.275***	0.095	0.062	0.145**	-0.099*	-0.033	-0.04	-0.015	-0.024	0.174***	0.523***	-
15. CIK	2.86	0.52	-0.078	0.179***	0.179***	0.101*	0.092	0.2***	-0.102*	-0.113*	-0.127*	-0.033	-0.007	0.203***	0.471***	0.512***

EBs: *PJ* Personal Justification, *JA* Justification by Authority, *JS* Justification by Multiple Sources, *JC* Justification by the Scientific Community, *CK* Certainty of Knowledge, *RN* Reflexive Nature of Knowledge; COR skills: *AOI* Acquisition of Online Information, *CES* Critical Evaluation of Sources, *CEI* Critical Evaluation of Information, *CIA* Critical Identification of Arguments, *IUG* Informative Use Generative AI; Internet-specific EBs: *JIK* Justification of Internet-based Knowledge, *SOK* Sources of Internet-based Knowledge, *SIK* Simplicity of Internet-based Knowledge, *CIK* Certainty of Internet-based Knowledge

Table A.7 Mean and correlation table for medicine.

	M	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1. PJ	2.11	0.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. JA	4.28	0.83	-0.173***	-	-	-	-	-	-	-	-	-	-	-	-	-
3. JS	5.01	0.88	-0.086	-0.014	-	-	-	-	-	-	-	-	-	-	-	-
4. JC	3.84	0.98	0.049	0.142**	0.244***	-	-	-	-	-	-	-	-	-	-	-
5. CK	4.32	1.17	-0.029	0.169***	0.025	0.075	-	-	-	-	-	-	-	-	-	-
6. RN	5.25	0.71	-0.194***	0.145**	0.375***	0.073	0.077	-	-	-	-	-	-	-	-	-
7. AOI	1.92	0.93	0.079	0.014	-0.068	0.028	-0.072	-0.045	-	-	-	-	-	-	-	-
8. CES	2.01	0.93	0.095*	0.091*	-0.04	-0.041	-0.019	0.03	0.559***	-	-	-	-	-	-	-
9. CEI	2.01	0.93	0.032	0.031	0.013	-0.053	-0.044	0.04	0.504***	0.571***	-	-	-	-	-	-
10. CIA	1.96	0.96	0.054	0.094*	-0.001	0.041	0.006	0.004	0.482***	0.518***	0.498***	-	-	-	-	-
11. IUG	3.22	1.24	-0.061	-0.055	0.114**	-0.035	0.031	0.149**	-0.047	0.004	0.02	0.02	-	-	-	-
12. JIK	3.22	0.52	-0.162***	0.051	0.259***	0.094*	0.105*	0.254***	-0.213***	-0.142**	-0.136**	-0.111*	0.006	-	-	-
13. SOK	2.96	0.56	-0.055	0.075	0.16***	0.101*	0.022	0.216***	0.029	-0.025	-0.028	-0.064	-0.038	0.083	-	-
14. SIK	3.07	0.57	-0.03	-0.021	0.177***	0.034	0.035	0.208***	-0.019	-0.072	-0.049	-0.115**	-0.046	0.117**	0.549***	-
15. CIK	3.02	0.54	0.012	0.062	0.165***	0.008	0.1*	0.198***	-0.044	-0.039	-0.035	-0.135**	0.008	0.102*	0.505***	0.557***

EBs: *PJ* Personal Justification, *JA* Justification by Authority, *JS* Justification by Multiple Sources, *JC* Justification by the Scientific Community, *CK* Certainty of Knowledge, *RN* Reflexive Nature of Knowledge; COR skills: *AOI* Acquisition of Online Information, *CES* Critical Evaluation of Sources, *CEI* Critical Evaluation of Information, *CIA* Critical Identification of Arguments, *IUG* Informative Use Generative AI; Internet-specific EBs: *JIK* Justification of Internet-based Knowledge, *SOK* Sources of Internet-based Knowledge, *SIK* Simplicity of Internet-based Knowledge, *CIK* Certainty of Internet-based Knowledge

Table A.8 Mean and correlation table for physics.

	M	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1. PJ	2.08	0.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. JA	4.41	0.82	-0.156*	-	-	-	-	-	-	-	-	-	-	-	-	-
3. JS	5.02	0.88	-0.012	-0.209**	-	-	-	-	-	-	-	-	-	-	-	-
4. JC	4.11	1.07	0.043	0.17*	0.155*	-	-	-	-	-	-	-	-	-	-	-
5. CK	4.22	1.28	-0.051	0.281***	-0.112	0.047	-	-	-	-	-	-	-	-	-	-
6. RN	5.43	0.61	-0.189**	0.069	0.455***	0.071	-0.07	-	-	-	-	-	-	-	-	-
7. AOI	2	0.86	-0.007	-0.07	-0.076	-0.137	0.023	-0.059	-	-	-	-	-	-	-	-
8. CES	2.04	0.93	0.134	0.064	-0.206**	-0.073	-0.025	-0.028	0.502***	-	-	-	-	-	-	-
9. CEI	2.12	0.91	0.067	0.074	-0.131	-0.056	0.031	-0.065	0.521***	0.517***	-	-	-	-	-	-
10. CIA	1.98	0.96	0.123	0.077	-0.153*	-0.071	0.053	-0.167*	0.453***	0.492***	0.397***	-	-	-	-	-
11. IUG	2.88	1.25	0.101	0.063	-0.111	-0.141*	-0.013	0.078	0.131	0.138	0.142*	0.052	-	-	-	-
12. JIK	3.12	0.56	-0.049	-0.004	0.366***	0.175*	0.008	0.335***	-0.185**	-0.129	-0.193**	-0.221**	-0.151*	-	-	-
13. SOK	3.05	0.61	-0.028	-0.048	0.078	0.007	0.017	-0.024	-0.004	-0.101	-0.027	-0.064	-0.079	0.183**	-	-
14. SIK	3	0.59	-0.022	-0.022	0.054	0.094	0.068	0.018	0.066	-0.006	0.035	0.018	-0.051	0.123	0.549***	-
15. CIK	3.08	0.56	-0.181*	0.049	0.116	0.005	0.061	0.075	-0.015	-0.147*	-0.121	-0.056	-0.074	0.117	0.47***	0.383***

EBs: *PJ* Personal Justification, *JA* Justification by Authority, *JS* Justification by Multiple Sources, *JC* Justification by the Scientific Community, *CK* Certainty of Knowledge, *RN* Reflexive Nature of Knowledge; COR skills: *AOI* Acquisition of Online Information, *CES* Critical Evaluation of Sources, *CEI* Critical Evaluation of Information, *CIA* Critical Identification of Arguments, *IUG* Informative Use Generative AI; Internet-specific EBs: *JIK* Justification of Internet-based Knowledge, *SOK* Sources of Internet-based Knowledge, *SIK* Simplicity of Internet-based Knowledge, *CIK* Certainty of Internet-based Knowledge

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