

RESEARCH REPORT
Skills for the Future

Navigating the (Mis)Information Age: A Conceptual Framework for Defining, Assessing, and Teaching Critical Thinking in Pre-Kindergarten to Grade 12 Education

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Navigating the (Mis)Information Age: A Conceptual Framework for Defining, Assessing, and Teaching Critical Thinking in Pre-Kindergarten to Grade 12 Education

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Abstract

Critical thinking is a vital skill for navigating the abundance of information, misinformation, and disinformation available to individuals of all ages. Critical thinking predicts successful outcomes in academic, workplace, and general life areas. Poor critical thinking skills may put individuals at risk for serious detrimental consequences. Given their importance, assessment and training of effective critical thinking skills need to be emphasized. Although these efforts are common in college and adult settings, programs designed for younger ages (i.e., prekindergarten through Grade 12, or preK–12) may be particularly effective and may help facilitate preK–12 students' postsecondary academic and occupational pursuits. In this paper, we utilized a systematic approach to developing a conceptual framework for critical thinking that includes four subskills: Information Seeking, Information Analysis, Argument Generation, and Logical Reasoning. We articulate key distinctions between our critical thinking definition and overlapping constructs and discuss assessment and training considerations for practical and research settings. With this framework, our goal is to provide a theoretical foundation for important measurement and development applications for preK–12 students, both inside and outside schools.

Keywords: critical thinking, information seeking, information analysis, argumentation, logical reasoning, socioemotional skills, competency-based education, durable skills, preK–12 education, skills for the future, framework

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Preface

This manuscript represents part of a larger initiative called Skills for the Future (SFF; Liu et al., 2023), in which we aim to expand beyond academic content knowledge to generate a holistic profile of prekindergarten through Grade 12 (preK–12) students’ skills and facilitate effective teaching and learning of these skills. The SFF initiative also aims to supplement traditional academic credentials with assessments and insights, aligning with competency-based education systems at the state level (e.g., Levine & Patrick, 2019). This initiative involves identifying noncognitive constructs or “durable skills” that are valued by various stakeholders in educational settings. This value is reflected in frameworks such as states’ Portrait of a Graduate, as well as by their prediction of postsecondary success. Recognizing preK–12’s role in preparing students for the workforce, the SFF project is also designed to support recent shifts toward skills-based hiring (Peterson et al., 2024). The skills-based hiring movement deprioritizes traditional educational degree (e.g., college degree) requirements in the hiring process, generating greater demand for valid and operationalized skills frameworks as the essential guiding tools (Society for Human Resource Management, 2024). In this paper, we focus on the durable skill of critical thinking by summarizing a thorough literature review and offering a new conceptual framework. This framework addresses gaps and confusion in the critical thinking literature, with the goal of guiding myriad theoretical, research, and practical applications.

Introduction

Living in an information age, prekindergarten through Grade 12 (preK–12) students have easier, quicker, and broader access to an overwhelming amount of knowledge on virtually any topic imaginable, compared to the prior era. Students are often required to acquire and apply information for class projects, assignments, essays, or other tasks as they acquire academic knowledge and skills. As technology becomes more integrated into classrooms, this information access has increased dramatically and is often considered fundamental to the learning experience. As students approach the end of their preK–12 journey, they may also wish to research topics such as postsecondary academic and occupational options, including college programs, financial support (e.g., scholarships, governmental postsecondary grants), and local job openings. Moreover, students may seek this information not only through in-school computers but on their personal or at-home devices or in other nonschool settings (e.g., public libraries). This type of self-directed information gathering continues upon graduation, suggesting

that skills students may develop in preK–12 relevant to seeking, analyzing, and applying information continue to be highly relevant into adulthood. For example, adults pursue information to inform important decisions regarding purchases, physical and mental health, civic engagement, educational and occupational pathways, leisure pursuits, financial endeavors, legal advice, and many others.

The open-access nature of the internet and other media requires students to differentiate credible, authentic, and verifiable information from claims that are unreliable, misleading, and factually incorrect. This necessity highlights how the information age soon coincided with the misinformation age (Cook et al., 2015). Whereas misinformation tends to be defined as information whose inaccuracy is unintentional, misinformation is also distinguished from *disinformation*, in that the latter is typically deliberately deceptive and designed to cause harm (Bennett & Livingston, 2021). The increasing ubiquitousness of artificial intelligence (AI) further emphasizes the importance of critical thinking, as students must recognize and evaluate information or other outputs that may have been generated or manipulated by AI (e.g., Ng et al., 2021). Regardless, these issues highlight the importance of equipping students with the skills necessary to constructively and safely navigate information sources.

Critical Thinking as a Skill

Critical thinking represents one significant skill for differentiating credible information from misinformation or disinformation. Especially important when dealing with the expansive amounts of information at hand (Kallet, 2014), critical thinking allows for the processing and filtering of incoming information in reaching quality judgments (Ennis, 1985; N. C. Facione & Facione, 2008) and facilitates the process of acquiring and sense-making of new information (Alwehaibi, 2012). That is, critical thinking involves students' strategies in seeking information and students' skill in analyzing this information, including its source, content, and supporting evidence or argumentation. Subsequently, students may apply this information to formulate arguments, to solve problems, to make decisions, or for other in-school and out-of-school situations. In turn, critical thinking skills are necessary to help students make positive and effective decisions while avoiding detrimental outcomes.

The value of critical thinking has been empirically supported by myriad research studies. In postsecondary academic settings, researchers have linked critical thinking to various positive outcomes. For instance, critical thinking has been meta-analytically linked ($r = .26$ under the

fixed effects model) with community college student academic achievements (e.g., degree attainment, college GPA, and test scores; Fong et al., 2017). Interestingly, college students higher in critical thinking abilities are also less likely to report making general mistakes in life (e.g., paying for late fees, taking the wrong train) compared to those lower in critical thinking abilities (Butler, 2012). Research has even demonstrated that critical thinking is a stronger predictor than general intelligence in predicting various life outcomes (Butler et al., 2017).

Beyond academia, employer surveys often identify critical thinking as a skill employers value in their employees (e.g., Desai et al., 2016; Indrašienė et al., 2023). Among the reasons for critical thinking's importance is that it aids in a wide variety of workplace problem solving, such as facilitating managers' and employees' decision-making by holistically evaluating all possible solutions, therefore mitigating negative outcomes (Murawski, 2014). Given the nature of critical thinking as a higher order skill, it is particularly valued for more complex jobs (Mainert et al., 2019). Moreover, because critical thinking is transferable to problems in novel contexts (Halpern, 1998), it demonstrates high value across a variety of life areas.

Considering the importance of critical thinking skills across various aspects of academic, occupational, and personal life, many efforts have been established to foster critical thinking for children and students. For instance, an American Philosophical Association Delphi report recommends that children should be trained on how “to reason, to seek relevant facts, to consider options, and to understand the views of others” from a young age (P. A. Facione, 1990, p. 27). Higher education faculties endorse critical thinking as one of the most important goals in undergraduate education (Gellin, 2003). In a survey of the American Association of Colleges and Universities, 74% of the member institutions indicated critical thinking as a core skill requiring more emphasis in general college education (Hart Research Associates, 2009). However, it is unclear whether these efforts are guided by objective and comprehensive conceptual frameworks of critical thinking.

Developing a Conceptual Framework for Critical Thinking in PreK–12 Settings

The relationship between critical thinking and various important outcomes suggests that critical thinking is a vital skill across multiple contexts. It is plausible that, to maximize efforts to cultivate individuals' critical thinking skills, assessments and teaching applications should begin in preK–12 settings. This strategy aligns with one of the primary goals of preK–12 education: to prepare students for postsecondary academic and occupational success. However, these efforts

require a clear conceptual framework of critical thinking to guide effective implementations. In this paper, we aim to consolidate and expand upon previous definitions of critical thinking, with an emphasis toward one that applies primarily to preK–12 students. As we elaborate in later sections, this emphasis on younger students is a key differentiator of our framework and one that addresses a significant gap in the literature. Briefly, many existing definitions of critical thinking are conceptualized in adult contexts (e.g., Santos-Meneses et al., 2023), and frameworks that have been proposed in education settings often focus on postsecondary students (e.g., Behar-Horenstein & Niu, 2011; McMillan, 1987). Thus, they may be inappropriate for informing efforts to measure or develop critical thinking in preK–12 students. Moreover, researchers have argued that extant educational definitions of critical thinking are too vague to be of practical value (e.g., assessment, training; Ennis, 1985; Sternberg, 1986). These concerns underline the need for a novel and expanded critical thinking framework for preK–12 settings.

The structure of this paper first presents our critical thinking definition and distinguishes it from those of other overlapping constructs. We then discuss theoretical, research, and practical implications for our new conceptual framework. Recognizing the importance of critical thinking development for students, the current paper (a) proposes a conceptual framework to represent critical thinking through a multidimensional process approach and (b) provides practical considerations for designing assessments that measure critical thinking. Specifically, we synthesize and extend existing definitions of critical thinking to develop a multidimensional conceptualization of critical thinking as a set of reasoning processes that involve information gathering and analysis and that generate understanding and support decision-making. In addition, we review insights on factors to consider in developing assessments of critical thinking. In short, this paper aims to operationalize critical thinking with a particular focus on skills assessment and development for preK–12 students. Importantly, we also distinguish critical thinking from other similar skills to avoid conflation and construct drift.

Methodology

Consistent with the other constructs in the Skills for the Future (SFF; Liu et al., 2023) framework (e.g., Chakraborty et al., 2025; Liu et al., 2025; Ober et al., 2025; Williams et al., 2026), we utilized a systematic process to gather and synthesize relevant information from various sources to develop our critical thinking conceptual framework. First, we conducted a thorough literature review to identify previous conceptualizations of critical thinking using

databases such as Google Scholar, which encompasses other databases (e.g., PsycInfo). Relevant articles were identified through this process then supplemented with forward and backward snowball searches. We also reviewed documents such as Portrait of a Graduate frameworks developed by state-level departments of education. We supplemented these frameworks with others conducted by established research organizations (e.g., America Succeeds, 2023; XQ Institute, n.d.) to consider additional alternate conceptualizations of critical thinking.

Second, we articulated a preliminary conceptual framework of critical thinking based on the common features in the literature. We then refined this preliminary framework using logical judgment, removing or adding conceptual aspects as warranted by related literature. This step also involved identifying relevant subskills for our critical thinking definition, including behavioral skill indicators representing these subskills. One focus in this step is to emphasize objective and overt indicators over more covert, subjective ones (e.g., Kell et al., 2017). This strategy facilitates the assessment of critical thinking by external observers while recognizing that critical thinking may manifest in various ways. These indicators should also guide educators and students in recognizing concrete examples of critical thinking, which may aid assessment, instruction, and monitoring development (e.g., learning progressions). As a result, we developed behavioral indicators for each of the subskills.

We then submitted our conceptual framework for expert evaluation. Specifically, we gathered feedback from psychological scientists, educators, and other relevant stakeholders to ensure that our framework was logical and intuitive, and that it demonstrated clear conceptual distinctions from other noncognitive constructs, especially others in the SFF taxonomy. A critical aspect of this step was to integrate socioculturally responsive assessment principles (Bennett, 2023) to ensure that the conceptual framework of critical thinking—including its behavioral manifestations—and its applications were inclusive of all students and reflects the influence of diverse cultural norms. It was also imperative that our framework applied to conceptualization and practical applications (e.g., assessment, curricula) for preK–12 students. We finalized our overall conceptual framework for critical thinking, including its subskills and exemplar behavioral indicators, following the steps described previously.

Reviewing and Synthesizing Previous Definitions of Critical Thinking

Critical thinking has been studied for decades in psychological and philosophical research, leading to a proliferation of construct definitions. Identifying common themes across

these definitions is crucial for understanding the scope of critical thinking, differentiating it from other constructs, and facilitating practical applications such as assessment and training. Initial conceptualizations of critical thinking describe the construct as “reflective and reasonable thinking for deciding what to believe or do” (Ennis, 1985, p. 45). Subsequently, definitions of critical thinking tended to emphasize a critical thinker’s motivations or end goals. Some examples of relevant definitions include the following:

- “purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or conceptual considerations upon which that judgment is based” (P. A. Facione, 1990, p. 3)
- “judging in a reflective way what to do or what to believe” (P. A. Facione, 2000, p. 61)

Conversely, cognitive psychologists approach critical thinking by examining the behaviors and processes performed by critical thinkers and relevant applications or outcomes, resulting in definitions such as these:

- “the mental processes, strategies, and representations people use to solve problems, make decisions, and learn new concepts” (Sternberg, 1986, p. 3)
- “seeing both sides of an issue, being open to new evidence that disconfirms your ideas, reasoning dispassionately, demanding that claims be backed by evidence, deducing and inferring conclusions from available facts, solving problems, and so forth” (Willingham, 2007, p. 8)

Although approached from different lenses, Lai (2011), based on their review, suggested a shared emphasis in the two domains as an individual’s abilities to logically analyze, evaluate, and infer arguments from evidence to reach a reasonable decision.

Conceptualization in the Education Domain

General, noncontextualized definitions of critical thinking were soon followed by ones situated in specific settings. Conceptualizations of critical thinking in educational contexts are arguably most relevant to our purposes, namely developing a framework for preK–12 contexts. Previous critical thinking definitions in education contexts tend to focus broadly on skills and abilities. One of the most cited conceptualizations of critical thinking in existing education

literature is Bloom's (1956) taxonomy for information processing. This skill-based framework adopts a hierarchical structure to assess thinking, ranging from lower-level comprehension skills to higher-level skills of critical evaluation and creation. Much research has been built on this taxonomy in developing critical thinking education of students in classrooms across many subjects. For example, Athanassiou et al. (2003) applied this taxonomy to develop a metacognitive framework for building undergraduate students' critical thinking skills and fostering self-learning in a management class. Rahman and Manaf (2017) examined the effectiveness of using Bloom's taxonomy as the basis for teaching strategies for improving students' critical thinking skills in English classroom settings. Taking an interdisciplinary approach, this taxonomy has also been used as a model for the teaching of critical thinking for all disciplines (Duron et al., 2006). Similarly, other broad skills-based interpretations of critical thinking include interpretation, prediction, analysis, and evaluation to engage in purposeful, self-regulatory judgment (Abrami et al., 2008) as well as ability to interpret information and approach problems across an array of domains (Huber & Kuncel, 2016).

One criticism that has been received for these broad frameworks in education is that they exhibit vagueness and insufficient clarity to guide classroom instructions and assessment development (Ennis, 1985; Sternberg, 1986). Literature has thus tried to identify more specific representations of skills to better facilitate assessment development. For instance, the American Association of Colleges and Universities (AAC&U) defined critical thinking as “a habit of mind characterized by the comprehensive exploration of issues, ideas, artifacts, and events before accepting or formulating an opinion or conclusion” (AAC&U, 2009; p. 1). Specifically, it identified skills that focus on information processing, such as understanding the issues, analyzing evidence and assumptions, and understanding the complexity of perspectives (AAC&U, 2009). In addition, Liu et al. (2014) reviewed critical thinking conceptualizations in higher education. Aggregating past literature, Liu et al. (2014) summarized an operational framework consisting of five dimensions to cover the factors of analytical (e.g., analyzing and evaluating argument structure, evaluating evidence and its use) and synthetic (e.g., developing valid arguments, understanding arguments) skills. Some examples of specific skills include identifying unstated assumptions and identifying information that would strengthen or weaken presented arguments. More recently, the XQ Institute (n.d.) developed competency progressions for critical thinking, describing subskills such as interpreting information, logical thinking, and synthesis. However,

these definitions tend to emphasize higher education and workplace settings. Nonetheless, these frameworks provide some examples of research that may inform our conceptualization of critical thinking for preK–12 settings.

Results: A New Conceptual Framework for Critical Thinking in PreK–12

Our conceptual framework for critical thinking builds upon the aforementioned research, largely conducted in college-age or adult contexts. Ideally, translating aspects of these conceptualizations to preK–12 settings should provide a common language to facilitate lifespan assessment and development efforts from adolescence into adulthood. Our definition of critical thinking involves obtaining, analyzing, and utilizing information and its supporting argumentation in a sound, objective, and evidence-based manner. We further describe four critical thinking subskills: Information Seeking, Information Analysis, Argument Generation, and Logical Reasoning. These four subskills overlap but also include some unique aspects. Our subskills and respective behavioral indicators for critical thinking are displayed in Table 1.

Subskill #1: Information Seeking

In prior conceptualizations of critical thinking, inquiry is often noted as a core stage or process (e.g., Battersby & Bailin, 2018; Sternberg, 1986). Thus, the first SFF subskill in our framework is Information Seeking, defined as effectively pursuing information to address knowledge gaps or errors or to pursue other specific goals. Several behavioral indicators represent students' skills in pursuing information effectively. As one important prerequisite, students must recognize gaps in their knowledge (i.e., know what they don't know). This stage has been recognized as a common challenge in information gathering, as individuals often fail to consider that they may have overlooked information (see Gehlbach et al., 2024). Once gaps have been identified, it is necessary for students to formulate the appropriate questions to address them. That is, the mere act of asking questions is insufficient; information seekers should be able to ask the right questions. Researchers have described this skill as *problem formulation*, emphasizing that ineffective demonstration of this behavior hinders subsequent problem-solving efforts (e.g., Schlosser & O'Neil-Pirozzi, 2006). Careful and precise question construction facilitates effective information gathering. Collectively, these steps represent the first behavioral indicator for the Information Seeking subskill in our framework: *Formulates relevant questions to address gaps in information (CT.IS.1)*.

Table 1. Critical Thinking Subskills and Behavioral Indicators

Subskills	Definition	Behavior indicators
Information Seeking (IS)	Effectively pursuing information to address knowledge gaps or errors or to pursue other specific goals	CT.IS.1: Formulates relevant questions to address gaps in information CT.IS.2: Pursues multiple, credible, relevant sources of information CT.IS.3: Objectively considers contradictory and alternate perspectives CT.IS.4: Pursues information through relevant personal experience
Information Analysis (IA)	Evaluating the relevance and credibility of informational sources, content, and supporting argumentation	CT.IA.1: Is neither overly trusting nor distrusting of information CT.IA.2: Recognizes how sources may be influenced by biases, subjectivity, motivations, and/or emotion CT.IA.3: Applies fact-based strategies to evaluate information CT.IA.4: Objectively evaluates the credibility of information and weights it accordingly CT.IA.5: Effectively synthesizes multiple pieces of information
Argument Generation (AG)	Generating well-informed, synthesized, and defensible arguments	CT.AG.1: Relies on evidence, data, and/or facts over opinions CT.AG.2: Doesn't allow emotion to undermine argumentation CT.AG.3: Communicates arguments that synthesize multiple claims, perspectives, and/or pieces of information CT.AG.4: Effectively addresses counterarguments
Logical Reasoning (LR)	Recognizing and applying effective logical reasoning based on argument structure and content to draw defensible conclusions (e.g., when analyzing information or generating arguments)	CT.LR.1: Recognizes and applies effective deductive reasoning CT.LR.2: Recognizes and applies effective inductive reasoning CT.LR.3: Recognizes and avoids logical fallacies

Note. The critical thinking skill is defined as obtaining, analyzing, and utilizing information and its supporting argumentation in a sound, objective, and evidence-based manner.

Effective information seeking also requires students to understand which sources are the most appropriate and credible. Depending on the subject matter, certain sources are more likely to provide relevant, sound information than others. For instance, sources possessing established expertise or experience in an area of interest represent ideal starting points. Pursuing multiple sources of information allows students to build a stronger knowledge base through replication and potential cross-validation. Collectively, these steps represent the second behavioral indicator for the Information Seeking subskill: *Pursues multiple, credible, relevant sources of information (CT.IS.2)*.

Similarly, seeking information from diverse perspectives facilitates a more holistic and comprehensive body of knowledge to consider. Particularly, this aspect reflects students' tendency to be open-minded to perspectives that may be unique, unfamiliar, or beyond those that are typically considered, including those that may conflict with each other (e.g., AAC&U, 2009; Willingham, 2007). Students' skill in this area protects them from exclusively seeking or considering sources that may support pre-existing knowledge or beliefs and from rejecting sources based on negative preconceptions (i.e., confirmation bias). This step represents the third behavioral indicator for the Information Seeking subskill: *Objectively considers contradictory and alternate perspectives (CT.IS.3)*.

Finally, information seekers may take an experiential approach to obtaining information, particularly for certain daily problems. This strategy aligns with the field of empiricism, which posits that knowledge is gained empirically through sensory experience (see review by Meyers, 2006). Empiricism relies heavily on the scientific method, including testing working hypotheses through observation and experimentation. For instance, in many everyday situations, students may “experiment” by manipulating various factors to evaluate cause-and-effect phenomena. An example of this strategy is troubleshooting, where a student may use tactics to investigate why their computer isn't working, such as manipulating variables sequentially (trying a different power source, connecting to a different monitor, etc.). Alternatively, students may modify ingredients in a cooking recipe to evaluate the impact on flavor and other features. These strategies are alternatives to pursuing information from a textbook, the internet, or another person. Note that the goal of these behaviors is not to improve skills (e.g., athletic ability, technical skills) but to obtain information, suggesting that these behaviors represent a specific subset of learning-by-doing activities. For example, empiricism may be often demonstrated in

classroom settings such as career and technical education. Information and knowledge gained through these experiences may then be applied to other skilled activities. This process represents the fourth behavioral indicator for the Information Seeking subskill: *Pursues information through relevant personal experience (CT.IS.4)*.

Subskill #2: Information Analysis

Students' skill in analyzing information is another essential feature of critical thinking, as outlined in various prior conceptualizations (e.g., Bloom, 1956; P. A. Facione, 1990). This feature is reflected in the second SFF subskill, Information Analysis, which we define as one's skill in evaluating the relevance and credibility of informational sources, content, and supporting argumentation. Fundamentally, there are important attitudinal dispositions and mindsets that influence how students process information. Students may vary in the degree to which they trust new information, which impacts the degree to which they may engage with the information on a deeper level. For instance, students with a highly trusting nature may naively accept that any new information is credible, which may make them susceptible to misinformation. Conversely, highly mistrustful students may inflexibly refuse to believe any new information they encounter, impeding their ability to consider potentially valuable knowledge. Ideally, students should be open to considering new information on a case-by-case basis, demonstrating a healthy skepticism rather than accepting or doubting indiscriminately. This tendency is one example of the dispositional aspect of critical thinking, which has been highlighted by previous researchers and educators (e.g., AAC&U, 2009; Willingham, 2007). This disposition is reflected in our first behavioral indicator for the Information Analysis subskill in our framework: *Is neither overly trusting nor distrusting of information (CT.IA.1)*.

Once students analyze information on a deeper level, aspects of its source, content, and supporting argumentation may vary widely in terms of their strengths and weaknesses. Most sources of information are human, meaning they are often inherently subjective. In other words, these sources may possess biases or motivations that may influence the information they provide. For instance, individuals may have a legitimate vested interest in sharing certain facts while withholding others, such as when attempting to sell a product or service. Human sources are also susceptible to emotional influences that may impact their perspective and the veracity of any evidence or knowledge they may offer. For example, a source with a strong emotional investment in a certain topic may fail to recognize alternative perspectives or evidence. Notably,

this subskill also includes one's tendency to understand that information gathered through their own personal experience (i.e., CT.IS.4) may be limited, biased, or flawed. Although other arguably nonhuman sources such as search engines and artificial intelligence are not directly susceptible to these shortcomings, they are designed and maintained by humans, whose biases and other limitations may influence these sources. Students' skill in evaluating sources' credibility in the context of these effects is represented by our second behavioral indicator for the Information Analysis subskill: *Recognizes how sources may be influenced by biases, subjectivity, motivations, and/or emotion (CT.IA.2)*.

Effective information analysis also requires reliance on facts, sound data, and strong evidence. This type of information is typically considered more objective and reliable than subjective opinions and unsupported claims. Prior researchers have also argued for the importance of fact-based analysis when articulating critical thinking conceptualizations (e.g., Willingham, 2007, p. 8). Students' skill in relying upon facts when evaluating information forms the basis of our third behavioral indicator for the Information Analysis subskill: *Applies fact-based strategies to evaluate information (CT.IA.3)*. At a basic level, this subskill depends on students' skill in distinguishing between facts and opinions. At moderate levels of this subskill, students become more likely to fact-check claims and ideas, particularly when the source or content of the information appears less credible. However, for students at higher levels of this skill, fact-checking behavior should continue even when the source and content appears credible, such that they are less likely to succumb to misinformation that is presented in a trustworthy, convincing, or technical manner. Ideally, students should place more weight on factual information than nonfactual or factually incorrect information when evaluating its credibility. This behavioral indicator is crucial in navigating the potentially overwhelming volume of information that to which individuals are exposed. Scrutinizing this information to determine whether it is factual or not assists students in discriminating "signal" from "noise."

Beyond the factual nature of information, it is important for students to evaluate information objectively based on other features. For example, the strength and credibility of information are influenced by features such as the nature in which supporting data are collected (e.g., rigorous scientific inquiry). As another example, information such as opinion polls may be presented technically (e.g., 70% of individuals believe X), but despite being based on opinions, they may still be relevant to certain problems or areas of inquiry. Additionally, certain

perspectives or topics may invoke strong emotional responses for individuals, influencing their evaluation in that they are more or less likely to endorse it regardless of its credibility. Once these features are evaluated, students should ideally place more weight on credible, strong, and relevant information in most situations. This skill is reflected in our fourth behavioral indicator for the Information Analysis subskill: *Objectively evaluates the credibility, strength, and relevance of information and weights accordingly (CT.IA.4)*.

Finally, another critical component of information analysis involves students' skill in synthesizing various ideas, perspectives, or claims. There are various forms in which this skill may manifest. At its simplest, this skill involves summarizing information or categorizing it based on superficial features such as the type of source, the pros and cons of an argument, and so forth. At more advanced skill levels, synthesis involves recognizing more sophisticated patterns among various pieces of information. This stage may include integrating other aspects of the information such as their credibility and relevance to evaluate whether some information should carry more weight than others. Unlike the previous behavioral indicator (CT.IA.4), this behavior involves evaluating the credibility and relevance of multiple pieces of information from multiple sources and perspectives. For example, the pro side of an argument may possess a greater volume of supporting evidence than the con side, but the credibility of the evidence supporting the con side may be greater. Synthesis may also allow students to hypothesize causal relationships that may explain various trends, to scrutinize and resolve incongruent claims, or to identify connections between seemingly disparate pieces of information. These examples are represented in our fifth behavioral indicator for the Information Analysis subskill: *Effectively synthesizes multiple pieces of information (CT.IA.5)*.

Subskill #3: Argument Generation

Most definitions of communication skills recognize both receptive (reading, listening) and expressive components (speaking, writing; e.g., Ober et al., 2025). Critical thinking may be conceptualized across a similar dichotomy. In our framework, information seeking and information analysis are largely considered receptive components of critical thinking. Conversely, students' skill in communicating information or ideas in a sound manner may represent an expressive form of critical thinking, one that is recognized in previous definitions (e.g., P. A. Facione, 2000; Willingham, 2007). Similarly, communicating information could exemplify the application and creation stages of Bloom's (1956) Taxonomy of Educational

Objectives. This perspective forms the basis of our third critical thinking subskill, Argument Generation, which we define as students’ skill in generating well-informed, synthesized, and defensible arguments. Notably, our definition of argument generation applies equally to verbal, written, or other types of communication.

Many features of the receptive components of effective critical thinking (i.e., information seeking and analysis) are necessary for effectiveness in the expressive domains. An important instance of this connection is that generating sound arguments relies on facts as opposed to unsupported or unverifiable opinions. Arguments supported by credible evidence are more likely to be defensible and objective. This assertion is reflected in our first behavioral indicator for the Argument Generation subskill in our framework: *Relies on evidence, data, and/or facts over opinions (CT.AG.1)*. Thus, this behavioral indicator may be considered parallel to Information Analysis subskill indicators such as CT.IA.3 or CT.IA.4.

In addition to the content of an argument, the way in which an argument is communicated may also impact its effectiveness. Similar to other critical thinking subskills, emotion may diminish students’ ability to generate effective arguments. For instance, if someone possesses a strong emotional connection to a topic, it may cause them to rely more on opinions, draw weak conclusions, overlook evidence, or undermine the process of generating a sound argument in other ways. It is often necessary for students to control or discount these emotions during the process of generating sound arguments. Notably, Willingham (2007) described this feature as “reasoning dispassionately” (p. 8) in their definition of critical thinking. This skill is noted in our second behavioral indicator for the Argument Generation subskill: *Doesn’t allow emotion to undermine argumentation (CT.AG.2)*. Note that it is possible for students to use emotion to strengthen their argument without weakening its content. That is, a student may deliver a logical, fact-based argument passionately. Thus, it is not necessarily true that students demonstrating high levels of this behavioral indicator must deliver arguments devoid of any emotion.

Another important aspect of argument generation is that it involves considering multiple pieces of information. This feature is similar to the synthesis behavioral indicator in our Information Analysis subskill (CT.IA.5). Accordingly, students may generate arguments that integrate knowledge from various sources or perspectives to support a sound conclusion. This behavior may include combining multiple arguments into a single new or summarizing argument. This skill is represented in our third behavioral indicator in the Argument Generation

subskill: *Communicates arguments that synthesize multiple claims, perspectives, and/or pieces of information (CT.AG.3).*

Related to this concept, once a student presents an argument, they are often subjected to counterarguments, both from others and as a part of their own reflective processing of a topic. There are several possible responses students may demonstrate when presented with counterarguments. For example, students may credibly defend their argument, adjust their argument based on new information or counterarguments, integrate these arguments into their own, or concede that the counterargument may be stronger than their initial argument. These responses are reflected in our fourth behavioral indicator for the Argument Generation subskill: *Effectively addresses counterarguments (CT.AG.4).*

Subskill #4: Logical Reasoning

Generally, definitions of logical reasoning describe it as a process of making inferences from premises to arrive at a conclusion (e.g., Simon, 2001). Several researchers have argued explicit connections between logical reasoning and critical thinking. For instance, Bronkhorst et al. (2022) posited that critical thinking “includes reasoning in formal and everyday situations, for which it is important to build, analyze, and verify reasoning, and identify and prevent incorrect arguments” (p. 291). Liu et al. (2015) argued that logical reasoning represents the “core foundation” (p. 337) of critical thinking. Other frameworks have included logical thinking as a distinct subskill within their conceptualization of critical thinking (XQ Institute, n.d.). Moreover, formal efforts to increase students’ critical thinking skills often target logical reasoning as a mechanism for improvement or vice versa (e.g., Bouhnik & Giat, 2009; Bronkhorst et al., 2021; Nagizadeh et al., 2023). These arguments suggest that logical reasoning plays a critical role in analyzing or sense-making of new information—including its content and supporting evidence—and in generating sound arguments.

In our framework, defining logical reasoning through overt, objective indicators suggests that it be evaluated within behavioral contexts such as information analysis or argument generation. This connection aligns with aforementioned critical thinking training courses in which logical reasoning is taught in the context of information analysis or argument formulation (e.g., Bouhnik & Giat, 2009). Within the context of these other subskills, we define logical reasoning as students’ skill in recognizing and applying effective logical reasoning based on argument structure and content to draw defensible conclusions (e.g., when analyzing information

or generating arguments). More specifically, we developed behavioral indicators that describe logical reasoning within the context of observable behaviors (i.e., information seeking/analysis and argument generation).

There are many different types of logical reasoning, and most of them play a critical role in analyzing information (e.g., Bronkhorst et al., 2022). One example of logical reasoning is deductive reasoning, in which one starts with a general statement or hypothesis and examines the possibilities to reach a specific, logical conclusion (e.g., Copi et al., 2005). If the general assumptions (or premises) in the specific deductive argument are true, then it is impossible for the specific conclusion drawn from this assumption to be false. One of the more common examples of a deductive argument is “All men are mortal. Socrates is a man. Therefore, Socrates is mortal.” The statements “All men are mortal.” and “Socrates is a man.” are assumptions, and the statement “Therefore, Socrates is mortal.” is the conclusion drawn from these statements. Effective deductive reasoning involves not only following appropriate argument structure but also utilizing accurate premises. That is, it is possible to form an ineffective deductive reasoning argument by following its structure but utilizing inaccurate premises. For example, the following argument is flawed: “All birds can fly. Penguins are birds. Therefore, penguins can fly.” Even though the argument adheres to the structural rules of deductive reasoning (i.e., a specific conclusion based on a general premise), the statement “All birds can fly.” is erroneous. Students’ skills in recognizing effective deductive reasoning when analyzing information and in articulating effective deductive reasoning when generating arguments are key components of our critical thinking framework. These skills are represented by our first behavioral indicator for the Logical Reasoning subskill in our framework: *Recognizes and applies effective deductive reasoning (CTLR.1)*.

Other forms of logical reasoning are generally categorized as nondeductive reasoning. This distinction reflects the fact that even when nondeductive reasoning arguments follow proper structure and include accurate premises, their conclusions may still be inaccurate. Perhaps the most common form of nondeductive reasoning is inductive reasoning, in which specific premises are used to form reasonable generalizations or predictions (e.g., Hayes & Heit, 2018). Inductive reasoning is common in formal scientific research, where specific observations or data are used to support broader, generalizable claims. For example, a pharmaceutical company may test a new medication on a sample of human research participants to draw conclusions about its efficacy

and side effects in the general population. As a smaller, less formal example, it is possible that the first time a student encounters a swan, that swan is white. This student may then conclude that all swans are white (general conclusion) based on their observation of a white swan (specific premise). Structurally, this argument follows the rules of inductive reasoning (i.e., drawing a general conclusion from a specific premise), and the premise used to draw the conclusion is accurate (that the student observed a white swan). Considered from a strictly deductive reasoning perspective the conclusion is flawed because it is possible for swans to be colors other than white; however, such conclusions are considered reasonable in contexts where inductive reasoning provides sufficient support for our beliefs.

A student's skill in utilizing inductive reasoning relies on their tendency to follow appropriate argument structure and form conclusions that are relatively defensible. However, students should also recognize that their argument may be flawed (e.g., less tenable premises; data that may not be generalizable) and that inductive reasoning is generally less defensible than deductive reasoning (or at least, is evaluated using different standards), given that inductive reasoning leads to probabilistic conclusions whereas the deductive reasoning leads to necessary conclusions (assuming all of its premises are accurate; e.g., Hayes & Heit, 2018). This process is reflected in our second behavioral indicator for the Logical Reasoning subskill, *Recognizes and applies effective inductive reasoning (CT.LR.2)*. Of note, both deduction and induction have been explicitly included in previous critical thinking definitions (e.g., Willingham, 2007, p. 8).

There are several rationales, based on prior research, that explain our decision to distinguish deductive reasoning from inductive reasoning by creating two separate subskills. First, deductive reasoning necessarily leads to only one logically valid conclusion, assuming all the assumptions in the argument are accurate (e.g., Goswami, 2011). This property is untrue for inductive reasoning, which is considered “necessarily probabilistic” (Hayes & Heit, 2018, p. 1). For this reason, researchers often describe deductive reasoning as a superior form of argumentation relative to inductive reasoning (e.g., Hayes & Heit, 2018). This distinction is described as *the problem view* of comparing inductive and deductive reasoning (Hayes & Heit, 2018). These differences supplement logical, functional distinctions between inductive and deductive reasoning, where “induction adds new beliefs whereas deduction draws out implications from what is already believed” (Evans & Over, 2013, p. 267).

Second, researchers have demonstrated that deductive and inductive reasoning reflect distinct psychological processes, accordingly named *the process view comparison* (Hayes & Heit, 2018). Specifically, two-process conceptualizations of reasoning suggest that heuristic and analytic processes are involved in assessing the strengths of arguments (Evans, 2008; Stanovich, 2009). Inductive reasoning relies more heavily on quick heuristic processes that access associative information (e.g., context, similarity) that do not impact an argument’s logical validity (Heit & Rotello, 2010). This conceptualization explains how inductive reasoning arguments can often be invalid. Conversely, deductive reasoning involves slower and more deliberate analytic processes, which explains why they are typically more accurate (Heit & Rotello, 2010). Put differently, inductive reasoning relies more heavily on intuitive (Type 1) processes whereas deductive reasoning more often involves reflective (Type 2) processes (Evans & Over, 2013). Although some researchers argue for a one-process model to explain both inductive and deductive reasoning (e.g., Stephens et al., 2020), a growing body of experimental research supports the two-process model (e.g., Hayes & Heit, 2018; Singmann & Klauer, 2011). The two-process model is also supported by neurological studies that have detected differences in brain activity associated with inductive versus deductive reasoning (Goel et al., 1997; Henson, 2006). Overall, this body of research has recently led some authors to describe the dual-process system as *the dominant paradigm* (Augusto, 2024, p. 279).

Finally, there are plausible practical differences between the types of academic and occupational tasks that involve deductive versus inductive reasoning. For example, deductive reasoning involves applying general principles to specific products or outcomes, such as applying general thermodynamic principles when designing motor vehicle engines or heating and cooling systems for buildings or applying general legal principles to specific criminal cases. Conversely, inductive reasoning involves making connections between various data and inferring general conclusions, such as diagnosing diseases from laboratory test results or synthesizing details of a crime scene to propose the larger nature of the crime (e.g., suspects, motives). In preK–12 settings, these patterns suggest that specific training of inductive versus deductive reasoning skills may facilitate students’ career pathways, regardless of whether those pathways involve employment directly upon graduation or indirectly through college or other postsecondary education avenues.

Students' logical reasoning skills also depend on how they navigate logical fallacies. These fallacies are objective flaws in reasoning that undermine arguments by making them weaker, illogical, invalid, or even deceptive. Although there is no definitive or exhaustive list of logical fallacies, common examples include causal fallacies (i.e., mistaking correlation with causation), “straw person” arguments (i.e., replacing one proposition with another proposition in order to better argue against it, such as quoting someone out of context), false equivalencies, false dichotomies, circular reasoning, and “slippery slope” arguments (i.e., proposing exaggerated potential consequences of a course of action; e.g., Bregant, 2014; Nippold, 2024; Stark, 2000). Logical fallacies are relevant when students seek or analyze information, specifically with regard to students' skill in recognizing such flaws in potential sources of information. Additionally, logical fallacies relate to argument generation through students' skill in avoiding these fallacies when developing and communicating argumentation. Notably, logical fallacies are often discussed in the context of critical thinking (e.g., Bregant, 2014; Nippold, 2024; Stark, 2023). Although students may be unable to articulate the technical or lay terms associated with specific fallacies, students' skill in recognizing and avoiding fallacies is a critical component of strong logical reasoning skills. These factors are reflected in our third behavioral indicator for the Logical Reasoning subskill: *Recognizes and avoids logical fallacies (CT.LR.3)*.

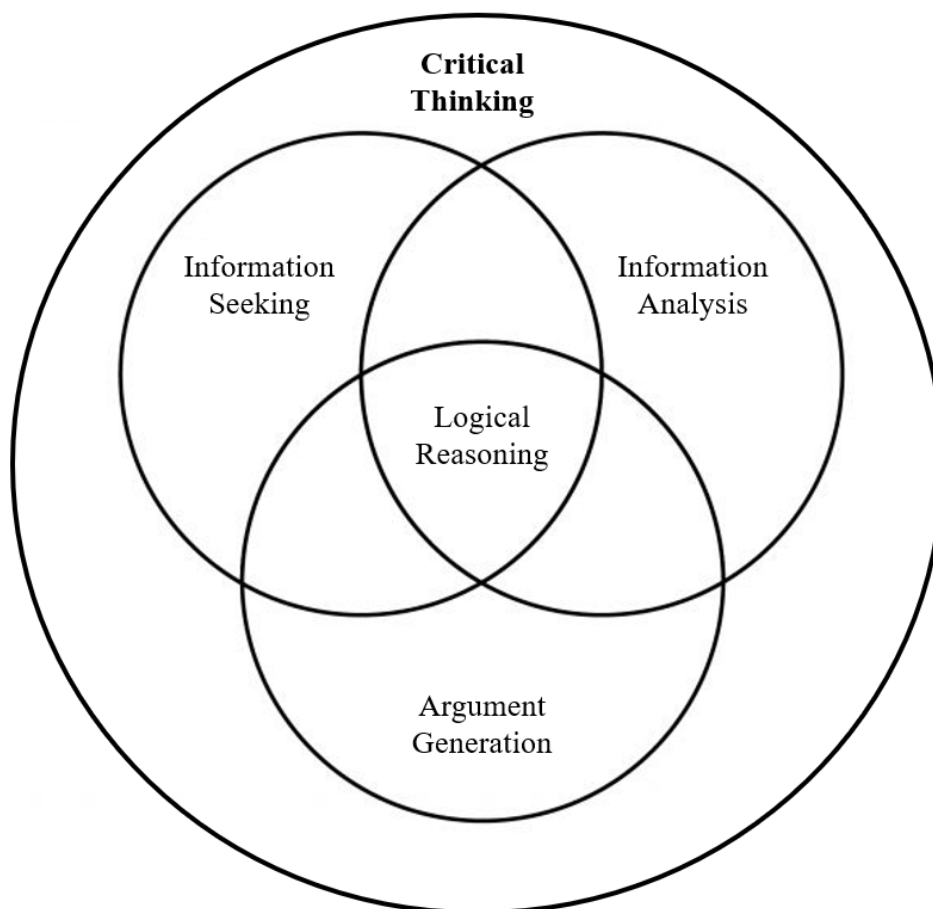
Synthesized Critical Thinking Conceptual Framework: Connecting Critical Thinking Subskills

Figure 1 graphically depicts the relationship among the subskills in our critical thinking conceptual framework. This figure demonstrates that logical reasoning behaviorally manifests within the context of each of the other three subskills. That is, students may seek information sources that have a reputation for demonstrating strong logical reasoning, may recognize sound logical reasoning when analyzing information, and may articulate proper logical reasoning when generating arguments. Our depiction also includes sections of information seeking, information analysis, and argument generation that do not overlap with logical reasoning, reflecting that these three skills may be evaluated through behavioral indicators beyond logical reasoning.

There are also aspects of information seeking, information analysis, and argument generation that may overlap with each other, as illustrated in our depiction. For example, students' skills in processing information may influence their information-seeking behaviors, including students' tendency to refine the types of sources they seek in the future based on their

experiences analyzing past information. Students may also improve their argument generation skills by emulating strong information sources (which they encountered during information seeking) and in recognizing sound information content (i.e., which they have refined during information analysis). Additionally, our depiction recognizes unique aspects of these three critical thinking subskills. It is possible for students to process information that they themselves did not seek out, to seek information but not logically process it for various reasons, or to generate arguments based on novel ideas rather than information that was previously acquired or processed. These variations may be reflected in students who demonstrate high skill levels for some subskills but low levels in others or in occupations that may only include responsibilities in a subset of the subskills (e.g., seeking information and then delegating the information analysis stage to a coworker).

Figure 1. Graphical Depiction of Critical Thinking Conceptual Framework



Significant Elements of the SFF Critical Thinking Conceptual Framework

In developing our conceptual framework for critical thinking, we followed several guidelines that were consistent across all constructs included in SFF. One significant consideration involves the extent to which critical thinking may be categorized under affective, behavioral, or cognitive domains. Our initial description of the SFF taxonomy (Liu et al., 2023) categorized critical thinking as a primarily cognitive construct. However, as outlined previously, our critical thinking framework also includes affective and behavioral elements. Specifically, one's skill in preventing emotions from undermining their critical thinking skills suggests an affective component. Additionally, as previously described, skill indicators were developed by emphasizing objective and overt indicators of critical thinking instead of more covert, subjective ones (e.g., Kell et al., 2017). Thus, critical thinking may be assessed more easily and objectively by external observers while acknowledging that critical thinking may be expressed in multiple specific ways. Nonetheless, our critical thinking definition retains cognitive aspects that have been consistently recognized in previous research. For example, critical thinking overlaps with constructs such as mathematical thinking, scientific thinking, systems thinking, pattern recognition, and other types of cognitive ability (e.g., Macpherson & Stanovich, 2007). Yet, these studies also demonstrate that critical thinking predicts outcomes such as academic performance independent of cognitive ability, suggesting additional noncognitive aspects of critical thinking (e.g., Ren et al., 2020).

Distinguishing SFF Critical Thinking From Other Relevant Noncognitive Constructs

In articulating a framework for critical thinking, we assert the importance of distinguishing this skill from other similar skills or terms. For example, our review of state Portraits of a Graduate, the scientific literature, and other frameworks (e.g., America Succeeds, 2023; XQ Institute, n.d.) identified several terms that are presented in the context of critical thinking. Some of these terms are included within our framework as example behavioral indicators, including *troubleshooting*, *analytical thinking*, *interpreting information*, *logical thinking*, and *synthesis*. Thus, we recommend that these terms should not be used interchangeably with critical thinking as a broader concept. Other terms found in the literature represent specific situations or contexts under which critical thinking may be applied, including *research*, *investigation*, and *data analysis*. These terms also describe technical skills and may be

influenced by skills beyond critical thinking. Thus, we again recommend that these terms should not be conflated with critical thinking.

Problem Solving

Another skill that is mentioned frequently in the context of critical thinking is problem solving (e.g., Sternberg, 1986; Willingham, 2007). Unfortunately, problem solving appears to be a poorly defined skill in most conceptual frameworks. For example, one of the more obvious definitions for problem solving is tautological (one's ability to solve problems). Moreover, we argue that problem solving is an outcome-driven skill that may be relevant to a wide range of other noncognitive constructs. For instance, constructs such as perseverance, collaboration, creativity, leadership, and many others may be utilized to solve the same problem. In fact, some definitions of problem solving describe it as the application of critical thinking skills (Golubovich et al., 2017; Sternberg, 1986; Willingham, 2007). That is, critical thinking may represent one process for solving some specific problems but is not considered a proxy for problem solving as a distinct skill. The issue of construct drift then arises when skills such as collaborative problem solving (e.g., Sun et al., 2020) and creative problem solving (e.g., Treffinger et al., 2006) are utilized. The contextual nature of problem solving is also reflected when discipline or subject matter terms are included in terminology (e.g., mathematical problem solving). These issues complicate practical applications such as assessment development and training. Thus, we strongly recommend that problem solving be omitted from critical thinking definitions, an explicit decision we made when developing our own conceptual framework.

Persuasiveness

Persuasiveness (or persuasion) is another skill that may be conflated with critical thinking, particularly with our Argument Generation subskill. Generally, persuasiveness is defined as one's skill in influencing others' attitudes or behaviors (e.g., Druckman, 2022). However, similar to problem solving, these definitions highlight that persuasiveness is largely an outcome-driven construct. It is also plausible that persuasiveness and critical thinking (i.e., argument generation) are independent constructs. For example, it is possible for a logically sound, fact-based argument to be nonpersuasive, and it is also possible to persuade individuals with arguments that are illogical and not based upon facts or strong evidence. Moreover, researchers have demonstrated that persuasion as an outcome may be influenced by several

factors such as the speaker, the content of the argument, the audience, and the medium by which the argument is communicated (Druckman, 2022). Thus, we explicitly separate persuasiveness from critical thinking. Specifically, students' skill in persuading others is considered distinct from students' skill in generating sound arguments. Similarly, a student's tendency to be persuaded by illogical, opinion-based, or otherwise flawed arguments conflicts with the definition of strong information analysis skills.

Communication Skills

There is also overlap between critical thinking and communication skills. However, this overlap is primarily due to the expansive scope that defines communication skills. Thus, depending on one's definition of communication skills, one may argue that critical thinking be considered a subset of communication skills. As noted previously, a commonality between communication skills and SFF critical thinking is that both involve receptive and expressive elements. Using our critical thinking subskills as a reference, the information-seeking behavioral indicators represent examples of receptive communication skills (e.g., reading information sources) and expressive communication (e.g., asking questions in writing, speaking, or other forms of communication). Information analysis also requires receptive communication (e.g., reading or listening to information, and processing the information read or heard) and expressive communication (e.g., fact checking by verbally asking, typing, or writing questions, or through other communicative means). By definition, argument generation is a largely expressive communication skill, either through writing, speaking, or other types of communication. For these reasons, effort was taken to ensure that the SFF definitions of critical thinking and communications skills (Ober et al., 2025) have minimal or low-level overlap. Practically, communication skills assessments should focus on the communication aspects, whereas critical thinking assessments should focus on critical thinking aspects. That is, examples of communication skills conducted for the purpose of information seeking, information analysis, and argument generation should be excluded from the SFF communication skills definition. Instead, this definition focuses on the underlying processes and act of communicating itself and regards communication skills as encompassing the use of multiple modalities to convey ideas, the ability to adapt communication styles, active listening and comprehension, as well as knowledge and use of social, emotion, and ethical aspects of communication (Ober et al., 2025). This practice was applied across the other constructs included in the SFF framework (e.g.,

perseverance, see Williams et al., 2026). We encourage researchers and practitioners to exercise similar efforts to avoid redundancies and confusion between various skills within a similar framework, particularly when considering sprawling constructs like communication skills.

Digital Literacy, Digital Information Literacy, and Artificial Intelligence (AI) Literacy

Digital literacy, digital information literacy, and AI literacy are three constructs that have seen growing interest recently (e.g., Sparks et al., 2016). Broadly, these constructs reflect one's skill in navigating and utilizing digital/AI tools and information. These constructs overlap with critical thinking in that much of the information individuals consume is through digital media. The digital space also represents a significant channel individuals use for communicating arguments. Critical thinking is also relevant to AI in contexts such as prompt generation and interacting with bots (i.e., information seeking) and when identifying AI-generated content or evaluating AI-summarized information (i.e., information analysis). However, digital literacy, digital information literacy, and AI literacy are relatively expansive concepts that include other durable and technical skills. Moreover, digital and AI contexts represent only a subset of those relevant to critical thinking. Thus, we posit that critical thinking overlaps with digital/AI literacy but is not synonymous.

Curiosity

By definition, one of the primary characteristics of curiosity is one's desire for knowledge. By this logic, the trait of curiosity overlaps with our critical thinking conceptualization, particularly the Information Seeking subskill. However, the key distinction between information seeking and curiosity as individual difference constructs is that the latter is largely viewed as a disposition. For example, the Big Five (see McCrae & Costa, 2008) and HEXACO (Ashton & Lee, 2007) personality models each describe curiosity—also referred to as inquisitiveness—as a subconstruct within the larger construct of Openness to Experience. However, unlike our Information Seeking subskill, these models make no assumptions about one's skill in seeking information. Instead, curiosity tends to be conceptualized as one's general tendency to ask questions and seek knowledge (McCrae & Costa, 2008). That is, curious individuals may demonstrate frequent information-seeking behaviors, though they may not be particularly adept at formulating pertinent questions or pursuing relevant sources. Thus, although curiosity may be considered a prerequisite for critical thinking (i.e., information seeking) in that

incurious individuals may not even attempt to pursue information, they remain subtly distinct constructs.

Discussion

With the abundance and free access of knowledge embodied by the information age and social media, the importance of strong critical thinking skills has grown dramatically. The rise of misinformation and disinformation further emphasizes this importance, given that critical thinking influences “what to do or what to believe” (P. A. Facione, 2000, p. 61). In turn, critical thinking is pertinent to various life areas, including academia, the workplace, and our personal lives. Researchers have explicitly argued for critical thinking skills’ importance to the process of learning (Sternberg, 1986), further supporting its relevance to preK–12 settings. However, the focus on critical thinking education in preK–12 settings also acknowledges that these efforts are designed to help students not only within their current academic studies but also in subsequent postsecondary and workplace settings. For example, as AI assumes more menial tasks previously conducted by humans and becomes more sophisticated, individuals’ use of critical thinking skills in interacting with AI agents and AI-generated information will become more common and more crucial. Specifically, in the context of human critical thinking applications, researchers have argued that information summarized or generated by AI may be prone to “potential for echo chambers, and difficulties in nuanced understanding” (Darwin et al., 2024, p. 2). In turn, there is sentiment that AI should not replace human intelligence, particularly in situations where human critical thinking intersects with AI-augmented educational applications (Spector & Ma, 2019). These applications may be found in both the classroom and the workplace.

Although some efforts have been made to formally cultivate critical thinking skills in structured settings such as classrooms and workplace training programs (e.g., Bronkhorst et al., 2021; Nagizadeh et al., 2023; Song et al., 2024), there are many other contexts that rely on the more autonomous practice of critical thinking. Particularly, as more individuals desire to “do their own research” on various critical topics, critical thinking is imperative for identifying potentially harmful misinformation. Although some forms of misinformation are relatively benign, others—particularly disinformation—have been linked to phenomena such as radicalization and extremism (Awan et al., 2023; Roberts-Ingleson & McCann, 2023), hate speech and racism (Kim & Kesari, 2021), medical fraud (Xiang & Lehmann, 2021), conspiracy theories (Pereira et al., 2020), identity theft (Gilbert & Gong, 2024), and financial scams

(Damulis, 2023). These outcomes highlight the need for rigorous assessment and teaching of critical thinking skills, which should be founded upon a clear conceptual framework. Again, these efforts may be most effective if initiated in preK–12 settings.

We describe a new conceptual framework for critical thinking that outlines its key components. These components relate to the various stages of navigating and utilizing information: information seeking, information analysis, argument generation, and logical reasoning. In defining these subskills, we emphasize overt behavioral indicators to facilitate objective and accurate measurement by self-report and by outside observers (e.g., parents, teachers, etc.). This strategy also permits variations in specific behavioral manifestations of critical thinking skills, which may reflect demographic, cultural, social, or regional norms. In addition to behavioral components, our definition reflects important affective and cognitive aspects of critical thinking. Moreover, we define critical thinking as both a skill and a disposition. That is, our behavioral indicators reflect individuals' proficiency in demonstrating critical thinking skills and their initiative in exhibiting these skills across situations without prompting. Importantly, we differentiate critical thinking from other overlapping skills such as cognitive ability, problem solving, digital/AI literacy, communication skills, and persuasiveness. The goal of this initiative is to facilitate clearer understanding of the critical thinking construct, which should benefit measurement and teaching applications.

Various specific assessment approaches may be informed by our critical thinking framework. For example, standardized, objective measurement of critical thinking through formats such as behaviorally anchored rating scales, surveys, situational judgment tasks, or observational methods (e.g., Kyllonen, 2012; Kyllonen et al., 2024) may be explored. Additionally, these strategies may include test-free methods such as process data, transcripts, or other sources that capture critical thinking behaviors demonstrated organically inside and outside of the classroom. Such applications should also be amenable to domain- or discipline-specific measurement of critical thinking (e.g., mathematics, social studies, science). Critical thinking assessments could also be utilized to guide and evaluate deliberate training efforts or in tracking natural longitudinal changes in preK–12 education, including their role in predicting academic success. Additionally, our preK–12 conceptualization of critical thinking may be usefully applied to adults, though this assertion should be empirically investigated. Such research could aid in describing the development of critical thinking from adolescence into adulthood.

Assessment-related research is vital for informing potential developmental benchmarks for critical thinking based on age or grade. However, by its very nature, critical thinking may be difficult to observe naturalistically in a classroom environment. Processes such as information seeking and analysis may be largely covert, requiring classroom activities to be structured such that there is adequate opportunity for critical thinking skills to be demonstrated. For example, students may articulate the difference between facts and opinions, or their evaluation and consequent weighting of more versus less credible evidence may be demonstrated through decision-making, argumentation, or problem-solving activities. Alternatively, educators may need to prompt students or utilize direct assessments to adequately measure critical thinking. The behavioral indicators included in our critical thinking framework may be useful in guiding these efforts.

Critical thinking assessment and training applications should also acknowledge that various student, situational, or sociocultural factors may influence the behavioral demonstration of critical thinking. For example, Bloom's (1956) taxonomy specifies that lower order skills related to memory and comprehension are prerequisites for demonstrating higher order skills related to critical thinking (e.g., information analysis and application). Similarly, a basic level of reading comprehension or written communication skills may be necessary to demonstrate specific behavioral demonstrations of critical thinking. Additionally, sociocultural influences may be integrated into critical thinking assessments by providing students with subject matter that is personalized to their lived experience. Alternatively, a variety of valid critical thinking demonstrations may be elicited through response formats such as open-ended assessment prompts, or by adopting assignment formats that encourage students to choose their own specific topics of inquiry within a broader scope of study (e.g., mathematics, social sciences). Thus, students are provided with the flexibility to demonstrate skills in a familiar way, as opposed to matching a rigid template or perspective (Bennett, 2023).

Related to these points, we also clarify that various contextual or other factors may influence students' behavioral manifestation of critical thinking. Specifically, we consider critical thinking to be domain general, in that it should be assessed in a similar manner across subject matter areas but may still be influenced by students' knowledge in particular areas. For example, in our framework, a student who only demonstrates critical thinking in domains that they are interested in would be considered to possess lower critical thinking skills than one who

demonstrates critical thinking regardless of their personal interest level. Subject matter knowledge may also influence critical thinking demonstrations, as a student may not fact-check information that they already conclusively know to be true or false, for instance. Other factors such as student motivation, teacher characteristics, or classroom environment may also moderate students' critical thinking behaviors. For these reasons, we recommend that students' critical thinking be assessed as an aggregate across multiple settings, domain areas, and contexts (e.g., in and out of school settings).

These assessments should facilitate research that may empirically support our critical thinking framework or suggest revisions. It is possible that some of the subskills or behavioral indicators in our framework may require consolidation or that additional elements should be included. For example, researchers often distinguish other types of nondeductive reasoning beyond inductive reasoning, such as abductive reasoning, analogical reasoning, and analytical reasoning. Kovács and Spens (2005) described abduction as “an intuitive leap that comes forth as a whole” and “the systematized creativity or intuition...to develop ‘new’ knowledge,” which “is necessary to break out of the limitations of deduction and induction” (p. 136). In research settings, abduction is utilized when attempting to explain novel or anomalous findings and, thus, follows a logical reasoning process that is distinct from induction and deduction (Kovács & Spens, 2005). Alternatively, analogical reasoning involves one's ability to recognize and articulate relationships between concepts using the general structure “A is to B as C is to D” and is, therefore, seen as critical in understanding and explaining complex or technical concepts in familiar or nontechnical terms (e.g., Gentner & Maravilla, 2018). Finally, analytic reasoning is described as the “ability to understand a structure of relationships and draw conclusions about that structure” as defined by the Law School Admission Test (LSAT) Analytical Reasoning section, which is separate from the LSAT Logical Reasoning section (Law School Admission Council, 2024a). Example analytical reasoning questions on the LSAT and other similar assessments often present hypothetical scenarios that require test takers to determine appropriate solutions for a problem given a set of restrictions and contingencies, such as seating arrangements around a table or a weekly schedule of events. Interestingly, the LSAT Analytical Reasoning section was replaced with the LSAT Argumentative Writing section, which is designed to measure analytical evaluation (Law School Admission Council, 2024b). For now, we have excluded these types of reasoning to maintain a relatively concise conceptual framework

for critical thinking. We included deductive and inductive reasoning as distinct behavioral indicators because they appear to be the most well-researched types of logical reasoning (e.g., Goswami, 2011), but additional research may support adding other subskills.

Conclusion

In this paper, we aimed to expand educational and psychological research by developing a conceptualization of critical thinking that is specifically relevant to preK–12 applications. These applications include assessment and development efforts, facilitated by emphasizing objective, overt indicators over subjective, covert ones. Specifically, largely based on a synthesis of prior research, our framework proposes four critical thinking subskills: Information Seeking, Information Analysis, Argument Generation, and Logical Reasoning. This framework is proposed to standardize and clarify behavioral demonstrations of critical thinking, while acknowledging that such demonstrations may be influenced by contextual or sociocultural norms. Overall, these applications and supporting research are critical for establishing empirical evidence relating to the nature of critical thinking. In turn, educators may support students' skills in navigating the information, misinformation, and disinformation age in preK–12 settings and beyond.

References

- Abrami, P. C., Bernard, R. M., Borokhovski, E., Wade, A., Surkes, M. A., Tamim, R., & Zhang, D. (2008). Instructional interventions affecting critical thinking skills and dispositions: A stage 1 meta-analysis. *Review of Educational Research*, 78(4), 1102–1134.
<https://doi.org/10.3102/0034654308326084>
- Alwehaibi, H. U. (2012). Novel program to promote critical thinking among higher education students: Empirical study from Saudi Arabia. *Asian Social Science*, 8(11), 193–204.
<https://doi.org/10.5539/ass.v8n11p193>
- America Succeeds. (2023). *Durable skills advantage framework*.
- Ashton, M. C., & Lee, K. (2007). Empirical, theoretical, and practical advantages of the HEXACO model of personality structure. *Personality and Social Psychology Review*, 11(2), 150–166. <https://doi.org/10.1177/1088868306294907>
- Association of American Colleges and Universities. (n.d.). *Valid assessment of learning in undergraduate education (VALUE)*. <https://www.aacu.org/value>
- Athanassiou, N., McNett, J. M., & Harvey, C. (2003). Critical thinking in the management classroom: Bloom’s taxonomy as a learning tool. *Journal of Management Education*, 27(5), 533–555. <https://doi.org/10.1177/1052562903252515>
- Augusto, R. (2024). Two kinds of process or two kinds of processing? Disambiguating dual-process theories. *Review of Philosophy and Psychology*, 15, 277–298.
<https://doi.org/10.1007/s13164-023-00673-1>
- Awan, I., Carter, P., Sutch, H., & Lally, H. (2023). Online extremism and Islamophobic language and sentiment when discussing the COVID-19 pandemic and misinformation on Twitter. *Ethnic and Racial Studies*, 46(7), 1407–1436.
<https://doi.org/10.1080/01419870.2022.2146449>
- Battersby, M., & Bailin, S. (2018). *Inquiry: A new paradigm for critical thinking*. University of Windsor. <https://doi.org/10.22329/wsia.07.2018>
- Behar-Horenstein, L. S., & Niu, L. (2011). Teaching critical thinking skills in higher education: A review of the literature. *Journal of College Teaching & Learning*, 8(2), 25–41.
<https://doi.org/10.19030/tlc.v8i2.3554>
- Bennett, R. E. (2023). Toward a theory of socioculturally responsive assessment. *Educational Assessment*, 28(2), 83–104. <https://doi.org/10.1080/10627197.2023.2202312>

- Bennett, W. L., & Livingston, S. (Eds.). (2021). *The disinformation age: Politics, technology, and disruptive communication in the United States*. Cambridge University Press.
<https://doi.org/10.1017/9781108914628>
- Bloom, B. S. (Ed.). (1956). *Taxonomy of educational objectives: The classification of educational goals: Handbook. I. Cognitive domain*. Longmans.
- Bouhnik, D., & Giat, Y. (2009). Teaching high school students applied logical reasoning. *Journal of Information Technology Education: Innovations in Practice*, 8(1), 1–16.
<https://doi.org/10.28945/169>
- Bregant, J. (2014). Critical thinking in education: Why to avoid logical fallacies? *Problems of Education in the 21st Century*, 61(1), 18–27. <https://doi.org/10.33225/pec/14.61.18>
- Bronkhorst, H., Roorda, G., Suhre, C., & Goedhart, M. (2021). Student development in logical reasoning: Results of an intervention guiding students through different modes of visual and formal representation. *Canadian Journal of Science, Mathematics and Technology Education*, 21, 378–399. <https://doi.org/10.1007/s42330-021-00148-4>
- Bronkhorst, H., Roorda, G., Suhre, C., & Goedhart, M. (2022). Students’ use of formalisations for improved logical reasoning. *Research in Mathematics Education*, 24(3), 291–323.
<https://doi.org/10.1080/14794802.2021.1991463>
- Butler, H. A. (2012). Halpern Critical Thinking Assessment predicts real-world outcomes of critical thinking. *Applied Cognitive Psychology*, 26(5), 721–729.
<https://doi.org/10.1002/acp.2851>
- Butler, H. A., Pentoney, C., & Bong, M. P. (2017). Predicting real-world outcomes: Critical thinking ability is a better predictor of life decisions than intelligence. *Thinking Skills and Creativity*, 25, 38–46. <https://doi.org/10.1016/j.tsc.2017.06.005>
- Chakraborty, S., Ober, T. M., & Liu, L. (2025). *Preparing K–12 students with AI literacy: Proposed framework, progression, and task design principles* (Research Report No. RR–25-14). ETS. <https://doi.org/10.64634/46jn1p41>
- Cook, J., Ecker, U., & Lewandowsky, S. (2015). Misinformation and how to correct it. In R. A. Scott & M. C. Buchmann (Eds.) with S. M. Kosslyn, *Emerging trends in the social and behavioral sciences: An interdisciplinary, searchable, and linkable resource*.
<https://doi.org/10.1002/9781118900772.etrds0222>

- Copi, I., Cohen, C., & Flage, D. (2005). *Essentials of logic* (2nd ed). Routledge.
<https://doi.org/10.4324/9781315389028>
- Damulis, M. (2023). Investigations of financial fraud: Literature analysis of selected financial scams. In A. Rafay (Ed.), *Theory and practice of illegitimate finance* (pp. 203–221). IGI Global. <https://doi.org/10.4018/979-8-3693-1190-5.ch011>
- Darwin, D. R., Mukminatien, N., Suryati, N., Laksmi, E. D., & Marzuki. (2024). Critical thinking in the AI era: An exploration of EFL students' perceptions, benefits, and limitations. *Cogent Education*, 11(1), Article 2290342.
<https://doi.org/10.1080/2331186X.2023.2290342>
- Desai, M. S., Berger, B. D., & Higgs, R. (2016). Critical thinking skills for business school graduates as demanded by employers: A strategic perspective and recommendations. *The Academy of Educational Leadership Journal*, 20(1), 10–31.
- Druckman, J. N. (2022). A framework for the study of persuasion. *Annual Review of Political Science*, 25, 65–88. <https://doi.org/10.1146/annurev-polisci-051120-110428>
- Duron, R., Limback, B., & Waugh, W. (2006). Critical thinking framework for any discipline. *International Journal of Teaching and Learning in Higher Education*, 17(2), 160–166.
<https://isetl.org/ijtlhe/pdf/IJTLHE55.pdf?pagewanted=all>
- Ennis, R. H. (1985). A logical basis for measuring critical thinking skills. *Educational Leadership*, 43(2), 44–48. <https://www.ascd.org/el/articles/a-logical-basis-for-measuring-critical-thinking-skills>
- Evans, J. S. B. T. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology*, 59, 255–278.
<https://doi.org/10.1146/annurev.psych.59.103006.093629>
- Evans, J. S. B. T., & Over, D. E. (2013). Reasoning to and from belief: Deduction and induction are still distinct. *Thinking & Reasoning*, 19(3–4), 267–283.
<https://doi.org/10.1080/13546783.2012.745450>
- Facione, N. C., & Facione, P. A. (2008). Critical thinking and clinical judgment. In N. C. Facione & P. A. Facione (Eds.), *Critical thinking and clinical reasoning in the health sciences: An international multidisciplinary teaching anthology* (pp. 1–3). California Academic Press.

- Facione, P. A. (1990). *Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction. Research findings and recommendations*. American Philosophical Association.
- Facione, P. A. (2000). The disposition toward critical thinking: Its character, measurement, and relationship to critical thinking skill. *Informal Logic*, 20(1), 61–84.
<https://doi.org/10.22329/il.v20i1.2254>
- Fong, C. J., Kim, Y., Davis, C. W., Hoang, T., & Kim, Y. W. (2017). A meta-analysis on critical thinking and community college student achievement. *Thinking Skills and Creativity*, 26, 71–83. <https://doi.org/10.1016/j.tsc.2017.06.002>
- Gehlbach, H., Robinson, C. D., & Fletcher, A. (2024). The illusion of information adequacy. *PLoS ONE*, 19(10), Article e0310216. <https://doi.org/10.1371/journal.pone.0310216>
- Gellin, A. (2003). The effect of undergraduate student involvement on critical thinking: A meta-analysis of the literature 1991–2000. *Journal of College Student Development*, 44(6), 746–762. <https://doi.org/10.1353/csd.2003.0066>
- Gentner, D., & Maravilla, F. (2018). Analogical reasoning. In L. J. Ball & V. A. Thompson (Eds.), *International handbook of thinking & reasoning* (pp. 186–203). Psychology Press.
https://groups.psych.northwestern.edu/gentner/papers/GentnerMaravilla_2018-Handbook.pdf
- Gilbert, A., & Gong, Z. (2024). Digital identity theft using deepfakes. In S. C. Wingreen & A. Samandari (Eds.), *Information technology security and risk management: Inductive cases for information security* (pp. 307–314). CRC Press.
<https://doi.org/10.1201/9781003264415-47>
- Golubovich, J., Su, R., & Robbins, S. B. (2017). Establishing an international standards framework and action research agenda for workplace readiness and success. In J. Burrus, K. D. Mattern, B. D. Naemi, & R. D. Roberts (Eds.), *Building better students: Preparation for the workforce* (pp. 303–338). Oxford University Press.
<https://doi.org/10.1093/acprof:oso/9780199373222.001.0001>
- Goel, V., Gold, B., Kapur, S., & Houle, S. (1997). The seats of reason? An imaging study of deductive and inductive reasoning. *NeuroReport*, 8(5), 1305–1310.

- Goswami, U. (2011). Inductive and deductive reasoning. In U. Goswami (Ed.), *The Wiley-Blackwell handbook of childhood cognitive development* (2nd ed., pp. 399–419). Blackwell. <https://doi.org/10.1002/9781444325485>
- Halpern, D. F. (1998). Teaching critical thinking for transfer across domains: Disposition, skills, structure training, and metacognitive monitoring. *American Psychologist*, 53(4), 449–455. <https://doi.org/10.1037/0003-066X.53.4.449>
- Hart Research Associates. (2009). *Trends in learning outcomes, general education, and assessment: A survey among members of The Association of American Colleges and Universities*. Association of American Colleges and Universities.
- Hayes, B. K., & Heit, E. (2018). Inductive reasoning 2.0. *WIREs Cognitive Science*, 9(3), Article e1459. <https://doi.org/10.1002/wcs.1459>
- Heit, E., & Rotello, C. M. (2010). Relations between inductive reasoning and deductive reasoning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 36(3), 805–812. <https://doi.org/10.1037/a0018784>
- Huber, C. R., & Kuncel, N. R. (2016). Does college teach critical thinking? A meta-analysis. *Review of Educational Research*, 86(2), 431–468. <https://doi.org/10.3102/0034654315605917>
- Indrašienė, V., Jegelevičienė, V., Merfeldaitė, O., Penkauskienė, D., Pivorienė, J., Railienė, A., & Sadauskas, J. (2023). Value of critical thinking in the labour market: Variations in employers' and employees' views. *Social Sciences*, 12(4), 221–235. <https://doi.org/10.3390/socsci12040221>
- Kallet, M. (2014). *Think smarter: Critical thinking to improve problem-solving and decision-making skills*. Wiley.
- Kell, H. J., Martin-Raugh, M. O., Carney, L. M., Inglese, P. A., Chen, L., & Feng, G. (2017). *Exploring methods for developing behaviorally anchored rating scales for evaluating structured interview performance* (Research Report No. RR–17-28). ETS. <https://doi.org/10.1002/ets2.12152>
- Kim, J. Y., & Kesari, A. (2021). Misinformation and hate speech: The case of anti-Asian hate speech during the COVID-19 pandemic. *Journal of Online Trust & Safety*, 1(1), 1–14. <https://doi.org/10.54501/jots.v1i1.13>

- Kovács, G., & Spens, K. M. (2005). Abductive reasoning in logistics research. *International Journal of Physical Distribution & Logistics Management*, 35(2), 132–144.
<https://doi.org/10.1108/09600030510590318>
- Kyllonen, P. C. (2012, May 7–8). *Measurement of 21st century skills within common core state standards* [Paper presentation]. Invitational Research Symposium on Technology Enhanced Assessments, ETS, Washington, D.C., United States.
<http://www.ets.org/Media/Research/pdf/session5-kyllonen-paper-tea2012.pdf>
- Kyllonen, P., Sevak, A., Ober, T., Choi, I., Sparks, J., & Fishtein, D. (2024). *Charting the future of assessments* (Research Report No. RR–24-13). ETS.
<https://doi.org/10.1002/ets2.12388>
- Lai, E. R. (2011). Critical thinking: A literature review. *Pearson's Research Reports*, 6, 40–41.
- Law School Admission Council. (2024a). *Types of LSAT questions*. Retrieved December 30, 2024, from <https://www.lsac.org/lsat/prepare/types-lsat-questions>
- Law School Admission Council. (2024b). *LSAT argumentative writing*. Retrieved December 30, 2024, from <https://www.lsac.org/lsat/about/lsat-argumentative-writing>.
- Levine, E., & Patrick, S. (2019). *What is competency-based education? An updated definition*. (ED604019). ERIC. <http://files.eric.ed.gov/fulltext/ED604019.pdf>
- Liu, H., Ludu, M., & Holton, D. (2015). Can K–12 math teachers train students to make valid logical reasoning? In X. Ge, D. Ifenthaler, & J. Spector (Eds.), *Emerging technologies for STEAM education: Full STEAM ahead* (pp. 331–353). Springer.
https://doi.org/10.1007/978-3-319-02573-5_18
- Liu, L., Courey, K. A., Kinsey, D., Ober, T. M., & Johnson, D. G. (2025). *Navigating the digital horizon: A proposed framework and strategies for assessing digital literacy* (Research Report No. RR–25-06). ETS. <https://doi.org/10.64634/9jatfh97>
- Liu, O. L., Frankel, L., & Roorh, K. C. (2014). *Assessing critical thinking in higher education: Current state and directions for next-generation assessment* (ETS Research Report Series No. RR–14-10). ETS. <https://doi.org/10.1002/ets2.12009>
- Liu, O. L., Kell, H. J., Liu, L., Ling, G., Wang, Y., Wylie, C., Sevak, A., Sherer, D., LeMahieu, P., & Knowles, T. (2023). *A new vision for skills-based assessment*. ETS.
<https://www.ets.org/pdfs/rd/new-vision-skills-based-assessment.pdf>

- Macpherson, R., & Stanovich, K.E. (2007). Cognitive ability, thinking dispositions, and instructional set as predictors of critical thinking. *Learning and Individual Differences, 17*(2), 115–127. <https://doi.org/10.1016/j.lindif.2007.05.003>
- Mainert, J., Niepel, C., Murphy, K. R., & Greiff, S. (2019). The incremental contribution of complex problem-solving skills to the prediction of job level, job complexity, and salary. *Journal of Business and Psychology, 34*(6), 825–845. <https://doi.org/10.1007/s10869-018-9561-x>
- McCrae, R. R., & Costa, P. T., Jr. (2008). Empirical and theoretical status of the Five-Factor Model of personality traits. In G. J. Boyle, G. Matthews, & D. H. Saklofske (Eds.), *The SAGE handbook of personality theory and assessment: Personality theories and models* (Vol. 1, pp. 273–294). Sage. <https://doi.org/10.4135/9781849200462.n13>
- McMillan, J. H. (1987). Enhancing college students' critical thinking: A review of studies. *Research in Higher Education, 26*, 3–29. <https://doi.org/10.1007/BF00991931>
- Meyers, R. G. (2006). *Understanding empiricism*. Routledge. <https://doi.org/10.4324/9781315712062>
- Murawski, L. M. (2014). Critical thinking in the classroom...and beyond. *Journal of Learning in Higher Education, 10*(1), 25–30.
- Nagizadeh, F., Nosratabad, T. H., & Ghaffari, A. (2023). Effectiveness of critical thinking strategies training in the questioning, evaluation, logical reasoning, and problem solving abilities among high school students. *Cognitive Strategies in Learning, 11*(21), 71–88. <https://doi.org/10.22084/j.psychogy.2023.28035.2598>
- Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence, 2*, Article 100041. <https://doi.org/10.1016/j.caeai.2021.100041>
- Nippold, M. A. (2024). Unlocking logical fallacies: A key to building critical thinking skills in adolescents. *Perspectives of the ASHA Special Interest Groups, 9*(1), 1–13. https://doi.org/10.1044/2023_PERSP-23-00108
- Ober, T. M., Johnson, D. G., Liu, L., Kinsey, D., & Courey, K. A. (2025). *Communication as a future ready skill: A proposed framework and strategies for assessment* (Research Report No. RR–25-05). ETS. <https://doi.org/10.64634/2h5c6j22>

- Pereira, P. S., da Silva Silveira, A., & Pereira, A. (2020). Disinformation and conspiracy theories in the age of COVID-19. *Frontiers in Psychology, 5*, Article 560681. <https://doi.org/10.3389/fsoc.2020.560681>
- Peterson, E. K., Douglas, D., & Van Noy, M. (2024). *The growth of skills-based hiring: An exploration of evidence from six states*. Education and Employment Research Center, Rutgers-New Brunswick School of Management and Business Relations.
- Rahman, S. A., & Manaf, N. F. A. (2017). A critical analysis of Bloom’s taxonomy in teaching creative and critical thinking skills in Malaysia through English literature. *English Language Teaching, 10*(9), 245–256. <https://doi.org/10.5539/elt.v10n9p245>
- Ren, X., Tong, Y., Peng, P., & Wang, T. (2020). Critical thinking predicts academic performance beyond general cognitive ability: Evidence from adults and children. *Intelligence, 82*, Article 101487. <https://doi.org/10.1016/j.intell.2020.101487>
- Roberts-Ingleson, E. M., & McCann, W. S. (2023). The link between misinformation and radicalisation: Current knowledge and areas for future inquiry. *Perspectives on Terrorism, 17*(1), 36–49. <https://doi.org/10.19165/LWPQ5491>
- Santos-Meneses, L. F., Pashchenko, T., & Mikhailova, A. (2023). Critical thinking in the context of adult learning through PBL and e-learning: A course framework. *Thinking Skills and Creativity, 49*, Article 101358. <https://doi.org/10.1016/j.tsc.2023.101358>
- Schlosser, R. W., & O’Neil-Pirozzi, T. M. (2006, Spring). Problem formulation in evidence-based practice and systematic reviews. *Contemporary Issues in Communication Science and Disorders, 33*, 5–10. https://doi.org/10.1044/cicsd_33_S_5
- Simon, H. A. (2001). Problem solving and reasoning, psychology of. In N. J. Smelser & P. B. Baltes (Eds.), *International encyclopedia of the social & behavioral sciences* (pp. 12120–12123). Elsevier.
- Singmann, H., & Klauer, K. C. (2011). Deductive and inductive conditional inferences: Two modes of reasoning. *Thinking & Reasoning, 17*(3), 247–281. <https://doi.org/10.1080/13546783.2011.572718>
- Society for Human Resource Management. (2024). *2024 talent trends*.
- Song, Y., Roohr, K. C., & Kirova, D. (2024). Exploring approaches for developing and evaluating workplace critical thinking skills. *Thinking Skills and Creativity, 51*, Article 101460. <https://doi.org/10.1016/j.tsc.2023.101460>

- Sparks, J. R., Katz, I. R., & Beile, P. M. (2016). *Assessing digital information literacy in higher education: A review of existing frameworks and assessments with recommendations for next-generation assessment*. (Research Report No. RR–16-32). ETS.
<https://doi.org/10.1002/ets2.12118>
- Spector, J. M., & Ma, S. (2019). Inquiry and critical thinking skills for the next generation: From artificial intelligence back to human intelligence. *Smart Learning Environments*, 6(8).
<https://doi.org/10.1186/s40561-019-0088-z>
- Stanovich, K. E. (2009). *What intelligence tests miss: The psychology of rational thought*. Yale.
- Stark, H. E. (2000). Fallacies and logical errors. *Inquiry: Critical Thinking Across the Disciplines*, 20(1), 23–32. <https://doi.org/10.5840/inquiryctnews200020112>
- Stephens, R. G., Dunn, J. C., Hayes, B. K., & Kalish, M. L. (2020). A test of two processes: The effect of training on deductive and inductive reasoning. *Cognition*, 199, Article 104223.
<https://doi.org/10.1016/j.cognition.2020.104223>
- Sternberg, R. J. (1986). *Critical thinking: Its nature, measurement, and improvement*. National Institute of Education (ED272882). ERIC. <http://files.eric.ed.gov/fulltext/ED272882.pdf>
- Sun, C., Shute, V. J., Stewart, A., Yonehiro, J., Duran, N., & D’Mello, S. (2020). Towards a generalized competency model of collaborative problem solving. *Computers & Education*, 143, Article 103672. <https://doi.org/10.1016/j.compedu.2019.103672>
- Treffinger, D. J., Isaken, S. G., & Stead-Dorval, K. B. (2006). *Creative problem solving: An introduction*. Routledge. <https://doi.org/10.4324/9781003419327>
- Williams, K. M., Ling, G., Sotelo, J., Brantley, W., Wang, Y., & Kinsey, D. (2026). *Keep calm and carry on: A conceptual framework for perseverance* (Research Report No. RR–26-01). ETS. <https://doi.org/10.64634/5qd2rx29>
- Willingham, D. T. (2007, Summer). Critical thinking: Why is it so hard to teach? *American Educator*, 2007, 8–19.
- Xiang, D., & Lehmann, L. S. (2021). Confronting the misinformation pandemic. *Health Policy and Technology*, 10, Article 100520. <https://doi.org/10.1016/j.hlpt.2021.100520>
- XQ Institute. (n.d.). *Discover actionable competencies that work with your standards*. XQ Competency Navigator. <https://xqcompetencies.xqsuperschool.org/>

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