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Editorial: Assessing information processing and online reasoning as a prerequisite for learning in higher education

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Editorial on the Research Topic
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A critical need

Over the last decades, the World Wide Web (WWW) has created new opportunities but also many challenges for teaching and learning in higher education. To build a coherent, well-informed knowledge base, university students must know how to effectively search for, select, and critically evaluate online information that is of extremely varied quality and credibility (Rouet and Britt, 2011). Students must also be able to analyze, synthesize, and integrate the information from multiple sources into some external product such as a written summary or argumentative essay, even sources espousing contradictory data and views (List and Alexander). However, in a review of over 500 studies of online information processing, Zlatkin-Troitschanskaia et al. (2021) found that university students habitually rely on the first few search results, evaluate information using inappropriate criteria, and systematically avoid information that contradicts their beliefs. Perhaps for these reasons, they can easily overlook important, factually correct content, and fall prey to biased information.

Paradoxically, recent studies indicate a decrease in students' acquisition of domain-specific knowledge over the course of their university studies, juxtaposed with an increase in the development of (counterfactual) misconceptions and false (inter-)disciplinary concepts (Schmidt et al., 2016). The acquisition of erroneous knowledge seems to be specifically pronounced among students who report that they predominantly use online sources for learning (Maurer et al., 2020), while also claiming to be confident in their knowledge and skills despite its inadequacies and errors (Brückner and Pellegrino, 2016).

Simply "googling" without critical reflection on the quality of sources or their contents is likely to result in the acceptance of unwarranted claims and inaccurate or

misleading information. Zlatkin-Troitschanskaia et al. (2020) termed this phenomenon *negative learning*, which can occur without students' awareness. In contrast, *positive learning* can be defined as *the acquisition of academically or scientifically substantiated conceptual, procedural, and transferable knowledge and understanding that has a long half-life, e.g., is flexible in adapting to new information, meets epistemic standards, and can be reconciled with ethical norms and moral values* (Zlatkin-Troitschanskaia et al., 2020, p. 2).

Although negative learning is a general problem, university students are confronted with an internet-based information and learning environment that can increase negative learning's occurrence and/or amplify its effects. For example, the radius and speed of the distribution of distorted and false information is substantial and continuously increasing on the WWW. Also, the dissemination mechanisms are not transparent on various levels, including algorithmic sorting and personalization, social recommendation and sharing of anonymous sources, commercial amplification, shifting of gatekeeping functions, decontextualization and cross-mediatization of content, and, in some areas, orchestrated censorship and propaganda. University students' skills and strategies for selecting, processing, and learning with online information have proven insufficient for what is required for knowledge development in a complex and ever-changing online environment (Zlatkin-Troitschanskaia et al., 2021). Consequently, when students do not recognize biased or false information and incorporate it into their knowledge base, negative learning occurs. This negative learning can then inhibit or distort subsequent information processing and knowledge acquisition over the course of their university studies (List and Alexander, 2019).

Current online learning environments also contribute substantially to cognitive overload and cognitive dissonance, increasing the danger that learners will commit reasoning errors or operate from biased perspectives. It has been shown that university students often neglect complex, more abstractly presented content in favor of less credible but quicker to access, and easier to comprehend information that tends to be consistent with their beliefs and biases (Goldman et al., 2016). No matter what field they decide to pursue, university students begin their studies after years of prior (in-)formal learning and knowledge gained from the Internet and after having been exposed to the information structures and engagement mechanisms of online media that by their very nature do not observe disciplinary boundaries. Domain-specific misconceptions and erroneous beliefs about the nature of knowledge and knowing (i.e., epistemic) are nothing new. Yet, such distorted notions seem far more entrenched and thus harder to eliminate these days.

Further, established theories and models aiming to explain, predict, or even influence learning in higher education stem mainly from an era in which learning was primarily institutionalized and moderated, technologically limited, highly disciplinary, and characterized by minor variations in teaching methodology. It is therefore evident that a thorough overview of theoretical and empirical research that serves to describe, assess, and predict online information processing and reasoning for students in higher education contexts is urgently required (Zlatkin-Troitschanskaia et al., 2021). The purpose of this issue is to provide such an overview.

The goals of this Research Topic

Our goals for this issue were to share cutting-edge research that examines important factors and forces that not only illuminate the general challenges that university students face when engaged in online searches for relevant and credible information, but also detail the effects that their pre-existing knowledge, beliefs, language background, and computer use can have on that search process. Most of the research presented in this issue focuses on the preconditions and processes of *self-directed and independent learning* of university students in Internet-based environments, both as part of university courses and outside regular courses. Contributors to this issue also explore the tools and techniques for gathering rich data on what is transpiring at each phase of information processing—from the search for documents to the way students' read and reflect on those documents. Finally, this overview of information processing and online reasoning considers students in higher education generally as well as special populations, e.g., students pursuing medical education.

Emerging themes

There are also themes that emerge across the 21 studies that form this issue. One such theme includes contributions that provide a profile of the information landscape that today's university students encounter. *Information landscape* refers to the online learning space freely available to students for their learning, which comprises all locatable online information resources for a given domain or topic (List and Alexander). The information landscape is analyzed using (computer-based) data and text mining technologies from linguistics (Mehler et al.) as well as qualitative content analyses, e.g., using established methods from media and communication sciences (Nagel et al.) and narrative analyses (Banerjee et al.). These studies, in particular, describe and analyze the sources and types of information university students select and use for learning and identify mis-information that may introduce misconceptions related to given concepts be they domain specific or otherwise.

Two other themes within the issue pertain to the learning processes and learner characteristics that are relevant to the execution and outcomes of online learning. *Learning processes* represent cognitive, metacognitive, motivational, and affective procedures enacted during online information processing. The

observable activities to which contributors to this issue refer include search for information, navigation on and between websites, and evaluation of information. In several articles, those activities are recorded by logging online activities and by means of observational techniques like eye tracking (Hahnel et al.; Leighton et al.; Mahlow et al.). The authors also share innovative quantitative and qualitative methods for analyzing the small and large data sets that result (e.g., process mining, Schmidt et al.). In addition, a range of data sources were used to craft a rich picture of these university students' learning processes, including data from cognitive labs on students' use of verified knowledge versus specific misconceptions, and their related attitudes such as overconfidence in incorrect answers (Zlatkin-Troitschanskaia et al.).

Learner characteristics or individual differences form the third theme within this issue. The characteristics that contributors investigate include students' figural-spatial abilities, linguistic facility, argumentation skills, socioeconomic background, domain-specific knowledge, and knowledge of computers (CITES). The range of learner characteristics was measured in a variety of ways, including tests, questionnaires, or behavioral patterns documented in log files (Fellman et al.; Wolgast et al.). For the big data sets used in several studies, machine learning techniques were employed to extract key learner characteristics (Lücking et al.).

Finally, *learning outcomes* (e.g., acquired domain-specific concepts), constitutes a fourth thematic element, primarily serving as dependent variables in various studies. Such outcomes are assessed using various types of achievement tests, including rubric-based and automated analyses of texts written by students (Brückner et al.; Roeper et al.).

Contributions to understanding information processing and online reasoning

Overall, the 21 studies in this issue present interesting and important results from contemporary international research that identifies and systematically describes properties of the various learning sources and information university students use for learning. For instance, researchers systematically examine key instructional texts, assessments, and thematically related online information used by students as well as their cognitive and non-cognitive effects that hinder or promote learning in higher education. Some studies in this issue also examine the interplay between text structures and features and test-takers' responses as well as variance depending on presented information in sources for learning. By systematically and comprehensively investigating student learning, the results from these studies have identified online information processing and online reasoning as a crucial prerequisite for successful learning in higher education in the age of mis-information.

Structurally, this issue is composed of empirical studies, combined with conceptual and literature reviews, grounded not only in higher education research but also in various intersectional disciplines (e.g., communication sciences). The empirical studies present innovative conceptual and measurement approaches, linking educational results with analysis methods from linguistics, computational linguistics, media science etc., which have not previously been applied and combined in research in higher education. Remarkably, the explanatory power of the new integrative, multi- and interdisciplinary approaches applied in these studies has exceeded that of typical explanatory variables and approaches from the educational and learning sciences alone. Overall, these studies illustrate how the new methods presented tie in with current challenges as well as current developments in higher education research and practice.

Overall, this issue illuminates a controversial and very timely topic in higher education of international importance, and addresses and investigates it from different cross-disciplinary perspectives. Original theoretical, conceptual, and empirical studies are presented that offer examinations and explanations of *Information Processing and Online Reasoning and their Effect on Learning in Higher Education* in the age of mis-information. This issue contains studies related to teaching and learning across different environments in the digital age, the generation and dissemination of knowledge, and modes of inquiry. Moreover, the work described in this issue comes from different countries and encompasses analyses in several disciplines related to higher education learning and its assessment. All contributors to this issue, which provides complementary and diverse perspectives and methodologies, are international scholars whose empirical and theoretical work is centered around the processing of digital content and online reasoning within higher education and their assessment. In this way, this issue serves as a benchmark contribution in this emerging, crucial new field of learning research. The work is foundational for addressing extremely controversial developments regarding students' use of online media for learning and helps to close the gap in corresponding learning research to date.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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