JIA-HAN YANG
GRADUATE STUDENT
COLLEGE OF EDUCATION
AND HUMAN DEVELOPMENT,
TEMPLE UNIVERSITY

EASIER SAID THAN TAUGHT: **Navigating the Development and Application of Critical Thinking**

Abstract Critical thinking (CT) is a key competency for undergraduates to be informed decision-makers. However, educators face challenges in fostering students' CT. Effective CT instruction is not a monolithic enterprise; it must account for domain-specific nuances, instructional design, and individual learner differences. This narrative review synthesizes existing literature to identify the crucial elements of CT development, examine the extent to which students cultivate CT during college education, and explore the transferability of these skills across academic disciplines and to real-world scenarios. Findings reveal that robust CT development hinges on a combination of student agency, pedagogical design, and co-constructed learning opportunities. While domain-specific instruction effectively promotes near transfer—the application of skills and dispositions to similar contexts—far transfer to novel situations is elusive. Achieving far transfer requires practice and innovative instructional designs that activate inert knowledge in unfamiliar contexts. The review calls for a more integrated approach to centering CT in higher education. Beyond isolated interventions, institutions should embed CT education systematically throughout the curriculum. This integration can be reinforced through professional development for faculty members and through high-impact practices, enabling students to apply CT effectively in their lives.

Keywords Critical Thinking, Higher Education, Learning Transfer, Instructional Design

Acknowledgments

The author would like to express gratitude to Dr. Benjamin E. Brock of the College of Education and Human Development at Temple University for his support and feedback on earlier versions of this manuscript.

All the content and analysis in the article were original and first conceived by the author. Tools with generative artificial intelligence (GenAI), including ChatGPT (GPT-4.1) and Gemini (Gemini 2.5 Pro), were subsequently used to enhance the flow and organization of the article, as well as to check grammar. The author occasionally prompted GenAI to correct grammatical errors and paraphrase sentences to streamline the meanings the author intended to convey. Additionally, ChatGPT (GPT-5) was used to improve the organization of the information in Tables 3 and the Appendix. Suggestions on grammar and cohesion from Grammarly were verified and edited again to ensure no hallucination and the use of a natural cadence. Finally, the author would like to thank tutors at the Student Success Center for polishing the language of this manuscript.

Critical thinking (CT), a cognitive and reflective endeavor related to one's ability of evaluation and generation as well as creativity (Zhou, 2022), is crucial to undergraduates given their forthcoming involvement in careers and high-stakes life events (Halpern & Butler, 2019; Holmes et al., 2015; Wong & Kowitlawakul, 2020). An OECD (2022) study reveals CT skills as a predictor of employability in written communication and problem-solving. However, simply framing the teaching and learning of CT with the expectation of measurable gains from pre- to post-test assessments is problematic. Additionally, effective CT instruction does not adhere to a one-size-fits-all model (Abrami et al., 2015).

Studies have shown that students primarily practice CT within the same class or field (As'ari et al., 2017; Holmes et al., 2015). Together with Zhou's (2022) framework, the studies offer a glimpse that CT development for learners is often domain-specific. Furthermore, the development of CT takes a significant amount of time, and the time needed varies depending on students' capacity and the curriculum they receive (Abrami et al., 2015; Lee et al., 2024; Ralston & Bays, 2015), and it can be complicated by cultural differences (Lu et al., 2021).

While substantial groundwork has been established to define CT instruction, scholars often approach CT through established models and a pre-post perspective. This approach, as apposite as it seems for researchers launching experiments and reforming curriculum within limited time and resources, overlooks the nature of CT. CT transcends the mere development of cognitive skills and taps into the impacts of curriculum and pedagogical practices beyond classrooms. Hence, the review aims to investigate these three elements: (1) the elements needed to develop CT, (2) the level of CT that students develop over the course of a 4-year college education, and (3) the transferability of CT across academic disciplines and other real-world scenarios. In the end, this review aims to propose future research directions and instructional and practical implications to foster more cohesive approaches to developing and teaching CT.

RESEARCH DESIGN

This section details the research design of the narrative literature review, including its guiding parameters and constraints, the research questions, and the researcher's positionality.

Methodology

I conducted a narrative literature review to address broad research questions and incorporate studies conducted in different methodologies (Pautasso, 2019; Taherdoost, 2023) (see summary table in the Appendix). This method allows for the synthesis of findings into theme-based narratives relevant to CT education. The search process was conducted from February to September 2025. The primary databases used were Google Scholar, ERIC, and ProQuest. Given the scope of the review and the breadth of the literature, ResearchRabbit and STORM by Stanford University were also employed to discover additional literature on near and far transfer of CT missed in the initial search. ResearchRabbit, which visualizes connections between papers, was applied to identify related works. Due to the lack of articles on learning transfer in the context of CT in traditional databases, I resorted to ResearchRabbit, which I fed with six seed articles to identify additional relevant articles. Eventually, among 21 articles (with one replicate entry), I identified Barnett & Ceci (2002)'s article as explaining far transfer. On the other hand, Synthesis of Topic Outlines through Retrieval and Multi-perspective Question Asking (STORM), an artificial intelligence tool that provides synopses of literature within a user-defined scope, was used to expand the range of literature by tracing sources cited in its reviews. It can generate an overview of a specific topic (e.g., critical thinking) through a keyword string in two steps. First, it conducts a thorough search and outlines the overview beforehand. During the writing process, it identifies different perspectives on the topic and interrogates itself based on the literature it has gathered, ultimately producing a multi-page introductory article (Jiang et al., 2024). A search on STORM highlighted two additional articles (Fong et al., 1986; Sellier et al., 2019) on far learning transfer that meet my inclusion criteria. No AI-generated content was taken directly from STORM; only bibliographic references to articles were used.

For article selection, except for works used in the sections "On Defining CT: What Constitutes It" and "Development of Students' CT," as well as theoretical frameworks on transfer and one illustrative case, all studies were published after 2010, with more than half published after 2015, to capture current developments in teaching and learning CT. Selected cases spanned STEM (Science, technology, engineering, and mathematics), business, and the humanities. The process began with an extensive search guided by keyword strings and inclusion/exclusion criteria (see Tables 1 and 2). Fifty-nine articles were identified for analysis using databases and tools such as ResearchRabbit and STORM. During the search process, a quick review was employed to assess relevance immediately, rather than indiscriminately downloading results. This approach facilitated the first round of selection. Subsequently, a second screening of these potential sources yielded 31 articles used to frame the theories, findings, and perspectives in this section. Selection was determined by the criteria listed in the Appendix. This two-stage process ensured that the final selection aligned with the core research questions established for this review. Articles were then reviewed and annotated, grouped by theme, and synthesized into sections based on the knowledge base. Regrouping was carried out when necessary to ensure alignment with the analysis scope, as addressed in the three research questions presented below.

TABLE 1 - Sample Keyword Strings

Dimension	Example Keyword String
Definition of critical thinking	critical thinking AND definition critical thinking AND (Facione OR Paul OR Elder OR Ennis) critical thinking AND (Brookfield OR McPeck OR Kurfiss OR Siegel) dispositions AND critical thinking
Students' critical thinking development (primarily case studies)	{undergraduate OR colleges} AND students AND critical thinking AND {development OR building} {undergraduate OR colleges} AND students AND critical thinking AND {development OR building} AND {instructors OR professors} {undergraduate OR colleges} AND students AND critical thinking AND {development OR building} AND {student perspective}
Transfer of critical thinking	{transfer OR transferability OR application OR practice} AND {undergraduate OR colleges} AND students AND critical thinking {transfer OR transferability OR application} AND {challenges OR obstacles OR process} AND {undergraduate OR colleges} AND students AND critical thinking domain-specific instruction AND critical thinking

TABLE 2 - Inclusion/Exclusion Criteria for Studies Included to Address the Three Research Questions

Criterion	Description
Geography	Cases are selected from North America, Europe, Africa, and Asia to reflect diverse instructional settings and practices
Publication date	Except for the theories and one experimental study on learning transfer, all the articles featuring cases in classrooms were published after 2010
Settings	Predominantly university instruction settings. Cases from secondary education in classroom settings are occasionally used as a supplement
Language of publication	Only articles written in English are included
Featured construct	Must adhere to the definition of critical thinking set at the beginning of this review; articles that feature a related but distinct construct (e.g., computational thinking) will be excluded from analysis

Research Questions

The research questions include the following:

1. In what ways do college students develop CT within classroom practices shaped by the curriculum and teachers' pedagogy?
2. In what forms do college students demonstrate CT in near transfer contexts?
3. In what forms do college students demonstrate CT in far transfer contexts?

Researcher Positionality

I served as a facilitator for the "Future Issues and Social Development" courses at two municipal high schools for the non-profit Lead for Taiwan between 2022 and 2023. During my short tenure, I examined my teaching and revised lessons on CT after every session. Occasionally, I experience post-teaching epiphanies sparked by "what if..." questions. While some students exhibited interest in the subjects I presented, I observed instances of disengagement from CT and limited progress in appreciating and analyzing topics with substantiated arguments and diverse perspectives. Moreover, CT can be applied across various settings, such as in classes and in personal life. Inspired by my teaching experience, I drafted this literature review.

ON DEFINING CT: WHAT CONSTITUTES IT?

Early definitions of CT emphasized the evaluation employed by thinkers (Ennis, 1964; Halpern, 1998). Subsequent accounts incorporated reflective control and metacognition, emphasizing the thinker's capacity to monitor and regulate reasoning (Ennis, 1991; Paul, 1988). The experts at the American Philosophical Association (1990), for example, frame CT as purposeful, self-regulated judgment supported by explicit attention to "evidential, conceptual, methodological, criteriological, and contextual considerations." Contemporary authors argue that CT necessitates both mindware (rules, knowledge, procedures, and strategies) and dispositional tendencies (open-mindedness, intellectual humility, and prudence), and that the operation of these elements varies across different domains (e.g., Eigenauer, 2024; Zhou, 2022). As such, in this article, CT is defined as effortful, metacognitively guided reasoning — both general and domain-sensitive — in which individuals interpret, evaluate, and synthesize information using appropriate strategies and dispositions to produce reasoned judgments and purposeful, self-regulated action.

The interest of the article, importantly, lies in understanding how CT is initiated and unfolds in higher education instructional settings. Thus, a review of the cluster of concepts on how CT works will be helpful. According to Davies (2015) and Zhou (2022), the development of CT encompasses a combination of skills, dispositions, and values. Skills and dispositions are intertwined. Skills refer to the ability to argue and think about one's thinking, such as "interpretation, analysis, inference, explanation, evaluation, metacognition, or self-regulation" (Davies, 2015, p.54). Dispositions, or "habits of character" in Zhou's (2022, p. 158) words, refer to the "attitudes and a sense of psychological readiness of the human being to be critical" (Davies, 2015, p.55). Finally, values can be regarded as mindware (the 'program' in our brain that guides our thinking; Clark, 2001) that drives one's actions and future trajectories, in consideration of one's social relations (Davies, 2015), similar to the intellectual virtues proposed by Zhou (2022).

Davies (2015) recognizes that one's dispositions and, subsequently, values and actions are determinants to actualize CT in real life (e.g., addressing inequity). Similarly, CT development helps individuals transcend fear and arrogance, allowing students to be humble and navigate mentally challenging questions (Zhou, 2022). These attributes enable individuals to act with prudence while remaining both organized and visionary. They also foster reflective awareness of one's actions and facilitate the translation of internal dispositions into behaviors that demonstrate humility and courage, particularly in time-consuming and cognitively demanding situations.

An individual's CT is fostered through the educational environment, especially as it pertains to problem-solving, decision-making, and collaboration (Davies, 2015). CT is considered to facilitate the execution of these tasks, as evidenced by instructions where coursework and assignments are structured to develop one's skills in examining interconnectedness, argumentation, balanced presentation of information, and generating sound conclusions and plausible implications (Ralston & Bays, 2015). Equally important, CT is associated with one's ability to communicate in both written and spoken forms, as information is exchanged during such processes (Hyytinen et al., 2024).

Additionally, CT development is discipline-specific; in philosophy and science, logic is central, while the humanities prioritize holistic perspectives, and the social sciences emphasize methodical, evidence-based analysis (Zhou, 2022). Its development—shaped by both individual learning and instructional guidance—extends beyond purely cognitive dimensions.

Challenges of Teaching and Learning CT

CT can be taught both explicitly (e.g., regular classes) and through student-teacher or student-student co-construction (e.g., inquiry-based learning or practicum) (Pnevmatikos et al., 2023; Wong & Kowitlawakul, 2020). When such instructional approaches are absent or insufficient, students often equate CT with specific cognitive activities (e.g., reasoning or discussion) rather than considering certain dispositions or activities as the components of CT (Pnevmatikos et al., 2023).

A myriad of challenges in the development of CT has long been standing for teachers and students. Bassok and Holyoak (1989) identified challenges that students face when applying similar concepts in physics and algebra. Additionally, insufficient interactions or discussions, stress, and students' characteristics (e.g., shyness) can hinder students' development of CT (Wong & Kowitlawakul, 2020). Another challenge is the time span required for the development of CT. Studies of CT typically present only a snapshot of students' CT development, often in experimental designs (Holmes et al., 2015). Yet, an extended duration is required to develop CT (Ralston & Bays, 2015), warranting the need to examine how college students develop CT and how CT can be transferred in both the short and long term.

DEVELOPMENT OF STUDENTS' CT

This section will mainly address the first question: In what ways do college students develop CT within classroom practices shaped by the curriculum and teachers' pedagogy? To address this question, perspectives are drawn from studies focused on students, instructors, and co-constructed student-instructor interactions. Both the content and the design and implementation of instruction are considered together, given that the subject matter in lessons itself cannot stand alone if the instruction aims to introduce thinking practices to students (Perkins, 1995).

Teachers, Curriculum, Pedagogy, and (Ultimately) Students

Developing students' CT to benefit their learning in the long run has been perceived as a challenge, as it requires instructors to build students' knowledge, skills, and dispositions, ultimately ushering in a mental and habitual shift (Holmes et al., 2015; Lee et al., 2024). A handful of studies on CT pertain to STEM education (Booth et al., 2015; Holmes et al., 2015; Ralston & Bays, 2015; Tiruneh et al., 2018), with language education (Mehta & Al-Mahrooqi, 2015) and pre-service teacher education (Golden, 2023; Slade et al., 2019) being another stream of studies on teaching CT.

A number of common elements can be distilled. For example, the close relationship between instructors and students is conducive to lively in-class engagement, leading to the co-construction and meaning-making of lessons as suggested by Vygotsky's view on the interactionist approach; this outcome can be attributed to students' feelings of safety and shared knowledge (Abrami et al., 2015; Golden, 2023).

Students' holistic understanding of the tasks and approaches also matters, regardless of their previous training. Mehta and Al-Mahrooqi (2015) reveal that even when students might know how to read critically, they may perform poorly in writing critically. However, when students understand the purpose of a task and receive guidance after discussions and brainstorming, their performance in writing that involves analysis, evaluation, and synthesis of ideas improves.

Experiments have demonstrated that after instruction over a duration, there is usually an increase in students' CT competencies (Holmes et al., 2015; Ralston & Bays, 2015; Straková & Cimermanová, 2018; van Peppen et al., 2021). For instance, Holmes et al. (2015) found that the effects of reflective instruction persisted. Once the instruction ended, students in the experimental group continued to revise their work 12 times more than those in the control group. Additionally, students in the experimental group were four times more likely to recognize and articulate a limitation of a physical model based on their data.

However, the complex nature of CT instruction should not be overlooked. There is no one-size-fits-all approach to CT instruction (Abrami et al., 2015), given the variations across academic disciplines and contexts. Scholars have also advocated diverging approaches to CT instruction. van Peppen et al. (2021) suggest that explicit instruction on CT, followed by practice, can elevate students' CT through comparisons of test results. They also note that the effect of instruction can last for months.

However, this does not guarantee that students will transfer CT to another task or domain. Students' performance on CT within a certain parameter can improve due to multiple factors, such as test-taking needs and motivation. Tiruneh et al. (2018) found that deliberately aligning instruction with an existing model may facilitate students' transfer of CT into the same or similar fields, but not into general life skills.

Still, Abrami et al. (2015) recognize that students benefit from developing their CT after instruction. For example, the infused model, which posits that CT concepts should be highlighted and that students ought to be primed about the instruction (Dumitru, 2013; Haber, 2020; Tiruneh et al., 2018; Zhou, 2022), is designed to develop students' skills and dispositions of CT (Zhou, 2022). The efficacy of this model, which demonstrates and reminds students of the target CT skills supplemented by reflections, outperforms that of the immersion model in which CT is implied in class activities (Tiruneh et al., 2018). Nonetheless, a cautionary note by Abrami et al. (2015) should be considered when opting for a single model, given the variability of classroom contexts. They suggest that content and CT should be integrated to maximize learning efficacy, given that authentic contexts allow students to use CT to address a problem directly, and techniques of "dialogue, authentic instruction, and mentorship," whether used separately or altogether, can best support students' CT development.

However, even when classes are designed for embedding CT, efficacy can still be limited. For example, fewer than 20% of teacher candidates in a context-situated, reflection-oriented practicum demonstrated reflections that extended beyond connecting themselves to knowledge and experiences (Slade et al., 2019). Even when opportunities for discussion abound, students may be constrained by the time and size of the class (Wong & Kowitlawakul, 2020) or by cultural differences that hinder them from meeting Westerners' expectations (e.g., raising questions in class) (Lu et al., 2021).

Finally, students' agentic role in shaping their CT development should not be neglected. Students' low expectations for themselves, their limited language proficiency—which is exacerbated by their failure to seek resources for assistance—and their tendency to rely on instructors are barriers to developing CT (Aouaf et al., 2023). CT is fully realized by students when they persevere in sharpening their approaches to mentally challenging tasks, apply CT beyond a single class, and appreciate its value after experiencing its applications across scenarios (Lee et al., 2024). Furthermore, Hyytinen et al. (2024) report that students who think ahead and plan multiple approaches to solving questions, guided by prudence and effort, perform better on their CT assessment.

Co-construction of CT by Instructors and Students

Learning and teaching CT involves parameters from the instructors (e.g., course objectives), the course content, instructional settings, peers, and even students' awareness and motivation (Aouaf et al., 2023; Davies, 2015; Lee et al., 2024; Ralston & Bays, 2015; Wong & Kowitlawakul, 2020) to ensure that students practice CT both inside and outside their domains. Students' development of CT can be demonstrated through the products of their learning. Nevertheless, the scope and efficacy of acquiring CT from a learner's viewpoint—as well as the potential strategies and dispositions learners may cultivate—warrant further discussion.

In Mehta and Al-Mahrooqi's (2015) tertiary-level English writing class for non-native English-speaking writers, some provided cogent arguments and clear thesis statements tightly connected to the main prompts that instructors asked for. Still, students missed intricacies, such as identifying potential biases in the prompt and strategizing the writing scope according to the essential questions in the prompt. This is similar to Slade et al.'s (2019) findings. Teacher candidates became aware of identifying niches to apply professional knowledge, and were aware of their attitudes and dispositions while examining the impacts of and needed changes in their personal actions and beliefs.

Students in STEM fields, while able to improve their CT, may still miss complexities and connections to the broader body of information in their writing (Ralston & Bays, 2015). Notably, though, students' evaluation skills and subsequent action-driven approaches have become more ingrained (Holmes et al., 2015). An instance is that students receiving instructions displayed an incremental improvement in exhibiting their CT, from pondering changes to their experiment and improvement of experiment results to evaluating the underlying causes of discrepancies between their experiments and the model. Holmes et al. (2015) and Lee et al. (2024) demonstrate that central to students' CT development are ample opportunities to prepare students to translate CT into dispositions and to engage in inquiry rather than to assess the information visible at the surface level. Still, robust CT development lies in instructors' scaffolding, where students are given analytical approaches and workable frameworks before they develop their tactics, as opposed to getting instructors' views (Lee et al., 2024). Additionally, students should be immersed in authentic contexts supplemented with opportunities to look into interconnectedness (Abrami et al., 2015).

Moreover, how instructors perceive and approach CT in their classes should be at their discretion, given that an all-purpose model does not always serve their purposes in highly heterogeneous educational contexts (Abrami et al., 2015; Booth et al., 2015; Zhou, 2022). Findings on improvements in students' general CT skills have been conflicting (Abrami et al., 2015; Tiruneh et al., 2018). As different disciplines require CT to be performed differently, teachers are advised to be trained on field-specific schemas to think critically (Janssen et al., 2019). Note, however, that instructors can also be overconfident, which hinders their ability to recognize biases as they provide incorrect reasoning in tasks with which they are unfamiliar.

Finally, instructors must be aware of diverse demonstrations of CT from students (Lu et al., 2021). Beyond explicit instruction in analytic reasoning using acquired rules, interaction-driven discourse and rapport (Abrami et al., 2015; Golden, 2023), as well as manageable class size and classroom inclusivity (Wong & Kowitlawakul, 2020), play an equally important role in training students to perform analytic reasoning with acquired rules.

TRANSFER OF STUDENTS' CT

After an examination of CT from the perspective of teaching and learning, our focus will be on another topic: transfer of learning. In this section, two questions will be addressed: (2) In what forms do college students demonstrate CT in near transfer contexts? and (3) In what forms do college students demonstrate CT in far transfer contexts?

Transfer of CT can be defined as the process by which learners actively apply, adapt, and extend the knowledge and skills they have acquired in one context to different and often unfamiliar contexts, whether in other academic disciplines or real-life situations (Haber, 2020; National Research Council, 2000, Chapter 3). This ability involves not only recalling learned concepts but also activating and reshaping knowledge to solve problems, innovate, and create tools tailored to emerging challenges. As such, transfer equips learners with advantages by fostering flexibility, adaptability, and a problem-solving mindset. Although there is a need to experiment with the effectiveness of transferable principles of CT, CT is invaluable (Dumitru, 2013). One's foundations in premise formation, argumentation, and decision-making abilities across life scenarios, as well as an individual's capacity to consider multiple facets within a given context, are benefits that arise from CT (Haber, 2020).

Transfer can be broken down into two types: near transfer and far transfer. Near transfer in CT refers to the ability to apply learned knowledge or skills to situations that closely resemble the original learning context (Mat Said et al., 2021; van Peppen et al., 2022). This type of transfer is typically observed when students encounter exam problems or exercises that require the same underlying concepts (van Peppen et al., 2022). It involves recognizing common traits or patterns between the original and new situations, whether within the same subject, across different subjects, or between related disciplines or academic years (Mat Said et al., 2021). On the other hand, far transfer involves applying CT from a learning situation to a new application context (Mat Said et al., 2021; van Peppen et al., 2022). This means using CT across different knowledge domains, functional contexts (e.g., social or physical situations), and varied physical, temporal, and social contexts (Barnett & Ceci, 2002).

What Transfers, What Doesn't, and Why

As a concept review, *near transfer* refers to applying the acquired principles to new tasks that preserve a problem's underlying structure within the same (or closely similar) domain; *far transfer* denotes application to different domains or everyday decisions. However, transfer distance is not binary; it covaries with structural similarity and assessment alignment (Bassok & Holyoak, 1989; van Peppen et al., 2021), as well as with the mindware a discipline demands.

Embedding CT outcomes, terms, and activities into subject courses yields dependable near-domain gains (Dumitru, 2013; Haber, 2020; Tiruneh et al., 2018; Zhou, 2022). Infusion approaches have remained effective across studies (Bensley & Spero, 2014; Tiruneh et al., 2018). Extended implementation in STEM fosters error detection and evidence-based argumentation (Holmes et al., 2015; Ralston & Bays, 2015). Compact designs can also work: brief video instruction plus aligned practice produces immediate—and sometimes stronger delayed—benefits (van Peppen et al., 2021), and approaches that compel learners to retrieve and re-map prior knowledge onto unfamiliar problems show promise (Corral et al., 2023). In humanities, focused discussion and clarification cycles strengthen argumentation quality and integrative thinking on the same prompts/topics (Mat Said et al., 2021; Mehta & Al-Mahrooqi, 2015).

However, the ultimate purpose of schooling is to transfer from school to the environments we encounter every day (National Research Council, 2000), with dividends for personal and social reasoning (Davies, 2015; Haber, 2020). Although multiple-context exemplars can broaden CT (Halpern & Butler, 2019) for everyday life, and successful cases do exist (E.g., Fong et al., 1986), studies have demonstrated that far transfer often falters (Tiruneh et al., 2018; van Peppen et al., 2018, 2021, 2022) and that, currently, the literature mostly features successful cases of near transfer. Learners may fail to notice applicability or retrieve relevant schemas (Bassok & Holyoak, 1989); memory limits and incentive structures (e.g., grades) can boost near performance yet leave far tasks unaffected (van Peppen et al., 2021). Fortunately, extended duration generally strengthens outcomes (Huber & Kuncel, 2016). Table 3 summarizes the findings of the case studies conducted on undergraduate students. Details and analysis of the literature will be presented in later sections of this article.

TABLE 3 - Evidence on Near and Far Transfer in Critical Thinking Interventions

Near and/or far transfer	Author and date	Instructional contexts	Duration of intervention/practice	Approaches to intervention/practice	Evidence and demonstration of transfer
Near (within physics)	Holmes et al. (2015)	Calculus-based physics labs (R1 university) + follow-on sophomore lab	Full course of weekly 3-hour labs	Repeated then faded cycles of data-model comparison; student-driven method/model revisions	Students were 12 times more likely to propose/implement method improvements and 4 times more likely to identify/interpret model limitations; these effects persisted in the next-year lab (behavioral transfer).
Near (structure-mapping)	Corral et al. (2023)	University participants; lab tasks	Short study/practice sessions	Retrieval practice vs. reread-study of base problems	Retrieval practice improved solving of novel analogs (structurally similar but new), evidencing near transfer.
Near	van Peppen et al. (2021)	University CT tasks	Short sessions	Study of correct vs. erroneous examples	Erroneous examples were not uniquely beneficial across outcomes; example-based studies alone may be insufficient for far transfer without additional supports.

TABLE 3 - Evidence on Near and Far Transfer in Critical Thinking Interventions

Near and/or far transfer	Author and date	Instructional contexts	Duration of intervention/practice	Approaches to intervention/practice	Evidence and demonstration of transfer
Near (within writing)	Mehta & Al-Mahrooqi (2015)	EFL(English as a Foreign Language) university writing courses	Semester	Writing-integrated CT activities	Reported improvements in CT within the writing context after instruction and student discussion.
Near (within CT tasks)	van Peppen et al. (2018)	First-year Applied Sciences CT course; classroom setting	Session 1 ≈ 90 min (pretest, instruction, practice, immediate posttest) Session 2 ≈ 30 min 2 weeks later (delayed posttest)	Explicit instruction on two task categories (logical/statistical) with worked examples; practice with or without self-explanation prompts after each task	Transfer was asymmetric—training on Wason/conjunction (WC) led to larger improvements on syllogism/base-rate (SB) than the reverse; prompting self-explanations did not add transfer benefits.
Near (within engineering)	Ralston & Bays (2015)	Engineering under graduates, large urban research university	4-year program (freshman -> senior); required courses each year	Paul-Elder framework infused across curriculum; authentic CT assignments; faculty training; holistic rubric	Significant increase in CT scores across four years for each cohort; authentic artifacts include internship reflections (application in work setting within the discipline).

TABLE 3 - Evidence on Near and Far Transfer in Critical Thinking Interventions

Near and/or far transfer	Author and date	Instructional contexts	Duration of intervention/practice	Approaches to intervention/practice	Evidence and demonstration of transfer
Near	Bensley & Spero (2014)	College psychology course	Course-length (duration unspecified)	Direct infusion of CT (explicit rules for argument analysis & critical reading) with practice, assessment, and feedback	CT-infused group > memory-infusion and content-only groups on argument analysis & critical reading; better metacognitive postdictions, albeit approaching significance only; effects demonstrated on course-aligned CT tests.
Near and Far	Tiruneh et al. (2018)	Introductory Electricity & Magnetism class at a university in Ethiopia	8 weeks 3×2-hr/week (24 lessons)	Immersion vs. Infusion embedded CT; problem-centered tasks; instructor modeling; coached practice; chapter-end reflection	Near: Both Immersion and Infusion > Control. Far: Infusion > Immersion/Control; no group differences on CT for everyday problems. Authors argue the feasibility of developing "near-far" (within sciences) but not "far-far" (from sciences to everyday life) transfer.

TABLE 3 - Evidence on Near and Far Transfer in Critical Thinking Interventions

Near and/or far transfer	Author and date	Instructional contexts	Duration of intervention/practice	Approaches to intervention/practice	Evidence and demonstration of transfer
Far (everyday reasoning)	Fong et al. (1986)	Laboratory & college courses	Exp. 1–3: ~25 min training Exp. 4: semester-long courses	Examples + principle abstraction in statistical/causal reasoning	Trained participants made better judgments on everyday problems requiring statistical principles.
N/A (focus on boundary conditions)	As'ari et al. (2017)	Prospective math teachers (under graduates and graduate students)	Three case studies; single-session problem-solving + interviews	Diagnostic tasks (incomplete, illogical, open-ended problems) + observation/ interview	It explains why near transfer may not occur, as students simply follow conventions without thinking outside the box.
N/A (focus on boundary conditions)	van Peppen et al. (2022)	University-level CT tasks	Not an intervention (diagnostic studies)	Three-step model: Recognize -> Recall -> Apply	Many learners fail at the application step, even when they can recognize/recall, clarifying why far transfer is rare without explicit support.

Fostering Near Transfer and Far Transfer: Conditions and Challenges

The capacity to transfer CT—including the application, adaptation, and extension of skills, mindwares, and dispositions to novel contexts (Haber, 2020; National Research Council, 2000)—stands as a central goal of education. Effective practice to activate the transfer of CT, however, requires extensive time to learn, deliberate prompting for reflection and elaboration, and hands-on practice (van Peppen et al., 2021)

The provided literature suggests distinct conditions for fostering near versus far transfer. Near transfer appears achievable when CT is explicitly integrated into subject-specific curricula rather than taught in isolation (Dumitru, 2013; Haber, 2020; Tiruneh et al., 2018; Zhou, 2022). Additionally, instructional designs incorporating video instruction with practice (van Peppen et al., 2021), structured group discussions (Mehta & Al-Mahrooqi, 2015), and focusing on argumentation (Holmes et al., 2015; Ralston & Bays, 2015) have demonstrated success in fostering near transfer within specific domains or disciplines. However, contextual factors like teaching approaches (As'ari et al., 2017), learner support (van Peppen et al., 2021), and the potential unidirectionality of transfer (Bassok & Holyoak, 1989) must be considered. The feasibility of fostering near transfer is relatively well-supported, with studies showing measurable improvements in domain-specific reasoning and skills following targeted interventions (e.g., Holmes et al., 2015; Ralston & Bays, 2015; Tiruneh et al., 2018).

Far transfer, conversely, demands additional conditions. Although far transfer is difficult to achieve, it is a critical educational goal for ensuring that students can use what they have learned in real-world and unfamiliar contexts (National Research Council, 2000, Chapter 3). While memory retrieval training can help learners activate prior knowledge for unfamiliar problems (Corral et al., 2023), the explicit, deductive approaches effective for near transfer may not suffice (Bensley & Spero, 2014; van Peppen et al., 2021).

Furthermore, far transfer is often described as notoriously difficult to achieve (Bensley & Spero, 2014; van Peppen et al., 2021). This inherent difficulty likely contributes to the relative scarcity of research demonstrating robust far transfer compared to near transfer studies. Achieving far transfer is complicated by learners' potential inability to recognize the applicability of learned skills in superficially different contexts (Barnett & Ceci, 2002) and fundamental issues with retrieving relevant knowledge when needed (van Peppen et al., 2021). Furthermore, factors like student motivation, which is tied to grades, may facilitate near transfer within academic settings but may not necessarily translate to the intrinsic motivation required for far transfer (van Peppen et al., 2021). However, Fong et al. (1986) suggest that explicit instruction and guided induction via examples can foster far transfer, although the effect may not be universal.

Temporal factors also influence CT transfer. Extended duration and consistent engagement yield great benefits for the development of CT, which is understood as a non-linear process (Huber & Kuncel, 2016; Lee et al., 2024). Studies demonstrating CT gains over semesters or years support this (Holmes et al., 2015; Ralston & Bays, 2015). While shorter interventions can produce effects, particularly for near transfer (Booth et al., 2015; Tiruneh et al., 2018; van Peppen et al., 2021), applying far transfer requires sustained practice over a considerable period (van Peppen et al., 2021). van Peppen et al. (2021) also argue that delayed post-tests show greater gains in CT performance than immediate ones.

Although transfer effects can be limited (Dumitru, 2013), the development of these skills equips students with capacities for argumentation, decision-making, and navigating the complexities of their personal and academic lives (Davies, 2015; Haber, 2020). Understanding the distinct conditions required for near and far transfer and acknowledging the significant roles of time and practice are essential for instructors to factor in when designing stimulating activities for CT development, even under limited class time.

EMERGING THEMES TO CONSIDER

After the three proposed questions on students' development of CT and learning transfer of CT are addressed, let us return to the bigger scope that this review aims to answer: (1) the crucial elements and sophistication of CT that students develop over the course of a 4-year college education, and (2) the transferability of CT across academic disciplines and other real-world scenarios. To answer these questions, prominent topics drawn from the literature on CT development and learning transfer in CT will be distilled.

CT Development as a Longitudinal Process

CT can be developed in a short amount of time, such as within a few weeks or even just a single intervention session (Fong et al., 1986; Mehta & Al-Mahrooqi, 2015; Tiruneh et al., 2018; van Peppen et al., 2021), as proven by both qualitative and quantitative analysis. However, concluding that CT can be developed through crash courses is an oversimplification. The CT that the authors referred to is mostly about near transfer, or applying CT within the same subject. Secondly, most of the cited studies are conducted in experimental settings, and the content covered in pre-tests and post-tests is similar, which may pose a question of whether students have acquired CT or merely the paradigms deeply rooted in a particular academic field.

Importantly, short-term experiments suggest that CT requires time to mature beyond instruction. van Peppen et al. (2021) suggest that a telltale jump in students' exhibition of CT, as well as their sophistication in thinking, manifested after instruction ended for a few weeks or months. On a positive note, facilitating far transfer does not necessarily mean having extended instructional time (Fong et al., 1986). The key lies in instructional design and consistent practice (Holmes et al., 2015; Ralston & Bays, 2015)—student engagement is central, and time is required to see noticeable gains in students' CT.

CT Instruction: Finding the Right Balance

Although research supports the infusion model (see the subsection "Teachers, Curriculum, Pedagogy, and (Ultimately) Students" for further information), the key to considering an approach to teaching CT lies in (a) a model's compatibility with the academic subject that one has been teaching and (b) the contexts of a particular classroom setting. Furthermore, CT instruction in classrooms is domain-specific unless one's instructional design is specifically designed for general CT (Tiruneh et al., 2018). Given the diversity of educational contexts, Abrami et al.'s (2015) perspective offers a guiding principle: there is no single best practice.

The central part of students' CT development also includes students' agency and the "take-the-initiative" mindset with tolerance for uncertainty (Aouaf et al., 2023; Hyytinen et al., 2024; Lee et al., 2024). Since instruction centered on CT is not equally effective for every student (Slade et al., 2019), opportunities to practice CT in authentic situations, including those directly and indirectly related to a specific academic field, matter most (Golden, 2023; Holmes et al., 2015).

What is equally important is mentorship and guidance. CT is formed through co-construction, which also supports the argument that the size of CT classes should be manageable for instructors to build bridges for individuals (Golden, 2023; Wong & Kowitlawakul, 2020). Ultimately, CT is meant to allow students to learn beyond digesting knowledge, and a student's action should be reflective of the elements of CT, which is the goal of far transfer and the value of university education (Davies, 2015; Haber, 2020; National Research Council, 2000, Chapter 3).

Bridging the Gap Between Near and Far Transfer

Effective near transfer is feasible, provided explicit CT integration occurs within subject-specific curricula rather than as isolated instruction (Dumitru, 2013; Haber, 2020; Tiruneh et al., 2018). Instructional strategies supporting near transfer include using worked examples (Booth et al., 2015), structured discussions (Mehta & Al-Mahrooqi, 2015), and explicit video instructions combined with practice tasks (van Peppen et al., 2021). Studies across STEM and humanities demonstrate measurable improvements in domain-specific CT abilities following interventions lasting from a few weeks to several years (Holmes et al., 2015; Ralston & Bays, 2015; Tiruneh et al., 2018).

However, the deductive teaching approaches effective for near transfer might not suffice for far transfer (Bensley & Spero, 2014). While retrieving memory and linking previously learned knowledge to new knowledge or examples benefits far transfer (Corral et al., 2023), activating far transfer requires extensive practice, reflective prompting, and hands-on problem-solving to overcome inert knowledge barriers (van Peppen et al., 2021). Game-based training has shown potential to engage learners in decision-making and reduce bias in novel scenarios because it is not only tied to curricular content but also emphasizes hands-on practice; moreover, such training introduces debiasing strategies at an abstract level and provides opportunities for learners to apply those strategies across different types of problems, as evidenced by experimental group's 29% lower likelihood of selecting a suboptimal, hypothesis-confirming solution compared to the control group (Sellier et al., 2019).

Still, near and far transfer can be and should be fostered together. CT, after all, taught as a competence with preconceived notions and dispositions, is similar to any other construct (e.g., self-regulation) that we hope individuals can apply outside classroom settings (Davies, 2015; National Research Council, 2000, Chapter 3). Although studies suggest that promoting near transfer or developing CT specifically for a given domain is more feasible (Tiruneh et al., 2018; Zhou, 2022), CT development should not be limited to domain-specific training. If one's reasoning skills are consolidated through far transfer, an individual will be afforded a critical lens on past and current affairs. An illustration is in Holmes et al.'s (2015) class, where students eventually learned to examine the applicability of theories in experiments.

DISCUSSION

While this review has identified significant elements contributing to students' development and transfer of CT, several questions and counterarguments warrant further clarification. First, it could be argued that this review implicitly supports the appropriate application of several instructional strategies, such as explicit infusion, authentic contexts, and mentorship, which will reliably yield measurable improvements in students' CT (Abrami et al., 2015; van Peppen et al., 2021; Zhou, 2022). Such an assertion could be criticized for overlooking the complexities inherent in teaching and learning, especially when we factor in the nesting issue and interconnectedness of a classroom environment (Kaplan & Garner, 2020). The reality of classroom instruction often varies across factors such as instructor expertise, student motivation, class size, and cultural context (Lu et al., 2021; Wong & Kowitlawakul, 2020).

Even if an instructor-driven approach works well, its implementation can be time-consuming due to an instructor's trial and error (Golden, 2023). Thus, it remains unresolved how instructors can implement instructional practices flexibly to address potential complexities and constraints (e.g., class time and course objectives). While explicit instruction appears beneficial, the relative merits of relying on structured guidance and prompting independent exploration and critical reflection warrant additional research.

Moreover, the effectiveness of the instructional methods discussed throughout the review has been mostly measured through standardized assessments for CT. Critics may argue that standardized tests capture only a subset of CT skills, focusing predominantly on domain-specific knowledge and limited problem-solving abilities, thereby neglecting broader dispositional and reflective aspects critical to CT (Davies, 2015; Tiruneh et al., 2018; Zhou, 2022).

Another unresolved issue pertains to the transferability of CT across contexts. Although near transfer within disciplinary boundaries is well-supported, the conditions facilitating far transfer remain to be clarified. van Peppen et al. (2021) indicate that robust instructional approaches yielding near transfer fail to guarantee that students can apply their CT to significantly different or novel situations. Tiruneh et al.'s (2018) and Fong et al.'s (1986) studies both highlight that while far transfer is possible, no evidence of improvement on exercising CT across situations (especially in life situations where contexts are starkly different from the instruction) exists. Namely, "near-far" transfer is feasible, but a real far transfer is not.

A final important consideration is the developmental aspect of CT, which is insufficiently addressed in the reviewed studies. Despite evidence indicating measurable gains from short-term interventions (Fong et al., 1986; van Peppen et al., 2021), the longitudinal trajectory of CT development over a typical four-year college education remains opaque. Although there have been studies tracking students' development of CT throughout their four-year college enrollment, the studies either operate on a limited view of CT (Ralston & Bays, 2015) or inconsistent definitions of CT given its nature of meta-analysis (Huber & Kuncel, 2016).

Implications for Theory Development

Although there is an abundance of theories regarding learning transfer and established approaches to teaching CT, a targeted theory could elucidate how learners transfer CT skills from classroom settings to other disciplines and daily life. Such a theory could further illuminate the mechanisms underlying near and far transfer, as well as other forms of transfer beyond this traditional dichotomy. Although this review identifies instructional practices in CT that may facilitate learning transfer, the findings may be superficial due to the diverse contexts examined, including variations in class sizes and countries. Moreover, significant effort is required to formulate a theory that addresses the longitudinal development of CT, as the review indicates that both long-term and short-term interventions can promote far transfer, though their effectiveness warrants further investigation.

Theories of transfer of learning are well established in other areas, such as education in general skills and academic subjects (Barnett & Ceci, 2002) and composition studies (DePalma & Ringer, 2011). These theories denote when and how different types of transfer may occur, facilitating research into optimal learning contexts. They also offer guidance for educators. Nevertheless, the absence of a dedicated theory for CT transfer—especially for far transfer—represents a gap for future investigation.

Implications for Future Research

Further studies on facilitating far transfer should be conducted, given that results from numerous designed experiments are inconsistent. Researchers may disentangle complexities by adopting various research designs and employing comprehensive approaches (e.g., state-space grids, as seen in Hollenstein, 2013) to capture the multifaceted nature of undergraduates' CT development throughout their college attendance.

A nuanced understanding of how sustained engagement with CT instruction contributes to students' long-term cognitive growth and intellectual maturity is also lacking. An approach to address this gap in literature is to undertake a small-scale study involving a small cohort (e.g., an honors college in the US) to assess individuals' advancement in CT development through their engagement with curricula, encompassing courses and activities. Students in an honors college typically involve themselves in common activities that boost their CT, such as research experiences, and they share homogeneous traits (e.g., being self-motivated). This approach will ensure tracking of students' progress, allow researchers to adhere to the same framework of CT throughout four years, and limit the confounds in research—ideal for a pilot study.

Implications for Instructional Practices

Given that a student's CT development unfolds at various temporal scales and that students' CT can have significant improvement (Huber & Kuncel, 2016) over the four years, with consideration of feasibility, institutions can mandate CT as an embedded component in select undergraduate classes as a pilot test and gradually expand CT embedment to other professional courses. Additionally, given the low feasibility of far–far transfer (i.e., transfer across conceptually and disciplinarily distant contexts; Fong et al., 1986; Tiruneh et al., 2018), achieving Halpern & Butler's (2019) vision of CT as a central component of learners' lives requires broad implementation across the curriculum.

Meanwhile, instructors should receive training on CT instruction, both from a domain-specific perspective and a general perspective. Some pedagogies can also be introduced to instructors, such as problem-based learning (PBL), which actively engages students in probing into knowledge and untangling the complexity of problems while fostering students' agency (Yew & Goh, 2016). The benefit of this approach is that instructors can create courses that blend CT to meet their needs without the constraints of an all-purpose model. In addition to being introduced to this pedagogy, instructors ought to perform a teaching demonstration and design a mini syllabus, while receiving assessment from both content and educational experts to identify appropriate methods for incorporating CT into courses.

Although transforming our professional courses to incorporate CT development can benefit undergraduates, a single, uniform solution may not suffice for students' CT development. For instance, Loes and Pascarella (2017) concluded that collaborative learning is effective, but it is significantly effective only for White students who scored below 26 on the ACT for college admission. Colleges may consider policies and extracurricular activities that build students' CT as a component that may be more effective at facilitating the far transfer of CT.

Implications for Future Institutional Practices and Policies

CT involves one's attitudes, actions, and dispositions. Experimenting with how CT can be best taught remains a prominent area for further work (Davies, 2015). While individual instructors play a vital role, sustainable CT development requires institutional support. To this end, colleges should leverage High Impact Practices (HIPs)—defined by Kuh (2008) as active learning practices that promote deep engagement, such as service learning, internships, and capstone projects. In addressing curriculum and instruction, this article focuses on both the class level and the institutional level, drawing on exemplary examples across institutions.

A launchpad can be Gen Ed (General Education) 3.0 by Hanstedt (2023), which can be considered learning beyond rote memorization and developing the dispositions conducive to CT development through a series of challenging activities in general education. In such a context, general education happens within and beyond the classroom, facilitated by HIPs (Hanstedt, 2023). HIPs center on the *whats* and *whys* of learning, emphasizing frequent interactions, high expectations, and applications to real-world problems. These practices are distinct from standard coursework because they demand sustained effort and interaction over time.

In the interest of practicality and broad applicability of this article, HIPs within classes should be considered, given that the classrooms are the most common places where students engage in educational experiences. At Sam Houston State University, an emphasis on CT was introduced in a restructured general education course (Rowe et al., 2015). There, students were exposed to texts that scaffolded their ability to evaluate arguments and build a schema of reasoning, bolstered by active learning activities and topics that helped them overcome their limitations in using heuristics. Students in this course had a 28% increase on their Critical Thinking Assessment Test (CAT) within a semester, compared to most college students, who had a 26% increase over four years in undergraduate programs.

Zooming out, we may consider how institutions orchestrate policies conducive to students' CT. At Wagner College in New York City, learning activities and communities go beyond taking courses across multiple disciplines; students are also required to complete a capstone project and engage in service learning (Hanstedt, 2023).

Another exemplary model is implemented at NUS College, National University of Singapore. There, students are required to take courses and team projects around the four pillars: Critical Competencies, Global Orientation, Making Connections, and Impact Experience. They cover the skills that students need (e.g., reasoning and argumentation), offer interdisciplinary and discipline-specific challenges inside and outside classrooms, and enable them to reflect on their perspectives, which ultimately translates into their developed propensities into action through Impact Experience. On top of the curriculum, students are required to complete a practicum in which they expand their perspectives or wield their impact to fulfill requirements for Global Pathways. Students are also entitled to a support system, such as Life Mentoring, which guides students on their life trajectories and possibilities to stimulate a student's growth beyond the curriculum (National University of Singapore, n.d.). Despite the many options being offered to instructors and administrators, the main ingredient, deliberately designed project-based learning, which empowers students to build connections and leverage their agency, remains consistent across the cases discussed.

APPENDIX - Summary of Research Studies Included in the Review

Authors	Study design	Data sources	Foci of paper	Age group	Discipline	Country
Aouaf et al. (2022)	Qualitative; non-experimental; classroom	Open-ended questionnaires	Barriers to students' CT in EFL settings	Undergraduate students	Language education	Morocco
As'ari et al. (2017)	Qualitative case study	Interviews, tasks, reflections	CT dispositions in prospective math teachers	Preservice teachers	STEM	Indonesia
Bensley & Spero (2014)	Quantitative quasi-experimental; Classroom	CT tests, metacognitive tasks	Effects of direct CT instruction	Undergraduate students	Social sciences & humanities	United States
Booth et al. (2015)	Quantitative quasi-experimental; middle school	Algebra assignments and tests	Worked examples in algebra learning	Secondary students	STEM	United States
Corral et al. (2023)	Quantitative experiments; lab	Analogical problem-solving tasks	Retrieval practice vs. restudy in analogical reasoning	Undergraduate students	Social sciences & humanities	United States
Fong et al. (1986)	Quantitative experiments; lab	Statistical reasoning tasks	Impact of statistical training on everyday reasoning	High school students and postsecondary students	Social sciences & humanities	United States

The summary table includes the studies analyzed in the two sections of this review article: "Development of Students' CT" and "Transfer of Students' CT."

APPENDIX - Summary of Research Studies Included in the Review

Authors	Study design	Data sources	Foci of paper	Age group	Discipline	Country
Golden (2023)	Qualitative self-study; classroom	Instructor journals, artifacts	Designing planning tools to support CT	Undergraduate students	Social sciences & humanities	Ireland
Holmes et al. (2015)	Quanti-tative quasi-experi-mental; lab course	Physics lab reports	Data-based reasoning in physics labs	Undergraduate students	STEM	United States
Hyytinen et al. (2024)	Quanti-tative cross-sectional	CT tests, self-regulation scales	Role of self-regulation and effort in CT performance	Undergraduate students	General CT	Finland
Janssen et al. (2019)	Quantitative cross-sectional correlational; higher-ed faculty context	Cognitive Reflection Test; surveys; background data	Teacher characteristics linked to CT performance and CT-teaching attitudes	University faculty/ instructors	Social sciences & humanities	Netherlands
Lee et al. (2024)	Qualitative case study	Interviews	Students' views on CT development	Undergraduate students	General CT	Singapore
Lu et al. (2021)	Quanti-tative cross-sectional	Surveys	Cultural differences in CT style	Undergraduate students	Agriculture	United States & China

The summary table includes the studies analyzed in the two sections of this review article: "Development of Students' CT" and "Transfer of Students' CT."

APPENDIX - Summary of Research Studies Included in the Review

Authors	Study design	Data sources	Foci of paper	Age group	Discipline	Country
Mehta & Al-Mahrooqi (2015)	Qualitative; classroom	Writing tasks, observation	CT development through writing in EFL	Undergraduate students	Language education	Oman
Ralston & Bays (2015)	Quantitative; longitudinal; engineering program	CT rubric scores across 4 years	CT development across curriculum	Undergraduate students	STEM	United States
Slade et al. (2019)	Qualitative; practicum	Written reflections	Reflective practice in teacher education	Preservice teachers	Social sciences & humanities	United States
Tiruneh et al. (2018)	Quanti-tative quasi-experi-mental; science classes	CT tests	Immersion vs infusion CT instruction	Undergraduate students	STEM	Ethiopia
van Peppen et al. (2018)	Quanti-tative experiment	CT tests	Prompting self-explanations for unbiased reasoning	Undergraduate students	General CT	Netherlands
van Peppen et al. (2021)	Quanti-tative experi-ment; repeated delayed posttests	CT learning and transfer tasks	Contrasting examples and transfer	Undergraduate students	General CT	Netherlands

The summary table includes the studies analyzed in the two sections of this review article: "Development of Students' CT" and "Transfer of Students' CT."

APPENDIX - Summary of Research Studies Included in the Review

Authors	Study design	Data sources	Foci of paper	Age group	Discipline	Country
van Peppen et al. (2022)	Quanti-tative experi-ments; lab + classroom	CT transfer tasks	Exploring why CT transfer fails	Undergraduate students	General CT	Netherlands
Wong & Kowit-lawakul (2020)	Qualitative interviews; natural nursing program	Semi-structured interviews	Nursing students' experiences with CT and clinical reasoning	Undergraduate students	Health sciences	Singapore

The summary table includes the studies analyzed in the two sections of this review article: "Development of Students' CT" and "Transfer of Students' CT."

CONCLUSION

The review concludes that CT development is a non-linear process, far from a steady growth of this competency throughout the four years of college. While studies have provided guidelines for designing impactful instruction to support CT development, these guidelines do not apply to every educational setting. Furthermore, the absence of a theory on the learning transfer of CT, complicated by temporal factors, signifies a need for empirical research on theories and teaching practices of CT.

While CT education has been implemented for decades, around 20% of graduates leave their institutions with limited critical thinking capacity (OECD, 2022). This is compounded by employers' dissatisfaction with the preparedness of these graduates' competencies. Most students showed improvements in CT as indicated by the Collegiate Learning Assessment (CLA+) test results, highlighting a mismatch between their qualifications and workplace expectations (OECD, 2022).

Critical thinking should be framed as a survival competency that students can demonstrate in real-world contexts. While theories and instructional models of CT development continue to evolve, classroom-based evidence from the humanities (e.g., Mehta & Al-Mahrooqi, 2015) to STEM (e.g., Ralston & Bays, 2015) indicates that effective CT development is attainable. Ultimately, CT is most likely to extend beyond the classroom when students perceive themselves as capable agents whose reasoning can shape decisions and actions in authentic settings (Davies, 2015).

REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. *Review of Educational Research, 85*(2), 275–314. https://doi.org/10.3102/0034654314551063

American Philosophical Association. (1990). *Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction. The Delphi Report: Research findings and recommendations prepared for the committee on pre-college philosophy.* P. Facione (Project Director). ERIC Doc. No. ED 315–423.

Aouaf, S., Azzouzi, L., & Housni, H. (2023). Perceived barriers to critical thinking development: The student's view. *International Journal of Linguistics, Literature and Translation, 6*(2), 63–69. https://doi.org/10.32996/ijllt.2023.6.2.10

As'ari, A. R., Mahmudi, A., & Nuerlaelah, E. (2017). Our prospective mathematic teachers are not critical thinkers yet. *Journal on Mathematics Education, 8*(2), 145–156. https://doi.org/10.22342/jme.8.2.3961.145-156

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn?: A taxonomy for far transfer. *Psychological Bulletin, 128*(4), 612–637. https://doi.org/10.1037/0033-

Bassok, M., & Holyoak, K. J. (1989). Interdomain transfer between isomorphic topics in algebra and physics. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*(1), 153–166. https://doi.org/10.1037/0278-7393.15.1.153

Bensley, D., & Spero, R. A. (2014). Improving critical thinking skills and metacognitive monitoring through direct infusion. *Thinking Skills and Creativity, 12*, 55–68. https://doi.org/10.1016/j.tsc.2014.02.001

Booth, J. L., Oyer, M. H., Paré-Blagoev, E. J., Elliot, A. J., Barbieri, C., Augustine, A., & Koedinger, K. R. (2015). Learning algebra by example in real-world classrooms. *Journal of Research on Educational Effectiveness, 8*(4), 530–551. https://doi.org/10.1080/19345747.2015.1055636

Clark, A. (2001). *Mindware: An introduction to the philosophy of cognitive science.* Oxford University Press.

Corral, D., Carpenter, S. K., & St. Hilaire, K. J. (2023). The effects of retrieval versus study on analogical problem solving. *Psychonomic Bulletin & Review, 30*(5), 1954–1965. https://doi.org/10.3758/s13423-023-02268-4

Davies, M. (2015). A model of critical thinking in higher education. In M. B. Paulsen (Ed.), *Higher education: Handbook of theory and research* (Vol. 30, pp. 41–92). Springer International Publishing. https://doi.org/10.1007/978-3-319-12835-1_2

DePalma, M.-J., & Ringer, J. M. (2011). Toward a theory of adaptive transfer: Expanding disciplinary discussions of "transfer" in second-language writing and composition studies. *Journal of Second Language Writing, 20*(2), 134–147. https://doi.org/10.1016/j.jslw.2011.02.003

Dumitru, D. (2013). The transfer and the transferability of critical thinking skills. *Transylvanian Review, 22*, 142–148. https://www.researchgate.net/publication/285117261_The_transfer_and_the_transferability_of_critical_thinking_skills

Eigenauer, J. (2024). Mindware: Critical thinking in everyday life. *Journal of Intelligence, 12*(2), Article 17. https://doi.org/10.3390/jintelligence12020017

Ennis, R. (1991). Critical thinking: A streamlined conception. *Teaching Philosophy, 14*(1), 5–24. https://doi.org/10.5840/teachphil19911412

Ennis, R. H. (1964). A definition of critical thinking. *The Reading Teacher, 17*(8), 599–612. https://www.jstor.org/stable/20197828

Fong, G. T., Krantz, D. H., & Nisbett, R. E. (1986). The effects of statistical training on thinking about everyday problems. *Cognitive Psychology, 18*(3), 253–292. https://doi.org/10.1016/0010-0285(86)90001-0

Golden, B. (2023). Enabling critical thinking development in higher education through the use of a structured planning tool. *Irish Educational Studies, 42*(4), 949–969. https://doi.org/10.1080/03323315.2023.2258497

Haber, J. (2020). *Critical thinking*. The MIT Press. https://doi.org/10.7551/mitpress/12081.001.0001

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

Halpern, D. F., & Butler, H. A. (2019). Teaching critical thinking as if our future depends on it, because it does. In J. Dunlosky & K. A. Rawson (Eds.), *The Cambridge handbook of cognition and education* (1st ed., pp. 51–66). Cambridge University Press. https://doi.org/10.1017/9781108235631.004

Hanstedt, P. (2023). Gen Ed 3.0: High impact models. In *General education essentials: A guide for college faculty* (2nd ed.). Routledge. https://doi.org/10.4324/9781003444992

Hollenstein, T. (2013). *State space grids: Depicting dynamics across development.* Springer New York. https://doi.org/10.1007/978-1-4614-5007-8

Holmes, N. G., Wieman, C. E., & Bonn, D. A. (2015). Teaching critical thinking. *Proceedings of the National Research Council, 112*(36), 11199–11204. https://doi.org/10.1073/pnas.1505329112

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

Hyytinen, H., Nissinen, K., Kleemola, K., Ursin, J., & Toom, A. (2024). How do self-regulation and effort in test-taking contribute to undergraduate students' critical thinking performance? *Studies in Higher Education, 49*(1), 192–205. https://doi.org/10.1080/03075079.2023.2227207

Janssen, E. M., Meulendijks, W., Mainhard, T., Verkoeijen, P. P., Heijltjes, A. E., van Peppen, L. M., & van Gog, T. (2019). Identifying characteristics associated with higher education teachers' Cognitive Reflection Test performance and their attitudes towards teaching critical thinking. *Teaching and Teacher Education, 84,* 139-149. https://doi.org/10.1016/j.tate.2019.05.008

Jiang, Y., Shao, Y., Ma, D., Semnani, S., & Lam, M. (2024). Into the unknown unknowns: Engaged human learning through participation in language model agent conversations. In Y. Al-Onaizan, M. Bansal, & Y.-N. Chen (Eds.), *Proceedings of the 2024 Conference on Empirical Methods in Natural Language Processing* (pp. 9917–9955). Association for Computational Linguistics. https://doi.org/10.18653/v1/2024.emnlp-main.554

Kaplan, A., & Garner, J. K. (2020). Steps for applying the complex dynamical systems approach in educational research: A guide for the perplexed scholar. *The Journal of Experimental Education, 88*(3), 486–502. https://doi.org/10.1080/00220973.2020.1745738

Kuh, G. D. (2008). *High-impact educational practices: What they are, who has access to them, and why they matter.* Association of American Colleges and Universities.

Lee, N. Y., Wang, Z., & Lim, B. (2024). The development of critical thinking: What university students have to say. *Teaching in Higher Education, 29*(1), 286–299. https://doi.org/10.1080/13562517.2021.1973412

Loes, C. N., & Pascarella, E. T. (2017). Collaborative learning and critical thinking: Testing the link. *The Journal of Higher Education, 88(*5), 726–753. https://doi.org/10.1080/00221546.2017.1291257

Lu, P., Burris, S., Baker, M., Meyers, C., & Cummins, G. (2021). Cultural differences in critical thinking style: A comparison of U.S. and Chinese undergraduate agricultural students. *Journal of International Agricultural and Extension Education, 28*(4), 49–62. https://doi.org/10.5191/jiaee.2021.28449

Mat Said, N. A., Bujang, S. M., Buang, N. A., Siraj @ Ramli, H. H., & Awang Besar, M. N. (2021). Conceptualizing critical thinking learning transfer model: A qualitative approach. *Malaysian Journal of Learning and Instruction, 18*(1), 111–130. https://doi.org/10.32890/mjli2021.18.1.5

Mehta, S. R., & Al-Mahrooqi, R. (2015). Can thinking be taught? Linking critical thinking and writing in an EFL context. *RELC Journal, 46*(1), 23–36. https://doi.org/10.1177/0033688214555356

National Research Council. (2000). How people learn: *Brain, mind, experience, and school* (Expanded ed.). The National Academies Press. https://doi.org/10.17226/98532909.128.4.612

National University of Singapore. (n.d.). *Growth mentoring - NUS College.* Retrieved June 10, 2025, from https://nuscollege.nus.edu.sg/college-life/growth-mentoring/

OECD. (2022). *Does higher education teach students to think critically?* (D. van Damme & D. Zahner, Eds.). OECD. https://doi.org/10.1787/cc9fa6aa-en

Paul, R. (1988). Critical thinking and learning: A maximalist versus minimalist approach. *Journal of College Reading and Learning, 21*(1), 113–130. https://doi.org/10.1080/10790195.1988.10849927

Pautasso, M. (2019). The structure and conduct of a narrative literature review. In M. Shoja, A. Arynchyna, M. Loukas, A. V. D'Antoni, S. M. Buerger, M. Karl, & R. S. Tubbs (Eds.), *A guide to the scientific career* (1st ed., pp. 299–310). Wiley. https://doi.org/10.1002/9781118907283.ch31

Perkins, D. (1995). *Outsmarting IQ: The emerging science of learnable intelligence.* Free Press.

Pnevmatikos, D., Christodoulou, P., Georgiadou, T., & Lithoxoidou, A. (2023). Undergraduate students' conceptualization of critical thinking and their ideas for critical thinking acquisition. *Education Sciences, 13*(4), Article 416. https://doi.org/10.3390/educsci13040416

Ralston, P., & Bays, C. (2015). Critical thinking development in undergraduate engineering students from freshman through senior year: A 3-cohort longitudinal study. *American Journal of Engineering Education, 6,* 85–98. https://doi.org/10.19030/ajee.v6i2.9504

Rowe, M. P., Gillespie, B. M., Harris, K. R., Koether, S. D., Shannon, L.-J. Y., & Rose, L. A. (2015). Redesigning a general education science course to promote critical thinking. *CBE—Life Sciences Education, 14*(3), Article 30. https://doi.org/10.1187/cbe.15-02-0032

Sellier, A.-L., Scopelliti, I., & Morewedge, C. K. (2019). Debiasing training improves decision making in the field. *Psychological Science, 30*(9), 1371–1379. https://doi.org/10.1177/0956797619861429

Slade, M. L., Burnham, T., Catalana, S. M., & Waters, T. (2019). The impact of reflective practice on teacher candidates' learning. *International Journal for the Scholarship of Teaching and Learning, 13*(2), Article 15. https://doi.org/10.20429/ijsotl.2019.130215

Straková, Z., & Cimermanová, I. (2018). Critical thinking development—A necessary step in higher education transformation towards sustainability. *Sustainability, 10*(10), Article 3366. https://doi.org/10.3390/su10103366

Taherdoost, H. (2023). Towards nuts and bolts of conducting literature review: A typology of literature review. *Electronics, 12*(4), Article 800. https://doi.org/10.3390/electronics12040800

Tiruneh, D. T., Gu, X., De Cock, M., & Elen, J. (2018). Systematic design of domain-specific instruction on near and far transfer of critical thinking skills. *International Journal of Educational Research, 87,* 1–11. https://doi.org/10.1016/j.ijer.2017.10.005

van Peppen, L. M., van Gog, T., Verkoeijen, P. P. J. L., & Alexander, P. A. (2022). Identifying obstacles to transfer of critical thinking skills. *Journal of Cognitive Psychology, 34*(2), 261–288. https://doi.org/10.1080/20445911.2021.1990302

van Peppen, L. M., Verkoeijen, P. P. J. L., Heijltjes, A. E. G., Janssen, E. M., & van Gog, T. (2021). Enhancing students' critical thinking skills: Is comparing correct and erroneous examples beneficial? *Instructional Science, 49*(6), 747–777. https://doi.org/10.1007/s11251-021-09559-0

van Peppen, L. M., Verkoeijen, P. P. J. L., Heijltjes, A. E. G., Janssen, E. M., Koopmans, D., & van Gog, T. (2018). Effects of self-explaining on learning and transfer of critical thinking skills. *Frontiers in Education, 3,* Article 100. https://doi.org/10.3389/feduc.2018.00100

Wong, S. H. V., & Kowitlawakul, Y. (2020). Exploring perceptions and barriers in developing critical thinking and clinical reasoning of nursing students: A qualitative study. *Nurse Education Today, 95,* Article 104600. https://doi.org/10.1016/j.nedt.2020.104600

Yew, E. H. J., & Goh, K. (2016). Problem-based learning: An overview of its process and impact on learning. *Health Professions Education, 2*(2), 75–79. https://doi.org/10.1016/j.hpe.2016.01.004

Zhou, Z. (2022). Critical thinking: Two theses from the ground up. *Journal of the Scholarship of Teaching and Learning, 22*(1), 154–171. https://doi.org/10.14434/josotl.v22i1.30983