



Rethinking ‘Thinking Skills’ in 21st-Century Education: Combining Conceptual Clarity with a Novel 4E Cognitive Framework

Gerry Dunne¹

Received: 9 October 2024 / Revised: 22 May 2025 / Accepted: 24 May 2025 /
Published online: 7 July 2025
© The Author(s) 2025

Abstract

In education, the concept of ‘*thinking skills*’ has long been contentious. This article revisits the 2010 debate between Stephen Johnson and Harvey Siegel on whether thinking can be taught as a general skill. To weigh in on this ongoing dispute, it contributes a novel perspective by augmenting key insights from 4E cognition to avoid treating cognition as a purely brain-based computational perspective which treats the brain as separate from the rest of the body and its environment. I argue that given the elusiveness of the concept of ‘thinking skills’, scholars must first reach a sufficiently precise and pluralistic understanding of so-called ‘thinking skills’ to avoid talking past another. Such precision, I contend, is a necessary condition, an antecedent epistemic obligation, so to speak, prior to the design of curricula which prioritize the acquisition of the much-heralded, yet heavily disputed, ‘21st-century thinking skills’ (Varas et. al., 2023) assortment of the following: Critical thinking, Creativity, Collaboration, Communication, information, and media literacy, Computing and ICT literacy, Cross-cultural understanding and Career, and learning self-reliance (Trilling and Fadel, 2009). See (Dishon and Gilead, British J Educ Stud 69:393–413, 2021)) for a critical analysis of the unquestioned exaltation of said twenty-first century skills). To ground the discussion in policy, I revisit the influential UK *McGuinness Report*, examining how it influenced higher education institutions’ approaches to thinking skills and how it shaped their understanding of those skills, including critical thinking. One key finding of my analysis is that both domain-specific knowledge and contextually sensitive, generalizable thinking skills are vital for fostering a robust understanding of how to nurture and enhance thinking skills in educational settings. More importantly, such thinking skills are best viewed through the lens of 4E cognition rather than as decontextualized, disembodied cognitive outcomes. In short, this paper demonstrates that in an era focused on developing 21st-century skills, clarifying exactly what we mean by ‘thinking skills’—particularly through the lens of novel 4E cognition frameworks—must inform the future design of effective thinking-skills curricula.

Keywords Thinking skills · Skill-talk · 4E cognition · Expertise · Higher education

✉ Gerry Dunne
gedunne@tcd.ie

¹ Trinity College Dublin, Education Department , Dublin, Ireland, College Green , Dublin 2

The Elusiveness of Teaching so-called ‘Thinking Skills’

What does it mean to ‘teach’ thinking skills? Is teaching such skills even possible? In this paper, I argue that resolving this enduring question requires a fresh approach: applying cognitive science perspectives, specifically, *4E* cognition, to achieve conceptual clarity about ‘thinking skills.’ This approach is crucial because contemporary educational policy (e.g., global 21st-century skills initiatives) places heavy emphasis on teaching “thinking,” which makes conceptual precision more important than ever. By ‘thinking skills’ I mean broad cognitive dispositions and abilities—such as close analysis, problem-solving, creativity and reasoning—that education might aim to develop in general. *Critical thinking, for our purposes here*, is framed as a specific subset of these skills—centering on erotetics, reasoning and accurate evaluation—rather than as an entirely separate concept.

Much has been written on the contested ontology of thinking skills, including the much-discussed generalizability debate. It’s worth noting that this issue is not new as it echoes earlier debates. Generalists such as Robert Ennis and Richard Paul argued that critical thinking skills are transferable, whereas specifists like John McPeck maintained that critical thinking is inherently bound to specific disciplines (Ennis 1989; Paul, 1992; McPeck 1981). More recently, scholars such as Tim Moore (2004) and Martin (2006) have revisited this ‘general vs. specific’ critical thinking debate, suggesting that this framing constitutes a false dichotomy—a reasonable conclusion I also endorse (see Dunne 2025).

A notable contribution by Stephen Johnson (2010, pp. 1–47) in the book *Teaching Thinking Skills*, takes aim at those who characterize ‘thinking skills’ as commensurate with generalizable non-domain specific, transferable competences (see, for instance, Halpern 1998). In his view, general transferability rests upon a number of fallacies and conceptual errors, which, once revealed, undermine the argument that thinking skills, (should such a thing exist), can be applied to disparate domains of expertise with minimal difficulty. He critiques the direct approach to teaching thinking, which risks knowledge playing an ancillary role; in some cases, relegating it to the side-lines, in other instances, even regarding it as an impediment. Finally, Johnson objects to the reductionist checklist approach to thinking. He is especially concerned with programmes which endeavour to equip students with supposedly enhanced general thinking skills.¹ In short, Johnson seeks to undermine the unexamined assumption that ‘thinking skills’ tout court (in and of themselves) have inherent educational value or even a coherent existence (Johnson 1999, p. 20). He argues this is because ‘thinking takes an ‘indirect object—in other words—one cannot think without thinking *about* something (p.20).

According to Johnson’s view, an unchecked preoccupation with enhancing thinking skills can lead to several negative outcomes: the disparagement or undervaluing of knowledge, the impersonalization and neutralization of thought, the neglect of truth,

¹ McPeck (1981) is also highly critical of this untested assumption. He claims, “it is a matter of conceptual truth that thinking is always thinking about X, and that X can never be ‘everything in general’ but must always be something in particular” (p. 4). There is merit in his view of course. But particular does not always have non-porous boundaries. I might be thinking about happiness/flourishing. My thoughts bleed into psychology (subjective accounts of wellbeing), epistemology (evidential basis supporting self-reports of mental states). ‘Particular’ does not always have fixed borders in the sense McPeck suggests. Indeed, as Andrews (2010) points out, “What are the criteria for identifying ‘something in particular’ (an X)?... [indeed]...” by what criteria are we to identify ‘specific’ problems?” (p.75) The worry is of course, the infinitesimal numbers of supposed Xs that McPeck’s account seems to leave open to theorists in light of the examples he offers, such as, ‘mathematics’ (p. 7), ‘politics’ (p. 7) and ‘mountain-climbing’ (p. 7).

and the “computerization” of thought (Johnson 2010, p. 2). This view is a long established one, echoed by A. N. Whitehead in the latter part of the 1920s. He too emphasized the dependence on content, since thought without content is blind. As Whitehead put it, “Nobody can be a good reasoner unless by constant practice he has realized the importance of getting hold of the big ideas and of hanging on to them like grim death” (1929, p. 91).

Another vocal critic of thinking skills rhetoric is M. S. Peters, who in a 2007 paper writes,

To talk of ‘thinking skills’—a concept that dominates contemporary educational discourse—is already to adopt a particular view of thinking, that is, thinking as a kind of technology. This view of thinking is a reductive concept of thinking as a means-ends instrumentality, a series of techniques that can move us from one space to another. In the so-called knowledge economy emphasis in the curriculum has passed from the knowledge and understanding of traditional subjects and disciplines to generic, *transferable skills* which allegedly equip learners with the means through which they can learn. These are often described in psychological language as metacognitive skills, that is, learning how to learn, and are now squared off against information-processing skills, knowledge management skills, entrepreneurial skills, and social skills like team-building (p.352).

Other notable critics of ‘general thinking skills’ (GTSs) are equally eager to debunk the allure of GTSs. This familiar argument is found framed in slightly different forms in the work of Paul Hirst (1969) and John McPeck (1981). For the sake of precision, I frame it here as follows:

- (i) Thinking always involves thinking of, or about, an X, where X stands for some object, activity, task, topic, subject-matter, etc.;
- (ii) X is always a ‘specific’ X,
- (iii) The nature of X necessarily determines the kind of thinking that can be appropriately-directed at it;
- (iv) As every X is a ‘specific’ X, appropriate thinking will always be a ‘specific’ kind of thinking;
- (v) Therefore, there will be as many kinds of appropriate thinking as there are ‘specific’ Xs to be thought about;
- (vi) It follows that there cannot be any general kind of thinking that is appropriate across specific Xs;
- (vii) Therefore, there cannot be any GTSs.

Perhaps a more constructive solution-oriented strategy addressing for this conceptual problem comes from Peter Facione (1990) in his analysis of critical thinking. He is not tied, as McPeck certainly is, to clearly demarcated disciplinary boundaries, beyond which prospective inquirers are trespassing. As he puts it,

Although the identification and analysis of critical thinking skills transcend, in significant ways, specific subjects or disciplines, learning and applying these skills in many contexts requires domain-specific knowledge. This domain-specific knowledge includes understanding methodological principles and competence to engage in norm-regulated practices that are at the core of reasonable judgments in those specific contexts... Too much of value is lost if critical thinking is conceived of simply as a list of logical operations and domain-specific knowledge is conceived of simply as an aggregation of information (p.10).

Hardly anyone really doubts that having a sufficient degree of background knowledge or experience is a necessary condition for critical thinking.² For example, asking my eight year old child to critically evaluate the mathematical principles underlying my engineering calculations (weight, rope density/material and span, including fixings) for her rope swing in the garden is pointless since she lacks a background in engineering. While she or her sisters can certainly learn in time, it remains true that background knowledge is often essential for effective critical thinking. Therefore, background knowledge and understanding are just as crucial as skill itself in the crucial development of critical thinking.

Despite their differing analyses, critics like Johnson, Peters, Hirst, and McPeck—and even the more optimistic Facione—converge on the point that a myopic focus on thinking skills at the expense of content, disciplinary expertise, and conceptual clarity can lead to several negative outcomes in education. Below I extrapolate some of these damaging effects, as identified by Johnson and others, in terms I hope useful for pedagogues and educationalists:

- **Undermining Knowledge:** According to this view, devaluing knowledge, as foundational content, is neglected in favour of developing, generic yet domain-transferable principles and thinking processes.
- **Technocratic Thought:** learning thinking skills is decontextualised, resulting in thought being reduced to impersonal and neutral propositions, at the expense of a grounding in the fundamental principles of responsible and effective inquiry. In short—this involves—focusing more on techniques—rather than engaging with specific subject matter meaningfully.
- **Questioning Knowledge Claims without Sufficient Content/Reason:** As I see this—scrutinizing claims to knowledge almost always involves background knowledge. Without a basis in such, erotetic competencies, should they exist, lack efficacy. This can lead to students developing a habit of routinely questioning established facts (an extreme scepticism of sorts) without a solid grounding in the very area under scrutiny.
- **Computerizing Thought:** Here students are taught to rely on rigid, myopic frameworks/checklists, to be ‘*logic choppers*’, as Nick Burbules and Berk (1999, p.47) puts in, rather than seeking to develop flexible, nuanced, deep understandings of phenomena under investigation.

Harvey Siegel (2010, pp. 51–83), in his response to Johnson, shares many of his concerns, particularly regarding the conceptual errors at the heart of the policy document on which much of Johnson’s critique is based, namely, the McGuinness Report (1999). While Siegel and Johnson agree on many points, Siegel is careful to draw distinctions: he separates criticisms grounded in a close reading of the policy document’s philosophical assumptions from those based on a broader conceptual analysis of the value of thinking skills in educational discourse. Siegel contends that Johnson’s arguments rely too heavily on the policy document’s assumptions instead of engaging with key philosophical work from other scholars in the field, scholars who have worked in the area of cognitive science, philosophy, experimental psychology and education (p.53). Before examining Johnson’s

² To be clear: I see CT as a subspecies of successfully executed thinking skills, generally defined. Like others, I endorse the view which views it as an evaluative judgment, stress-testing the strength of reasons supporting (i) what a person believes, (ii) accepts or (iii) does (see Dunne 2025). See Fridland and Pavese (2020) for an excellent handbook on the concept of skill and expertise.

and Siegel's arguments in detail, it is important to understand the policy backdrop that sparked their debate—most notably the influential 1999 *McGuinness Report* in the UK, which aimed to operationalize 'thinking skills' in curricula.

In the next section, I trace the background of the McGuinness Report (1999). Although the McGuinness Report was a UK (Northern Ireland) initiative, its influence has been global in reach—shaping discourse on thinking skills far beyond the UK and Ireland. For instance, its ideas anticipated global efforts like the OECD's early 21st-century skills assessments and have parallels in contemporary curriculum reforms worldwide. I maintain that much of the content of this report still informs HEI thinking on critical thinking (see AHELO 2013, Foster & Piacentini 2023; OECD 2013a, b).³, and, more generally, twenty-first century thinking skills.

From there, I turn to some of Johnson's key points—specifically his most salient objections to the idea of thinking as a skill. Finally, I present Siegel's response to Johnson's concerns about pursuing thinking skills in educational settings, incorporating insights from more recent philosophical work on skills.

The McGuinness Report

Interest in the value and efficacy of 'thinking skills' within UK curricula was revived by the 1999 publication of: *From Thinking Skills to thinking Classrooms: a review and evaluation of approaches for developing pupils' thinking* (hereafter the McGuinness Report). The report is named after Dr Carol McGuinness of Queen's University, former director of the Activating Children's Thinking Skills project, which was funded by the Northern Ireland Council for Curriculum, Examination and Assessment. In her report, McGuinness (1999) outlines "several general taxonomies" of thinking skills including:

sequencing and ordering information; sorting, classifying, grouping; analysing, identifying part/whole relationships, comparing and contrasting; making predictions and hypothesising; drawing conclusions, giving reasons for conclusions; distinguishing fact from opinion; determining bias and checking the reliability of evidence; generating new ideas and brainstorming; relating cause and effect, designing a fair test; defining and clarifying problems, thinking up different solutions, setting up goals and sub-goals; testing solutions and evaluating outcomes; planning and monitoring progress towards a goal, revising plans; making decisions, setting priorities, weighing up pros and cons (p. 5).

According to McGuinness, students should be taught thinking skills in a manner consistent with the broader aims of a liberal education. While not exhaustive, this list includes skills such as drawing conclusions (Lipton 2004); distinguishing fact from opinion; checking the reliability of evidence (Lipman 1991); relating cause and effect; defining and clarifying problems and testing solutions and evaluating outcomes. McGuinness identifies three principal approaches to teaching thinking: the *general* approach, the *subject-specific approach*, and the *infusion* approach.

³ AHELO was an OECD initiative which sought to measure learner outcomes, one of which was critical thinking across OECD countries. You can read the full report here: See <https://www.oecd.org/education/skills-beyond-school/AHELOFSReportVolume3.pdf>

Talk of a *general* approach, McGuinness claims, rests upon the idea that “cognitive development is driven by a general central processor. On this basis, intervention at this level will have widespread effects across many thinking domains” (p.7). Implicit in this understanding is that some courses strive (and ought to strive) to enhance general information processing skills within a context-free setting. Tests like the *Cornell Critical Thinking Test*, *Cambridge International AS and A Level Thinking Skills* are obvious cases in point. These tools are marketed as methods for enhancing problem-solving and critical thinking skills independent of domain-specific knowledge or expertise.

Other approaches target general cognitive development from within particular subject areas (e.g., Cognitive Acceleration through Science Education (CASE), see Shayer and Adey, 2002). The aim of the *subject-specific* approach is to enhance thinking within domain-specific contexts. Several examples of this exist, for instance, *Engineering Reasoning* (Paul, Niewoehner, & Elder 2013), and the *Thinking through History* project (Fisher 2002). Finally, we have the approach personally favoured by McGuinness, “the *infusion method*” (Johnson, 2010, p.6). This pedagogic approach seeks to enhance thinking skills by utilizing contexts naturally occurring within certain curricular content as a kind of hook to hang general thinking skills on. As McGuinness puts it, “this approach does have a generic character, it seeks to embed thinking skills...and exploit naturally occurring opportunities for developing thinking within the ordinary curriculum” (p. 19). Notably, these approaches mirror trends seen internationally at the turn of the century—with some education systems experimenting with stand-alone ‘thinking skills’ courses (general approach—Ireland being one such example), others embedding thinking within subjects (subject-specific), with others still adopting variants of McGuinness’s preferred *infusion method* in curricula globally (see Swartz, 1992).

Reification, Essentialism and Generalization: Johnson’s Key Objections

Johnson’s critique zeroes in on conceptual confusions embedded in ‘skill-talk’—precisely the kind of issues that this paper seeks to clarify. He identifies four *fallacies* that often underlie talk of thinking skills, each illustrating how loose definitions can mislead educational practice. These he labels: (i) reification, (ii) essentialism, (iii) naming, and (iv) generalization. Since much turns on the conceptual exactitude of these, let us examine each one in turn.

Reification refers to “wrongly treating X as if it were a thing” (p.20). Johnson contends that while we can refer to thinking, there is no such thing as thinking in isolation, as to ‘think’ always requires an indirect object. He rejects the assumption that if someone can skilfully perform a task (Y), it implies there is a specific skill (Y-ing) that can be isolated and trained. Johnson considers this a fundamental error. Thus, referring to someone as a “skilful thinker” falsely implies that there is a distinct thinking skill that can be isolated and taught. For Johnson, this is regrettable and basic conceptual mistake.

Essentialism holds that thinking critically or solving problems can be explained by underlying brain or mental structures governed by scientific, verifiable principles. Simply put, essentialists believe mental operations work function in much the same way as physics: magnets attract iron fillings and acid turns litmus red. Thus, once a person develops a sufficiently sophisticated mental process, it is assumed they will consistently think critically. Johnson warns that essentialism might lead to “beliefs desires and context being ignored” (p.21). He further cautions that general labels such as problem-solving or critical thinking

can gain a “spurious unity and precision” (p.21). He argues that, on this view, it becomes difficult to explain why individuals labelled “critical thinkers” sometimes fail to think critically—just as it would be puzzling for a magnet to fail to attract iron.

According to Johnson, the *Naming Fallacy* arises from assuming that the existence of a general term implies a corresponding general ability. From the truth of “Jones is evaluating the applicant’s CV”, it does not follow that there is a general activity, *evaluating* that he is currently engaging in (Winch, 2010, p.111). Drawing on Wittgenstein, Johnson suggests that rather than one common feature running through all instances of a concept, there is a network of overlapping similarities. Much like in the case of games (family resemblances) where Wittgenstein makes his point, Johnson thinks “you will not find something common to all, but [rather] similarities, relationships” (p.31). So because we can recognize specific acts as acts of “judging” or “being accurate”, it does not follow that there are corresponding general skills, such that we could coherently claim to be able teach a person judging skills or accuracy skills *simpliciter* (p.23).

Finally, Johnson identifies the *Generalizing Fallacy*. Knowing how to open a tin does not necessarily imply one knows how to open all kinds of objects (Winch, 2010, p. 112). While this seems intuitive, one might argue that general principles could still apply when performing various ‘opening’ tasks. For instance, opening a zipped bag follows a similar process regardless of the specific bag. Likewise, opening a tin of tennis balls may not be identical to opening a tin of tuna, but the procedures are similar enough to manage without difficulty. That said, it is incorrect to infer from such examples that a “general activity of opening” exists that can be universally applied to all objects (Winch, 2010, p. 112). A property that applies to one specific task—like opening a can—cannot automatically be extended to all similar tasks; it is “false to conclude of some property that applies to a specific type of instance... that it can be applied to a range of types of activity” (p. 112).

In summary, Johnson’s analysis warns contemporary educators that the fashionable pursuit of generic ‘21st-century thinking skills’ may rest on shaky conceptual ground. Should *thinking* be proven to always have an object or context, then attempts to teach context-free thinking skills could be misguided. Johnson’s stringent critique raises a crucial question: if thinking skills *cannot* be taught as general capacities, what then is the alternative? Harvey Siegel’s response takes up this very question, agreeing in part with some of Johnson’s concerns but ultimately challenging his conclusion about generalizability.

Challenging Johnson’s Resistance to Skill-Talk

According to Johnson, claims about the existence or teachability of thinking skills rest on a mistaken assumption—that they are clearly identifiable processes that can be manipulated or improved. To be clear: he does not deny that thinking is an important activity, nor does he deny that it is an activity that some fare at better than others. Rather, he argues that whatever thinking skills may be, they should not be classified as skills in the conventional sense. More formally, as Christopher Winch (2010) points out, “whatever these abilities are, they are poorly characterized as skills, and to say that they involve thinking is also problematic, as thinking is too vague or rarefied a concept to be associated with a particular kind of activity” (p.107).

Reductionist approaches to understanding/teaching thinking as a skill are likely to be unsuccessful according to Johnson (2010) because “mastery of the so-called sub-skills still leaves the learner well short of mastering the whole” (p.11). For example, Johnny

Sexton might be a superb free-kick taker in rugby, yet still lack a theoretical understanding of the broader procedural techniques behind it. David Beckham, Johnson argues, does not go through a checklist covering feet, body-angle, follow-through and so on before he takes a free kick (p.11). Similarly, if we reduce critical thinking to a skill—implying thought is redundant and the skill is merely habitual—we risk conceptualizing it as an unreflective activity carried out under minimal understanding (pp. 7–13). In the same way, Johnson argues, equating thinking with ‘know-how’ is inappropriate since to have “mastered a skill usually means to be able to exercise it without thinking” (p.10).

Two key points emerge here. First is Johnson’s claim that mastering a skill—like thinking—typically allows it to be exercised ‘without thinking.’ The second is Johnson’s suggestion that thinking skills can often be implemented under only ‘minimal conditions of understanding.’ Contra both of these claims, I argue that both readings betray a misunderstanding of so-called mastered skills, firstly in terms of them being exercised “without thinking”, and secondly, in terms of such skills operating with only “minimal conditions of understanding”.

In my view, equating skill mastery with the ability to perform it “without thinking” is a mistake. For instance, I may have mastered the skill of playing padel, but if my cognitive faculties were removed during a match, I wouldn’t be able to hit the ball, anticipate my opponent’s moves, or adapt to the game’s evolving demands. Similarly, I may have a strong forehand, but on some days, my usual “go-to” shot fails me. To exercise my skill effectively therefore, I might take a shorter backswing or adjust my grip to a less extreme western one, thus optimizing the probability of getting more forehands back into play (Hacking 2006). Such adjustments (which some call matchplay or skilled/embodied expertise and judgement), is linked to my possessed skill of playing padel. It also requires an understanding of the subskills (stroke, stance, footwork, balance, back-lift etc.) involved in hitting a forehand. Without such knowledge, it would be impossible to adapt or refine the shot effectively. According to virtue epistemology, skill and know-how come before knowledge: knowledge is to be understood as a kind of skillful performance (Zagzebski 1996; Sosa 2007, 2015; Pritchard 2012; Turri 2018). Should we take knowledge to be knowledge to be a form of skilled performance/action, which one might attempt and fail, it’s easy to see how attempts can be either accurate, as when the aim of the attempt is attained, adroit, as when the attempt manifests a competence, or apt, where accuracy of the attempt manifests the competence (see Sosa, 2007). Framed this way, a competence is defined as a *disposition to succeed* and is understood as having a tripartite structure, according to which, whether one is competent to perform on a certain occasion depends not only on one’s pertinent skills (Skill) but also on the shape one is in (Shape) and on the favourability of one’s relevant situation (Situation).

A more nuanced interpretation suggests that, as Elizabeth Anscombe (1957) sees it, agential knowledge depends on skill or know-how. Put differently, one can intentionally do something (A) only if they know how to do it. Otherwise, her successful completion of A would seem accidental. This *entailment condition*—that from intentionally A to knowing how to A—a view widely endorsed in the current debate on knowing-how by both intellectualists and anti-intellectualists (Ryle 1949; Stanley and Williamson 2001; Pavese 2018), still, at least on my reading, needs a bit of tweaking with regard to skill-talk in relation to thinking. This is why I prefer a *bifurcationist conception of know-how*—one that distinguishes between propositional know-how and non-propositional, basic know-how. Embracing this bifurcationist approach helps resolve some of the persistent issues in the debate between intellectualists and anti-intellectualists.

In line with the above, Johnson's claim that mastering a skill means it can be exercised "without thinking" is susceptible to several clear counterexamples. In reality, thought plays a role in the effective execution of any skill. Furthermore, many skills are interconnected or dependent on others and cannot be separated from their context. Take Kevin de Bruyne, for example—he doesn't take the same amount of steps for every free kick he takes. Instead, he decides—through deliberate judgment, not just habit—how many steps to take based on the distance from goal, pitch conditions, shooting angle, and the kind of shot he intends to deliver. Striking the ball effectively requires more than rote execution; it involves situational thinking. Predictably, it is inextricably linked (and in some cases contingent on) factors, such as, the position and ability of the keeper, the positioning and composition of the wall (are there draft excluders there, for instance), the quality of the playing surface, other relevant contextual factors such as player fatigue, to name but a few. Whichever way we frame it, practical reasoning—or *phronesis*—is essential for effectively executing a wide range of skills, whether those of a good listener, a golfer, or anyone else engaged in skilled activity.

I suggest that Johnson mistakenly treats a skill as something static—once acquired, unchanging. On his reading, skills appear to be possessions that operate independently of thought or genuine understanding. He further treats skills as inert possessions. Once acquired, they function beyond the reach of reflection, refinement, or critique (Siegel, 2010, p. 67). This view risks suggesting that skills function independently of context, judgment, or insight. Here is where my view diverges from Johnson's.

A professional pianist may play differently on a Steinway as opposed to a Yamaha given the sensitivities and tone of the soundboards on both. While the underlying technique remains consistent, the effective application of the skill varies with the instrument. Similarly, Rhasidat Adeleke—an elite Irish 400 m runner—may alter her strategy when racing in wet conditions or against opponents known for strong finishes. This avoidable confusion stems from Johnson's failure to distinguish between skill as a possession (a noun) and skill as performance (a verb). On such a reading, there exists both the skill itself and its performative realization, which varies across contexts. However, there is also the performative dimension where such activities are carried out in diverse settings. In both cases they require thought to be sustained and practised effectively. Winch (2010) offers clarification, suggesting that Johnson should acknowledge that "thinking is very often concerned with broader categories of activities than tasks... but these examples can be resolved by refusing to confine thinking to skills and by admitting that the adjective 'thinking' can be applied to broader categories of agency as well as to the performance of highly specific tasks" (p. 103).

One way to move beyond the constraints of reductionist 'skill-talk' is through the theory of embodied cognition (Shapiro 2010). Varela et al.'s (1991) book, 'The Embodied Mind' is typically referred to as the earliest proponent of this view. They present a compelling case that cognition is,

... inextricably linked to histories that are lived, much like paths that exist only as they are laid down in walking [because] ... cognition is no longer seen as problem solving on the basis of representations; instead, cognition in its most encompassing sense consists in the enactment or bringing forth of a world by a viable history of structural coupling (Varela et al., p. 205).

This view argues that cognition is grounded in our embodiment (embodied action) and that these histories are 'lived' (experiences). Additionally, adaptation to the environment—termed "natural drift"—yields a cognitive architecture shaped by ongoing structural coupling and constrained by previously formed pathways (Shapiro 2010). Crucially, the 4E

cognition paradigm—embodied, embedded, enactive, and extended—emphasizes the causal influence of the body and its natural, social, and cultural environments on human cognition (Clark & Chalmers 1998; Shapiro 2010).

Whatever cognition might be, it is not best understood through a purely brain-based computational perspective that treats the brain as separate from the rest of the body and its environment. Cognition is often poorly understood when framed solely in terms of computational processes isolated from bodily and environmental contexts. Many modern policy documents neglect 4E models, instead presenting thinking skills as disembodied and transferable across contexts, ignoring the cultural, historical, and social factors that shape cognitive activity. My core argument is that neither McGuinness, Johnson, nor Siegel sufficiently address the theoretical and practical implications of embodied cognition for education. Instead, they remain largely tied to classical cognitivist views that treat the brain like a computational processor. By ignoring 4E insights, their discussions remain hampered by a reductive, disembodied view of thinking skills—exactly the conceptual oversimplification this paper aims to challenge (Gallagher 2023).

Fortunately, 4E cognition research has exposed key weaknesses in traditional cognitivist models, stressing that cognition cannot be separated from the body or environment (Gallagher 2005; Rosch et al., 1992; Hutto & Myin, 2012). For now, I set aside the more complex internal debates within 4E cognition to focus instead on how the framework challenges reductionist models that view the mind as software running digital computations (see Pylyshyn, 1985).

Embodied Cognition posits that cognitive processes are deeply rooted in the physical body, involving both neural and non-neural systems. Sensorimotor experiences such as movement, posture, and bodily interaction fundamentally shape perception, memory, and reasoning. The body actively contributes to cognition—not just by supplying inputs to the brain, but by participating in perception, emotion, and action. This challenges the idea that the mind is confined to the brain, proposing instead that bodily engagement is essential to how we think and understand the world (Newen et al. 2018; Gallagher 2023). For instance, Simone Biles' experience of the 'twisties' at the 2020 Olympics illustrates how balance and spatial orientation are deeply tied to bodily awareness. Likewise, learning how to balance by riding a bicycle demonstrates how understanding can emerge directly through embodied experience.

Embedded Cognition emphasizes that cognitive processes are inseparable from the environments in which they unfold. Physical, social, and cultural contexts are essential in shaping and supporting thought. This view highlights how external artifacts, spatial arrangements, and social interactions scaffold cognition, enabling or constraining what and how we think. For example, when cooking, arranging ingredients in order helps support memory of procedural steps. In such cases, cognition is not purely internal but distributed across the person and their structured environment.

Enactive Cognition posits that cognition emerges through an organism's active interaction with its environment. Perception, in this view, is not passive but an embodied, dynamic process involving cycles of action and feedback. Meaning is enacted through interaction with affordances provided by the world. A clear example is found in music education: when students clap, stomp, and move with rhythms before learning notation, they embody rhythm physically. This embodied engagement facilitates them to internalize tempo and phrasing, creating understanding through action rather than passive observation.

Extended Cognition challenges conventional boundaries of the mind, proposing that cognition can stretch beyond the individual to include tools and artifacts. When people habitually use external tools—like smartphones, notebooks, or calendars—these resources

become part of their cognitive processes. For instance, recording a child's birthday in a phone calendar and depending on it for reminders effectively incorporates the device into one's memory system. In this way, the task of remembering is distributed between brain and environment, showing that the mind operates as a network rather than an isolated system.

Taken together, the 4Es provide a more holistic view of cognition, highlighting how bodily experience, environmental context, and active participation shape thinking and understanding. In my view, adopting a 4E cognition approach offers five distinct advantages over traditional reductionist cognitivist models:

- a. Avoids Reification
- b. It avoids reducing thinking skills to static, decontextualized competencies by foregrounding the importance of thinking is being dynamic, flexible, and situated within real-world contexts. It critiques traditional cognitivist models and emphasizes that cognition is not a set of abstract computations but a lived, context-sensitive activity (Gallagher 2005, 2023).
- c. Explains Transfer Limitations
- d. It provides a rich conceptual framework for understanding why thinking skills are often difficult to transfer across domains—because such skills emerge from embodied, social, and material interactions specific to each context (Lobato 2006).
- e. Supports Realistic Pedagogy
- f. It underpins a more grounded pedagogical model—one that emphasizes experiential learning, situated practice, and active participation, rather than passive knowledge transmission (Kolb 1984).
- g. Attends to Ecological Learning Environments
- h. It encourages educators to engage with the full ecology of learning—considering tools, spatial arrangements, cultural practices, and social dynamics that shape how students think and learn (Greeno 1998)
- i. Aligns with Contemporary Research
- j. It aligns more closely with current cognitive science and educational research, offering a robust interdisciplinary foundation for designing future curricula and assessments that reflect how people actually think and learn (see Gallagher 2005; Clark 2008).

In practical terms, adopting a 4E perspective requires efforts to teach 'thinking skills' to be thoughtfully embedded in rich, real-world contexts and active learning experiences. Rather than relying on decontextualized drills or 'logic chopping' checklists, educators could incorporate bodily engagement, environmental scaffolds, and collaborative problem-solving – aligning teaching methods more closely with how cognition actually works in non-ideal environments.

Leaving the countless evident advantages of 4E cognition aside, vis-à-vis, embodied, embedded, enacted, and extended thinking, along with the clear lack of conceptual precision the likes of the McGuinness and AHELO Report offer on thinking skills, let's return briefly to some everyday examples which tease out some of what Winch is trying to get at. Here are two everyday examples that tease out the implications of his analysis:

- a) **Cooking a Meal:** When someone prepares a meal, thinking is not just confined to the specific skills of chopping vegetables or boiling water. It involves broader activities such as planning the menu, considering dietary restrictions, balancing flavours, and managing

time effectively. These broader categories of activities demonstrate that thinking encompasses more than just the individual tasks and includes higher-level decision-making and problem-solving.

- b) Writing an Academic Essay: Writing an essay is not just about the technical skill of putting words on paper. It involves selecting a topic, researching, organizing thoughts coherently, developing a strong argument, and critically scrutinizing empirical and conceptual sources. Even using Chat GPT 4 draws on some of these broad spectrum thinking resources. This broader scope of zetetic activities illustrates that thinking is about synthesizing information, evaluating evidence, and crafting a cogent argument based on solid evidence, demonstrating that the process of thinking applies to a wide range of intellectual activities beyond just writing.

What these examples illustrate, as Winch is keen for us to understand, is that thinking is clearly a multifaceted process that cannot be confined to specific tasks or sub-skills but instead should be understood as encompassing a broader range of activities and cognitive processes. More formally—thought is not atomistic, a mere process or outcome, confined to limited propositions governing the successful implementation of tasks in a specific field⁴ (see Singley and Anderson, 1989).

The second point Johnson makes in relation to viewing thinking as a skill hinges on his claim that often skills are only “minimally involved in understanding” (Barrow, 1987, pp.190–191). This view is echoed by Scheffler (1965) who maintains that ‘knowing-how’ is applicable in cases where “repeated trial or practice is thought relevant to performance and where it is carried out under minimal conditions of understanding” (p.93). This claim is much harder to refute. No doubt there are a huge range of skills which operate according to a limited understanding. But this is more complex and nuanced than it first seems however. Ask an expert painter such as Claude Monet (1840–1926) to explain his painting style and you might find it difficult to follow his explanation. In such a case however, is this because his skill is carried out under minimal conditions of understanding?

Might his inability (in your eyes) to explain his skill in minute detail be a result of the limits of language, your imperfect technique, or indeed, your inadequate interpretation? Certainly a strong argument could be made that in such instances it could be one or a combination of the above. When it comes to the painter himself/herself carrying out his skill with minimal understanding, one could also claim that without understanding of perspective, colour, texture and so on, Monet’s painting skills would be greatly diminished. This leaves us with a question: to understand one’s skill, is it a necessary condition that one be able to explain it satisfactorily? Can understanding be an internal matter where the agent understands perfectly well their particular skill, but might find it beyond their reach (or beyond the person’s reach) to model, demonstrate or explain?

⁴ Questions of transfer of learning have been addressed by a number of contemporary cognitive scientists (e.g., Barnett & Ceci 2002; Halpern 1998; Singley & Anderson, 1989). Much discussion has been around issues of what is “far” transfer, how much transfer instructional improvements can achieve, and what kind of instruction does so. A key observation is that when transfer occurs some change in the mind of the student is carrying that transfer from the instructional setting to the transfer setting. It might be a new skill, a general schema, a new mental model, better metacognition, better learning strategies, a change in epistemological stance, new motivation or disposition toward learning, or a change in self-beliefs about learning or social roles. I aim to show that transfer is an empirically established fact. The degree of transfer, and the precise makeup of the principles governing such are what we require to generate richer data for future empirical studies.

Understanding is a key component of knowledge acquisition and sharing. I don't wish to get into much conceptual detail here but, generally speaking, understanding can be conceived along the following axes (see Hannon 2021):

1. Understanding as Knowledge of Causes: Understanding is often equated with knowledge of causes. For example, Aristotle's view suggests that understanding why something is the case is equivalent to knowing why it is the case. In other words, understanding involves knowing that a particular outcome (X) occurs because of a specific cause (Y). This view is prominent in social science research, including educational studies, where understanding a phenomenon typically involves grasping the causal relationships that explain it.

2. Understanding as Grasping Explanatory Relations: Understanding involves more than just knowing facts; it requires grasping the explanatory relationships between those facts. This "grasping" is a kind of cognitive ability that equips an individual to see how different pieces of information fit together to form a coherent whole. For instance, understanding the causes of the 1916 Rising in Ireland, involves not just knowing the event's historical unfolding (facts and details) but also grasping the broader context and causal relationships that explain it comprehensively.

3. Holistic Understanding: Holistic or objectual understanding refers to an individual's comprehensive grasp of a subject matter or domain. This type of understanding involves a systematized knowledge of a broad body of information, coherence among the various pieces of information, and a cogent grasp of the dependency relations among them.

4. Practical Understanding: Practical understanding is the ability to perform certain actions or tasks skilfully. This form of understanding is closely related to know-how and is manifested through abilities or skills rather than mere theoretical knowledge. For example, a baseball player who understands how to catch a fly ball demonstrates this understanding through their ability to perform the task effectively, even if they cannot explicitly explain the mechanics involved.

Recent years has witnessed an explosion in philosophical works on the nature, scope, value, and varieties of human understanding (Grim, 2006; Hannon 2021). Despite much excellent work in this area there are still no satisfactory accounts as to what precisely constitutes understanding, including, when/why/and under what conditions, it is important. Questions remain about whether understanding is reducible to knowledge, and the related question of whether it requires distinct conditions such as truth, belief, or justification. Similar questions remain around whether it can be obtained through luck, and similarly, does it necessitate a form of 'grasping' or 'know-how'? I sidestep these debates, and merely point to some of the main definitions of understanding in the literature. It's hoped that these serviceable conceptions/definitions explain the range of forms of understanding, ranging from theoretical and explanatory grasp to practical know-how. As we can see, philosophical accounts of understanding are complex and wide-ranging. Moreover, they are not always the most edifying. For that reason—I do not restrict myself to one conception over the other, mostly because context dictates the target of understanding.

Siegel's Response to Johnson on Generalizability

Though Siegel's response to Johnson takes up most of his key objections, space precludes a full discussion here. To narrow the scope of our discussion, I focus on Siegel's response to one of Johnson's arguments regarding the inherent educational dangers of thinking of

thinking in terms of skills,⁵ specifically, the disparagement of subject knowledge. According to Johnson (2010), “there is a real danger that subject knowledge will be seen as nothing more than material on which to practice skills, or even as something that gets in the way of the real business of education: thinking skills” (p. 37). On this matter, Siegel agrees that knowledge is vitally important. To be fair to Siegel, he has never declared otherwise (see Siegel, 1988; 1997; 2017). While I concur with Johnson’s caution against teaching thinking in a vacuum, I ultimately find Siegel’s stance on *generalizable* thinking skills more compelling—provided these skills are taught without sacrificing rich subject context. What he has carefully, and, to my mind, successfully, argued for, is the centrality and importance of subject knowledge along with “the mastery of skills and abilities which are general in that they can be applied, exercised and manifested in many diverse situations and subject matters” (pp.80–81).

Where Siegel and Johnson diverge is the generalisability of such skills. For Siegel, a thorough understanding of probability is useful for the mathematician, the actuary, the hedge fund manager, and the ordinary punter just about to take a plane. A person with a good grasp of probability can bring this generalizable skill into banking, equities and bonds investments, along with calculating the risk of a plane crash in the event of being a nervous flyer. The principles hold across the disciplines (see Hacking 2006). Similarly a person with a knowledge of logic, eliminative induction or abductive reasoning, has the capacity to speak with a level of credibility about empirical studies which rely on such principles to determine their conclusions. However, despite the cogency of these everyday evidence-based claims, Johnson remains sceptical of the generalizability of such skills, whether they be probability, reasoning, or conceptual analysis. He posits such a view as being inherently dangerous because it can lead to the disparagement of knowledge, where knowledge is at times seen as an impediment to the generalizable skills educators seek to foster in their students.

Here I think Siegel makes the more compelling case for the generalizability of thinking skills. Siegel’s insistence that some reasoning abilities can ‘be applied, exercised and manifested in many diverse situations’ (2010, pp.80–81) provides philosophical backing for today’s 21st-century skills movement—it affirms that broadly applicable skills like logical reasoning or probabilistic thinking *do* have a place across the curriculum, so long as they are grounded in knowledge. At stake here is—the extent to which these generalizable skills apply (Winch, 2010, p.107). Probability is a good example insofar as its utility is easily explained. A hostile interlocutor to Johnson might argue that several of his arguments rely on the principles of informal logic. The whole point of fallacious reasoning for example is that these principles are generally applicable, regardless of subject matter or domain. This reading would undermine his claim that generalizable skills and transfer rest on a series of conceptual and fallacious errors. Concepts, as are well known, are typically the domain of the philosopher and psychologist (Dunne 2024). In utilising conceptual analysis, is this yet another example of Johnson undermining his arguments? If concepts carry across disciplines, is there not a strong argument for including them as part of one’s education? Finally, most of Johnson’s critiques take the form of carefully crafted arguments. In his arguments, he relies on conceptual clarifications, philosophical analysis, pointing out fallacious reasoning (naming fallacy etc.), and uses reasons to convince his reader of the

⁵ Skill essentially involves an agent’s being excellent in some way (Annas 1995). The skilled agent is skilled – possesses an excellence, exercises an excellence – at something. Carlotta Pavese (2018) proposes that an agent is skilled at A-ing if and only if that agent knows how to A sufficiently well.

cogency of his views. Animating each of these endeavours is thoughtful deliberation. Taking up this point, Winch (2010, pp.112–13) questions whether some of this work actually undermines Johnson's own project? After all, conceptual clarifications and analysis are not always confined to individual disciplines, nor are the principles of argumentation or reasoning (Siegel, 2010, p.78). There are, of course times when subject-specific background knowledge is necessary to engage in critical thought. But there are equally times when generalized principles hold across subject domains. For the philosopher of education, Winch maintains, the dispute is the extent to which these generalizable skills apply (Winch, 2010, p.107). Unfortunately, despite the evident richness of the debate, this question largely goes unanswered.

Johnson and Siegel agree on a great deal. Much of their agreement derives from a shared disregard for the cognitivist approach to thinking skills in the McGuinness Report, especially its unstated assumptions recommending pedagogic interventions to enhance such skills in educational settings. The main substantive disagreement between the two theorists concerns generalizability. Siegel holds that it makes perfect sense to think that some thinking skills/abilities are generalizable, in the sense that—once acquired—they can be applied in numerous diverse situations/contexts. He emphasises the importance of refraining from treating thinking skills in terms of mysterious processes or habitual and mindless routines. Instead he suggests that theorists view skilled thinking in terms of *quality*: that is, thinking that admits of positive normative evaluation in that it meets relevant criteria of acceptability (see Bailin and Siegel 2003). To re-cap: Johnson and Siegel agree that knowledge and thinking go hand-in-hand, but diverge on whether certain thinking skills can transfer across domains. This divergence sets the stage for considering how we might move forward—balancing these insights in educational theory and practice.

Where Does this Leave Us Now?

It is easy to be sceptical about the possibility of progress in such matters. But progress has been made. More specifically, progress has been made in relation to clarifying what a balanced approach to thinking skills should entail in *21st-century education*. Likewise—with regard to the generalizability of thinking skills—it's clear that what is important is to that, in many instances, generalizable thinking skills cannot be taught in atomistic decontextualised ways—a point on which this analysis concurs: thinking skills teaching must resist the lure of pure abstraction. Exceptions exist, of course, one obvious one being informal logic and reasoning (probabilistic), to include, learning about fallacies. But for the most part, most scholars agree that most generalizable skills require background, sometimes domain-specific knowledge. Siegel agrees that domain-specific knowledge is necessary for criticality; what he is keen to emphasise is that certain thinking skills can be applied across various disciplines. Think of an actuary. They utilise probabilistic reasoning to determine the relative risks of you meeting an untimely death based on an interpretation of salient contextual factors. Mathematics guides a lot of what they do. The principles of mathematical reasoning apply not just in mathematics but also in physics and actuarial science, to name but a few. The temptation, that must be resisted, in my mind, is to throw the baby out with the bathwater. It is not an all or nothing response. There are clearly degrees of transferability in play (Halpern 1998; Perkins and Salomon, 1989).

The second thread to emerge from the literature is a collective response to challenging reductionist approaches to thinking skills. This is something again most scholars are

in broad agreement with (see Baron and Sternberg, 1987; Dunne, forthcoming; Perkins and Salomon, 1989; Siegel 2017). Care must be taken to avoid reducing thinking skills to a mindless checklist of rule-following, where, say for instance, rationality is reduced to checklist performativities. On this point, as one critic points it, “after all, following rules is not always required [for reasoned thinking], since “one task of rational assessment is to determine which rules should be followed in a particular situation...mindlessly applying rules just because they are logically correct is foolish” (Brown, 1995, p.744). One risk of educating a generation of logic choppers is slipping into draconian thinking styles, where rules outweigh reason, context is unimportant and salient contextual features which are part of the agential experience are relegated or affixed a credibility deficit.

Relatedly there is the importance of context and understanding. The article emphasizes that effective thinking requires not only skills but also a deep understanding of the context in which these skills are applied. Thirdly, the McGuinness Report (1999), though flawed in several respects, still plays a significant role in shaping contemporary educational approaches to thinking skills, demonstrating that despite philosophical critiques, the appeal of a ‘skills’ taxonomy persists in practice. Categorizing thinking in terms of skills and sub-skills, and suggesting methods for their integration into the curriculum, such as the general, subject-specific, and infusion approaches, are still widely endorsed in higher education settings (see OECD, 2008). Finally, great care has been taken to appropriately balance knowledge and skills. As I have shown, both Johnson and Siegel agree on the importance of balancing the acquisition of thinking skills with robust subject knowledge/understanding. While they differ on the generalizability of these skills, as we have seen, both caution against educational approaches that either overly emphasize skills at the expense of knowledge, or fail to recognize or downplay or ignore the potential for certain skills to enhance learning across multiple domains. This balanced perspective is crucial for developing curricula that effectively foster critical thinking and intellectual growth and humility in students (see Baehr 2015; Dunne & Martin forthcoming).

Conclusion

In conclusion, the debate between Johnson and Siegel in *Teaching Thinking Skills* highlights the intricate challenge of defining thinking as a skill, reinforcing this paper’s call for greater conceptual precision. Johnson remains sceptical of treating thinking as a general skill, raising both conceptual and pragmatic objections. He fears that emphasizing generic “thinking skills” undermines deep subject knowledge and reduces thought to an impersonal, context-free exercise. Johnson warns against assuming that thinking can be broken into isolated techniques that learners master and apply universally without rich understanding or context. In contrast, Siegel acknowledges the importance of subject knowledge yet contends that certain thinking skills are indeed generalizable and can strengthen critical thinking across diverse domains. He emphasizes that truly skilled thinking must be evaluated by rigorous standards of reasoning, suggesting that the quality of thought should meet relevant criteria of acceptability. Despite their differing stances, both Johnson and Siegel find common ground in criticizing the simplistic assumptions of the “McGuinness Report,” and both caution against any reductive, one-size-fits-all approach to teaching thinking skills. Building on these insights, I propose adopting a novel 4E (embodied, embedded, enacted, extended) cognition perspective as a more context-sensitive and conceptually robust framework for understanding thinking. This 4E approach posits that thinking is not

an abstract, contextless technique but rather an activity that thrives through embodied, interactive experiences in real-world contexts. Such an understanding of cognition should directly inform how policymakers and educators cultivate 21st-century thinking skills in practice. Ultimately, advancing the teaching of thinking will require navigating these nuanced considerations. Educators and policymakers must balance broad thinking strategies with deep domain knowledge while leveraging insights from embodied cognition, so that learners are fully prepared for the complex challenges of the twenty-first century.

Funding Open Access funding provided by the IReL Consortium.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- OECD AHELO project, summary <https://www.oecd.org/education/skills-beyond-school/AHELOFSReportVolume3.pdf>
- Andrews, John. 2010. General Thinking Skills: are there such things?, *Journal of Philosophy of Education*, Volume 24, Issue 1, 30 May 2006, Pages 71–79.
- Annas, J. 1995. Virtue as a Skill. *International Journal of Philosophical Studies* 3:227–243.
- Anscombe, G. E. M. 1957. *Intention*. England: Basil Blackwell.
- Baehr, Jason S., ed. 2015. *Intellectual Virtues and Education: Essays in Applied Virtue Epistemology*. New York: Routledge.
- Barnett, S. M., and S. J. Ceci. 2002. When and Where do we Apply what we Learn? A Taxonomy for Far Transfer. *Psychological Bulletin* 128 (4): 612–637.
- Baron, J. B., & Sternberg, R. J. (Eds.). 1987. *Teaching Thinking Skills: Theory and practice*. W H Freeman/ Times Books/ Henry Holt & Co.
- Burbules, N. C., and R. Berk. 1999. Critical thinking and critical pedagogy: Relations, difference, and limits. In *Critical theories in education: Changing terrains of knowledge and politics*, ed. T. S. Popkewitz and L. Fender, 45–64. New York: Routledge.
- Cath, Y. 2011. Knowing How Without Knowing That. In *Knowing How: Essays on Knowledge, Mind and Action*, ed. J. Bengson and M. Moffett, 136–160. Oxford: Oxford University Press.
- Clark, A. 2008. *Supersizing the Mind: Embodiment, Action, and Cognitive Extension*. Oxford University Press.
- Clark, A., and D. Chalmers. 1998. The Extended Mind. *Analysis* 58:10–23. <https://doi.org/10.1093/analysis/58.1.7>.
- Davies, Martin (2006). An infusion approach to critical thinking: Moore on the critical thinking debate. *Higher Education Research and Development* 25 (2):179–193.
- Dishon, Gideon, and Tal Gilead. 2021. Adaptability and its Discontents: 21St-Century Skills and the Preparation for an Unpredictable Future. *British Journal of Educational Studies* 69 (4): 393–413.
- Dunne. 2024. *Concepts in Education: A Philosophical Defence*, in book, 'Concepts in Education', edited by Jane Gately and Christian Norefalk, Brill Press
- Dunne. 2025. *Stress-Testing Competing reasons in the Practical Domain*, *Journal of Philosophy of Education*, Oxford University Press
- Ennis, R. H. 1989. Critical Thinking and Subject Specificity: Clarification and Needed Research. *Educational Researcher* 18 (3): 4–10.
- Facione, P. A. 1990. *The Delphi Report: Critical Thinking: A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction*. Millbrae, CA: The California Academic Press.
- Fisher, R. 2002. *Teaching Thinking: Philosophical Enquiry in the Classroom*. Continuum.

- Fridland, Ellen, and Carlotta Pavese, eds. 2020. *The Routledge Handbook of Philosophy of Skill and Expertise*. New York, NY: Routledge.
- Gallagher, S. 2005. *How the Body Shapes the Mind*. Oxford University Press.
- Gallagher, S. 2023. *Embodied and Enactive Approaches to Cognition*. Cambridge University Press. <https://doi.org/10.1017/9781009209793>
- Foster, N., and Piacentini, M., (eds.) 2023. Innovating Assessments to Measure and Support Complex Skills, OECD Publishing, Paris, <https://doi.org/10.1787/e5f3e341-en>
- Greeno, J. G. 1998. The Situativity of Knowing, Learning, and Research. *American Psychologist* 53 (1): 5–26.
- Hacking, I. 2006. *The Emergence Of Probability: A Philosophical Study Of Early Ideas About Probability, Induction And Statistical Inference*. Cambridge: Cambridge University Press.
- Halpern, D. F. 1998. Teaching Critical Thinking for Transfer Across Domains: Dispositions, Skills, Structure Training, and Metacognitive Monitoring. *American Psychologist* 53 (4): 449–455.
- Hannon, Michael & Nguyen, James (forthcoming). Understanding Philosophy. Inquiry: An Interdisciplinary Journal of Philosophy.
- Hannon, Michael. 2021. Recent Work in the Epistemology of Understanding. *American Philosophical Quarterly* 58 (3): 269–290.
- Hirst, Paul H., 1969. The Logic of Curriculum. *Journal of Curriculum Studies* 1:142–158.
- Johnson, Stephen, and Harvey Siegel. 2010. Teaching Thinking Skills. (2nd Ed). Key Debates in Educational Policy. Ed. by Christopher Winch. Continuum.
- Johnson, Steve, and Peter Gardner. 1999. Some Achilles' heels of thinking skills: A response to Higgins and Baumfield. *Journal of Philosophy of Education* 33 (3): 435–449.
- Kolb, D. A. 1984. *Experiential Learning: Experience as the Source of Learning and Development*. Prentice Hall
- Lipman, M. 1991. *Thinking in Education*. Cambridge: Cambridge, MA.
- Lipton, P. 2004. Inference to the best explanation. 2nd edition. London
- Lobato, J. 2006. Alternative perspectives on the transfer of learning: History, issues, and challenges for future research. *Journal of the Learning Sciences* 15 (4): 431–449.
- Dunne & Martin. 2026. *Epistemic Paternalism in Education*, in Encyclopaedia of Education, BERA, edited by Vivienne Baumfield
- McPeck, J. 1981. *Critical Thinking and Education*. Oxford: Martin Robertson.
- McGuinness, Carol. 1999. From Thinking Skills to Thinking Classrooms: A review and evaluation of approaches for developing pupils' thinking. <https://doi.org/10.13140/RG.2.1.4000.1129>.
- Moore, T. (2004). The critical thinking debate: how general are general thinking skills. *Higher Education Research & Development* 23(1):3–18. <https://doi.org/10.1080/0729436032000168469>
- Newen, A., L. de Bruin, and S. Gallagher. 2018. *4E Cognition: Historical Roots, Key Concepts, and Current Debates*. MIT Press.
- OECD 2013. *Synergies for better learning: an international perspective on evaluation and assessment*. OECD Publishing.
- OECD 2013. *AHELO feasibility study report*
- Paul, R. (1992). *Critical Thinking: What Every Person Needs to Survive in a Rapidly Changing World*. Santa Rosa, CA: Foundation for Critical Thinking
- Paul, R., Niewoehner, R., & Elder, L. 2013. *The Thinker's Guide to Engineering Reasoning*. Foundation for Critical Thinking.
- Pavese, C. 2018 Know-How and Gradability. *Philosophical Review* 126: 345–83. Routledge.
- Perkins, D. N., and G. Salomon. 1989. Are Cognitive Skills Context-Bound? *Educational Researcher* 18 (1): 16–25. <https://doi.org/10.3102/0013189X018001016>.
- Pritchard, Duncan 2012. Anti-Luck Virtue Epistemology. *Journal of Philosophy* 109 (3):247–279.
- Ryle, G. 1949. *The Concept of Mind*. London: Hutchinson & Co.
- Schwartz, S. H. 1992. Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. In M. P. Zanna (Ed.), *Advances in experimental social psychology* 25:1–65. Academic Press. [https://doi.org/10.1016/S0065-2601\(08\)60281-6](https://doi.org/10.1016/S0065-2601(08)60281-6)
- Shapiro, Lawrence A. 2010. *Embodied Cognition*. New York: Routledge.
- Shayer, M., and Adey, (Eds.) (2002). Learning intelligence : cognitive acceleration across the curriculum from 5 to 15 years. Open University Press.
- Siegel, H. 2010. Knowledge and Truth⁵⁴. In Richard Bailey, The SAGE handbook of philosophy of education. Thousand Oaks, CA: SAGE Publication. pp. 283
- Siegel H 2017. *Education's epistemology: rationality, diversity, and critical thinking*. New York, NY: Oup Usa.

- Sosa, Ernest 2007. A virtue epistemology: Apt belief and reflective knowledge, volume I * by Ernest Sosa. *Analysis* 69 (2):382-385
- Sosa, Ernest 2015. *Judgment & Agency*. Oxford, GB: Oxford University Press UK.
- Stanley, J., and T. Williamson. 2001. Knowing How. *Journal of Philosophy* 98:411–444.
- Trilling, B., and C. Fadel. 2009. *21st Century Skills: Learning for Life in Our Times*. San Francisco, CA: John Wiley & Sons.
- Turri, John 2018. Revisiting norms of assertion. *Cognition* 177 (C):8–11.
- Varas D., et al, 2023. Teachers' Strategies and Challenges in Teaching 21st Century Skills: Little common Understanding, *Thinking Skills and Creativity* 48. <https://doi.org/10.1016/j.tsc.2023.101289>
- Varela, F. J., E. Thompson, and E. Rosch. 1991. *The embodied mind: Cognitive science and human experience*. Cambridge, MA: MIT Press.
- WINCH, C. 2010, Vocational Education, Knowing How and Intelligence Concepts. *Journal of Philosophy of Education* 44:551-567. <https://doi.org/10.1111/j.1467-9752.2010.00775.x>
- Zagzebski, L. 1996. *Virtues of the Mind*. Cambridge: Cambridge University Press.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.