What is critical thinking? There are many definitions. Ennis (2016) lists 14 philosophically oriented scholarly definitions and three dictionary definitions. Following Rawls (1971), who distinguished his conception of justice from a utilitarian conception but regarded them as rival conceptions of the same concept, Ennis maintains that the 17 definitions are different conceptions of the same concept. Rawls articulated the shared concept of justice as

a characteristic set of principles for assigning basic rights and duties and for determining… the proper distribution of the benefits and burdens of social cooperation. (Rawls 1971: 5)

Bailin et al. (1999b) claim that, if one considers what sorts of thinking an educator would take not to be critical thinking and what sorts to be critical thinking, one can conclude that educators typically understand critical thinking to have at least three features.

It is done for the purpose of making up one's mind about what to believe or do.
The person engaging in the thinking is trying to fulfill standards of adequacy and accuracy appropriate to the thinking.
The thinking fulfills the relevant standards to some threshold level.
One could sum up the core concept that involves these three features by saying that critical thinking is careful goal-directed thinking. This core concept seems to apply to all the examples of critical thinking described in the previous section. As for the non-examples, their exclusion depends on construing careful thinking as excluding jumping immediately to conclusions, suspending judgment no matter how strong the evidence, reasoning from an unquestioned ideological or religious perspective, and routinely using an algorithm to answer a question.

If the core of critical thinking is careful goal-directed thinking, conceptions of it can vary according to its presumed scope, its presumed goal, one's criteria and threshold for being careful, and the thinking component on which one focuses. As to its scope, some conceptions (e.g., Dewey 1910, 1933) restrict it to constructive thinking on the basis of one's own observations and experiments, others (e.g., Ennis 1962; Fisher & Scriven 1997; Johnson 1992) to appraisal of the products of such thinking. Ennis (1991) and Bailin et al. (1999b) take it to cover both construction and appraisal. As to its goal, some conceptions restrict it to forming a judgment (Dewey 1910, 1933; Lipman 1987; Facione 1990a). Others allow for actions as well as beliefs as the end point of a process of critical thinking (Ennis 1991; Bailin et al. 1999b). As to the criteria and threshold for being careful, definitions vary in the term used to indicate that critical thinking satisfies certain norms: "intellectually disciplined" (Scriven & Paul 1987), "reasonable" (Ennis 1991), "skillful" (Lipman 1987), "skilled" (Fisher & Scriven 1997), "careful" (Bailin & Battersby 2009). Some definitions specify these norms, referring variously to "consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends" (Dewey 1910, 1933); "the methods of logical inquiry and reasoning" (Glaser 1941); "conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication" (Scriven & Paul 1987); the requirement that "it is sensitive to context, relies on criteria, and is self-correcting" (Lipman 1987); "evidential, conceptual, methodological, criteriological, or contextual considerations" (Facione 1990a); and

“plus-minus considerations of the product in terms of appropriate standards (or criteria)” (Johnson 1992). Stanovich and Stanovich (2010) propose to ground the concept of critical thinking in the concept of rationality, which they understand as combining epistemic rationality (fitting one’s beliefs to the world) and instrumental rationality (optimizing goal fulfillment); a critical thinker, in their view, is someone with “a propensity to override suboptimal responses from the autonomous mind” (2010: 227). These variant specifications of norms for critical thinking are not necessarily incompatible with one another, and in any case presuppose the core notion of thinking carefully. As to the thinking component singled out, some definitions focus on suspension of judgment during the thinking (Dewey 1910; McPeck 1981), others on inquiry while judgment is suspended (Bailin & Battersby 2009, 2021), others on the resulting judgment (Facione 1990a), and still others on responsiveness to reasons (Siegel 1988). Kuhn (2019) takes critical thinking to be more a dialogic practice of advancing and responding to arguments than an individual ability.

In educational contexts, a definition of critical thinking is a “programmatic definition” (Scheffler 1960: 19). It expresses a practical program for achieving an educational goal. For this purpose, a one-sentence formulaic definition is much less useful than articulation of a critical thinking process, with criteria and standards for the kinds of thinking that the process may involve. The real educational goal is recognition, adoption and implementation by students of those criteria and standards. That adoption and implementation in turn consists in acquiring the knowledge, abilities and dispositions of a critical thinker.

Conceptions of critical thinking generally do not include moral integrity as part of the concept. Dewey, for example, took critical thinking to be the ultimate intellectual goal of education, but distinguished it from the development of social cooperation among school children, which he took to be the central moral goal. Ennis (1996, 2011) added to his previous list of critical thinking dispositions a group of dispositions to care about the dignity and worth of every person, which he described as a “correlative” (1996) disposition without which critical thinking would be less valuable and perhaps harmful. An educational program that aimed at developing critical thinking but not the correlative disposition to care about the dignity and worth of every person, he asserted, “would be deficient and perhaps dangerous” (Ennis 1996: 172).

Dewey thought that education for reflective thinking would be of value to both the individual and society; recognition in educational practice of the kinship to the scientific attitude of children’s native curiosity, fertile imagination and love of experimental inquiry “would make for individual happiness and the reduction of social waste” (Dewey 1910: iii). Schools participating in the Eight-Year Study took development of the habit of reflective thinking and skill in solving problems as a means to leading young people to understand, appreciate and live the democratic way of life characteristic of the United States (Aikin 1942: 17–18, 81). Harvey Siegel (1988: 55–61) has offered four considerations in support of adopting critical thinking as an educational ideal. (1) Respect for persons requires that schools and teachers honour students’ demands for reasons and explanations, deal with students honestly, and recognize the need to confront students’ independent judgment; these requirements concern the manner in which teachers treat students. (2) Education has the task of preparing children to be successful adults,

a task that requires development of their self-sufficiency. (3) Education should initiate children into the rational traditions in such fields as history, science and mathematics. (4) Education should prepare children to become democratic citizens, which requires reasoned procedures and critical talents and attitudes. To supplement these considerations, Siegel (1988: 62–90) responds to two objections: the ideology objection that adoption of any educational ideal requires a prior ideological commitment and the indoctrination objection that cultivation of critical thinking cannot escape being a form of indoctrination.

Despite the diversity of our 11 examples, one can recognize a common pattern. Dewey analyzed it as consisting of five phases:

suggestions, in which the mind leaps forward to a possible solution;
an intellectualization of the difficulty or perplexity into a problem to be solved, a question for which the answer must be sought;
the use of one suggestion after another as a leading idea, or hypothesis, to initiate and guide observation and other operations in collection of factual material;
the mental elaboration of the idea or supposition as an idea or supposition (reasoning, in the sense on which reasoning is a part, not the whole, of inference); and
testing the hypothesis by overt or imaginative action. (Dewey 1933: 106–107; italics in original)

The process of reflective thinking consisting of these phases would be preceded by a perplexed, troubled or confused situation and followed by a cleared-up, unified, resolved situation (Dewey 1933: 106). The term ‘phases’ replaced the term ‘steps’ (Dewey 1910: 72), thus removing the earlier suggestion of an invariant sequence. Variants of the above analysis appeared in (Dewey 1916: 177) and (Dewey 1938: 101–119).

The variant formulations indicate the difficulty of giving a single logical analysis of such a varied process. The process of critical thinking may have a spiral pattern, with the problem being redefined in the light of obstacles to solving it as originally formulated. For example, the person in Transit might have concluded that getting to the appointment at the scheduled time was impossible and have reformulated the problem as that of rescheduling the appointment for a mutually convenient time. Further, defining a problem does not always follow after or lead immediately to an idea of a suggested solution. Nor should it do so, as Dewey himself recognized in describing the physician in Typhoid as avoiding any strong preference for this or that conclusion before getting further information (Dewey 1910: 85; 1933: 170). People with a hypothesis in mind, even one to which they have a very weak commitment, have a so-called “confirmation bias” (Nickerson 1998): they are likely to pay attention to evidence that confirms the hypothesis and to ignore evidence that counts against it or for some competing hypothesis. Detectives, intelligence agencies, and investigators of airplane accidents are well advised to gather relevant evidence systematically and to postpone even tentative adoption of an explanatory hypothesis until the collected evidence rules out with the appropriate degree of certainty all but one explanation. Dewey’s analysis of the critical thinking process can be faulted as well for requiring acceptance or rejection of a possible solution to a defined problem, with no allowance for deciding in the light of the available evidence to suspend judgment. Further, given the great variety of kinds of problems for which reflection is appropriate, there is likely to be

variation in its component events. Perhaps the best way to conceptualize the critical thinking process is as a checklist whose component events can occur in a variety of orders, selectively, and more than once. These component events might include (1) noticing a difficulty, (2) defining the problem, (3) dividing the problem into manageable sub-problems, (4) formulating a variety of possible solutions to the problem or sub-problem, (5) determining what evidence is relevant to deciding among possible solutions to the problem or sub-problem, (6) devising a plan of systematic observation or experiment that will uncover the relevant evidence, (7) carrying out the plan of systematic observation or experimentation, (8) noting the results of the systematic observation or experiment, (9) gathering relevant testimony and information from others, (10) judging the credibility of testimony and information gathered from others, (11) drawing conclusions from gathered evidence and accepted testimony, and (12) accepting a solution that the evidence adequately supports (cf. Hitchcock 2017: 485).

Checklist conceptions of the process of critical thinking are open to the objection that they are too mechanical and procedural to fit the multi-dimensional and emotionally charged issues for which critical thinking is urgently needed (Paul 1984). For such issues, a more dialectical process is advocated, in which competing relevant world views are identified, their implications explored, and some sort of creative synthesis attempted.

If one considers the critical thinking process illustrated by the 11 examples, one can identify distinct kinds of mental acts and mental states that form part of it. To distinguish, label and briefly characterize these components is a useful preliminary to identifying abilities, skills, dispositions, attitudes, habits and the like that contribute causally to thinking critically. Identifying such abilities and habits is in turn a useful preliminary to setting educational goals. Setting the goals is in its turn a useful preliminary to designing strategies for helping learners to achieve the goals and to designing ways of measuring the extent to which learners have done so. Such measures provide both feedback to learners on their achievement and a basis for experimental research on the effectiveness of various strategies for educating people to think critically. Let us begin, then, by distinguishing the kinds of mental acts and mental events that can occur in a critical thinking process.

Observing: One notices something in one's immediate environment (sudden cooling of temperature in Weather, bubbles forming outside a glass and then going inside in Bubbles, a moving blur in the distance in Blur, a rash in Rash). Or one notes the results of an experiment or systematic observation (valuables missing in Disorder, no suction without air pressure in Suction pump)
Feeling: One feels puzzled or uncertain about something (how to get to an appointment on time in Transit, why the diamonds vary in spacing in Diamond). One wants to resolve this perplexity. One feels satisfaction once one has worked out an answer (to take the subway express in Transit, diamonds closer when needed as a warning in Diamond).
Wondering: One formulates a question to be addressed (why bubbles form outside a tumbler taken from hot water in Bubbles, how suction pumps work in Suction pump, what caused the rash in Rash).

Imagining: One thinks of possible answers (bus or subway or elevated in Transit, flagpole or ornament or wireless communication aid or direction indicator in Ferryboat, allergic reaction or heat rash in Rash).
Inferring: One works out what would be the case if a possible answer were assumed (valuables missing if there has been a burglary in Disorder, earlier start to the rash if it is an allergic reaction to a sulfa drug in Rash). Or one draws a conclusion once sufficient relevant evidence is gathered (take the subway in Transit, burglary in Disorder, discontinue blood pressure medication and new cream in Rash).
Knowledge: One uses stored knowledge of the subject-matter to generate possible answers or to infer what would be expected on the assumption of a particular answer (knowledge of a city's public transit system in Transit, of the requirements for a flagpole in Ferryboat, of Boyle's law in Bubbles, of allergic reactions in Rash).
Experimenting: One designs and carries out an experiment or a systematic observation to find out whether the results deduced from a possible answer will occur (looking at the location of the flagpole in relation to the pilot's position in Ferryboat, putting an ice cube on top of a tumbler taken from hot water in Bubbles, measuring the height to which a suction pump will draw water at different elevations in Suction pump, noticing the spacing of diamonds when movement to or from a diamond lane is allowed in Diamond).
Consulting: One finds a source of information, gets the information from the source, and makes a judgment on whether to accept it. None of our 11 examples include searching for sources of information. In this respect they are unrepresentative, since most people nowadays have almost instant access to information relevant to answering any question, including many of those illustrated by the examples. However, Candidate includes the activities of extracting information from sources and evaluating its credibility.
Identifying and analyzing arguments: One notices an argument and works out its structure and content as a preliminary to evaluating its strength. This activity is central to Candidate. It is an important part of a critical thinking process in which one surveys arguments for various positions on an issue.
Judging: One makes a judgment on the basis of accumulated evidence and reasoning, such as the judgment in Ferryboat that the purpose of the pole is to provide direction to the pilot.
Deciding: One makes a decision on what to do or on what policy to adopt, as in the decision in Transit to take the subway.

Educational researchers use the term 'dispositions' broadly for the habits of mind and attitudes that contribute causally to being a critical thinker. Some writers (e.g., Paul & Elder 2006; Hamby 2014; Bailin & Battersby 2016a) propose to use the term 'virtues' for this dimension of a critical thinker. The virtues in question, although they are virtues of character, concern the person's ways of thinking rather than the person's ways of behaving towards others. They are not moral virtues but intellectual virtues, of the sort articulated by Zagzebski (1996) and discussed by Turri, Alfano, and Greco (2017).

On a realistic conception, thinking dispositions or intellectual virtues are real properties of thinkers. They are general tendencies, propensities, or inclinations to think in particular ways in particular circumstances, and can be genuinely explanatory (Siegel 1999). Sceptics argue that

there is no evidence for a specific mental basis for the habits of mind that contribute to thinking critically, and that it is pedagogically misleading to posit such a basis (Bailin et al. 1999a). Whatever their status, critical thinking dispositions need motivation for their initial formation in a child—motivation that may be external or internal. As children develop, the force of habit will gradually become important in sustaining the disposition (Nieto & Valenzuela 2012). Mere force of habit, however, is unlikely to sustain critical thinking dispositions. Critical thinkers must value and enjoy using their knowledge and abilities to think things through for themselves. They must be committed to, and lovers of, inquiry.

A person may have a critical thinking disposition with respect to only some kinds of issues. For example, one could be open-minded about scientific issues but not about religious issues. Similarly, one could be confident in one's ability to reason about the theological implications of the existence of evil in the world but not in one's ability to reason about the best design for a guided ballistic missile.

Facione (1990a: 25) divides "affective dispositions" of critical thinking into approaches to life and living in general and approaches to specific issues, questions or problems. Adapting this distinction, one can usefully divide critical thinking dispositions into initiating dispositions (those that contribute causally to starting to think critically about an issue) and internal dispositions (those that contribute causally to doing a good job of thinking critically once one has started). The two categories are not mutually exclusive. For example, open-mindedness, in the sense of willingness to consider alternative points of view to one's own, is both an initiating and an internal disposition.

Some theorists postulate skills, i.e., acquired abilities, as operative in critical thinking. It is not obvious, however, that a good mental act is the exercise of a generic acquired skill. Inferring an expected time of arrival, as in Transit, has some generic components but also uses non-generic subject-matter knowledge. Bailin et al. (1999a) argue against viewing critical thinking skills as generic and discrete, on the ground that skilled performance at a critical thinking task cannot be separated from knowledge of concepts and from domain-specific principles of good thinking. Talk of skills, they concede, is unproblematic if it means merely that a person with critical thinking skills is capable of intelligent performance.

Despite such scepticism, theorists of critical thinking have listed as general contributors to critical thinking what they variously call abilities (Glaser 1941; Ennis 1962, 1991), skills (Facione 1990a; Halpern 1998) or competencies (Fisher & Scriven 1997). Amalgamating these lists would produce a confusing and chaotic cornucopia of more than 50 possible educational objectives, with only partial overlap among them. It makes sense instead to try to understand the reasons for the multiplicity and diversity, and to make a selection according to one's own reasons for singling out abilities to be developed in a critical thinking curriculum. Two reasons for diversity among lists of critical thinking abilities are the underlying conception of critical thinking and the envisaged educational level. Appraisal-only conceptions, for example, involve a different suite of abilities than constructive-only conceptions. Some lists, such as those in

(Glaser 1941), are put forward as educational objectives for secondary school students, whereas others are proposed as objectives for college students (e.g., Facione 1990a).

The abilities described in the remaining paragraphs of this section emerge from reflection on the general abilities needed to do well the thinking activities identified in section 6 as components of the critical thinking process described in section 5. The derivation of each collection of abilities is accompanied by citation of sources that list such abilities and of standardized tests that claim to test them.

Observational abilities: Careful and accurate observation sometimes requires specialist expertise and practice, as in the case of observing birds and observing accident scenes. However, there are general abilities of noticing what one's senses are picking up from one's environment and of being able to articulate clearly and accurately to oneself and others what one has observed. It helps in exercising them to be able to recognize and take into account factors that make one's observation less trustworthy, such as prior framing of the situation, inadequate time, deficient senses, poor observation conditions, and the like. It helps as well to be skilled at taking steps to make one's observation more trustworthy, such as moving closer to get a better look, measuring something three times and taking the average, and checking what one thinks one is observing with someone else who is in a good position to observe it. It also helps to be skilled at recognizing respects in which one's report of one's observation involves inference rather than direct observation, so that one can then consider whether the inference is justified. These abilities come into play as well when one thinks about whether and with what degree of confidence to accept an observation report, for example in the study of history or in a criminal investigation or in assessing news reports. Observational abilities show up in some lists of critical thinking abilities (Ennis 1962: 90; Facione 1990a: 16; Ennis 1991: 9). There are items testing a person's ability to judge the credibility of observation reports in the Cornell Critical Thinking Tests, Levels X and Z (Ennis & Millman 1971; Ennis, Millman, & Tomko 1985, 2005). Norris and King (1983, 1985, 1990a, 1990b) is a test of ability to appraise observation reports.

Emotional abilities: The emotions that drive a critical thinking process are perplexity or puzzlement, a wish to resolve it, and satisfaction at achieving the desired resolution. Children experience these emotions at an early age, without being trained to do so. Education that takes critical thinking as a goal needs only to channel these emotions and to make sure not to stifle them. Collaborative critical thinking benefits from ability to recognize one's own and others' emotional commitments and reactions.

Questioning abilities: A critical thinking process needs transformation of an inchoate sense of perplexity into a clear question. Formulating a question well requires not building in questionable assumptions, not prejudging the issue, and using language that in context is unambiguous and precise enough (Ennis 1962: 97; 1991: 9).

Imaginative abilities: Thinking directed at finding the correct causal explanation of a general phenomenon or particular event requires an ability to imagine possible explanations. Thinking about what policy or plan of action to adopt requires generation of options and consideration of

possible consequences of each option. Domain knowledge is required for such creative activity, but a general ability to imagine alternatives is helpful and can be nurtured so as to become easier, quicker, more extensive, and deeper (Dewey 1910: 34–39; 1933: 40–47). Facione (1990a) and Halpern (1998) include the ability to imagine alternatives as a critical thinking ability.

Inferential abilities: The ability to draw conclusions from given information, and to recognize with what degree of certainty one's own or others' conclusions follow, is universally recognized as a general critical thinking ability. All 11 examples in section 2 of this article include inferences, some from hypotheses or options (as in Transit, Ferryboat and Disorder), others from something observed (as in Weather and Rash). None of these inferences is formally valid. Rather, they are licensed by general, sometimes qualified substantive rules of inference (Toulmin 1958) that rest on domain knowledge—that a bus trip takes about the same time in each direction, that the terminal of a wireless telegraph would be located on the highest possible place, that sudden cooling is often followed by rain, that an allergic reaction to a sulfa drug generally shows up soon after one starts taking it. It is a matter of controversy to what extent the specialized ability to deduce conclusions from premisses using formal rules of inference is needed for critical thinking. Dewey (1933) locates logical forms in setting out the products of reflection rather than in the process of reflection. Ennis (1981a), on the other hand, maintains that a liberally-educated person should have the following abilities: to translate natural-language statements into statements using the standard logical operators, to use appropriately the language of necessary and sufficient conditions, to deal with argument forms and arguments containing symbols, to determine whether in virtue of an argument's form its conclusion follows necessarily from its premisses, to reason with logically complex propositions, and to apply the rules and procedures of deductive logic. Inferential abilities are recognized as critical thinking abilities by Glaser (1941: 6), Facione (1990a: 9), Ennis (1991: 9), Fisher & Scriven (1997: 99, 111), and Halpern (1998: 452). Items testing inferential abilities constitute two of the five subtests of the Watson Glaser Critical Thinking Appraisal (Watson & Glaser 1980a, 1980b, 1994), two of the four sections in the Cornell Critical Thinking Test Level X (Ennis & Millman 1971; Ennis, Millman, & Tomko 1985, 2005), three of the seven sections in the Cornell Critical Thinking Test Level Z (Ennis & Millman 1971; Ennis, Millman, & Tomko 1985, 2005), 11 of the 34 items on Forms A and B of the California Critical Thinking Skills Test (Facione 1990b, 1992), and a high but variable proportion of the 25 selected-response questions in the Collegiate Learning Assessment (Council for Aid to Education 2017).

Experimenting abilities: Knowing how to design and execute an experiment is important not just in scientific research but also in everyday life, as in Rash. Dewey devoted a whole chapter of his How We Think (1910: 145–156; 1933: 190–202) to the superiority of experimentation over observation in advancing knowledge. Experimenting abilities come into play at one remove in appraising reports of scientific studies. Skill in designing and executing experiments includes the acknowledged abilities to appraise evidence (Glaser 1941: 6), to carry out experiments and to apply appropriate statistical inference techniques (Facione 1990a: 9), to judge inductions to an explanatory hypothesis (Ennis 1991: 9), and to recognize the need for an adequately large sample size (Halpern 1998). The Cornell Critical Thinking Test Level Z (Ennis & Millman 1971;

Ennis, Millman, & Tomko 1985, 2005) includes four items (out of 52) on experimental design. The Collegiate Learning Assessment (Council for Aid to Education 2017) makes room for appraisal of study design in both its performance task and its selected-response questions.

Consulting abilities: Skill at consulting sources of information comes into play when one seeks information to help resolve a problem, as in Candidate. Ability to find and appraise information includes ability to gather and marshal pertinent information (Glaser 1941: 6), to judge whether a statement made by an alleged authority is acceptable (Ennis 1962: 84), to plan a search for desired information (Facione 1990a: 9), and to judge the credibility of a source (Ennis 1991: 9). Ability to judge the credibility of statements is tested by 24 items (out of 76) in the Cornell Critical Thinking Test Level X (Ennis & Millman 1971; Ennis, Millman, & Tomko 1985, 2005) and by four items (out of 52) in the Cornell Critical Thinking Test Level Z (Ennis & Millman 1971; Ennis, Millman, & Tomko 1985, 2005). The College Learning Assessment's performance task requires evaluation of whether information in documents is credible or unreliable (Council for Aid to Education 2017).

Argument analysis abilities: The ability to identify and analyze arguments contributes to the process of surveying arguments on an issue in order to form one's own reasoned judgment, as in Candidate. The ability to detect and analyze arguments is recognized as a critical thinking skill by Facione (1990a: 7–8), Ennis (1991: 9) and Halpern (1998). Five items (out of 34) on the California Critical Thinking Skills Test (Facione 1990b, 1992) test skill at argument analysis. The College Learning Assessment (Council for Aid to Education 2017) incorporates argument analysis in its selected-response tests of critical reading and evaluation and of critiquing an argument.

Judging skills and deciding skills: Skill at judging and deciding is skill at recognizing what judgment or decision the available evidence and argument supports, and with what degree of confidence. It is thus a component of the inferential skills already discussed.

Lists and tests of critical thinking abilities often include two more abilities: identifying assumptions and constructing and evaluating definitions.

Some of the initiating dispositions, such as open-mindedness and willingness to suspend judgment, are also internal critical thinking dispositions, in the sense of mental habits or attitudes that contribute causally to doing a good job of critical thinking once one starts the process. But there are many other internal critical thinking dispositions. Some of them are parasitic on one's conception of good thinking. For example, it is constitutive of good thinking about an issue to formulate the issue clearly and to maintain focus on it. For this purpose, one needs not only the corresponding ability but also the corresponding disposition. Ennis (1991: 8) describes it as the disposition "to determine and maintain focus on the conclusion or question", Facione (1990a: 25) as "clarity in stating the question or concern". Other internal dispositions are motivators to continue or adjust the critical thinking process, such as willingness to persist in a complex task and willingness to abandon nonproductive strategies in an attempt to

self-correct (Halpern 1998: 452). For a list of identified internal critical thinking dispositions, see the Supplement on Internal Critical Thinking Dispositions.

In addition to dispositions and abilities, critical thinking needs knowledge: of critical thinking concepts, of critical thinking principles, and of the subject-matter of the thinking.

We can derive a short list of concepts whose understanding contributes to critical thinking from the critical thinking abilities described in the preceding section. Observational abilities require an understanding of the difference between observation and inference. Questioning abilities require an understanding of the concepts of ambiguity and vagueness. Inferential abilities require an understanding of the difference between conclusive and defeasible inference (traditionally, between deduction and induction), as well as of the difference between necessary and sufficient conditions. Experimenting abilities require an understanding of the concepts of hypothesis, null hypothesis, assumption and prediction, as well as of the concept of statistical significance and of its difference from importance. They also require an understanding of the difference between an experiment and an observational study, and in particular of the difference between a randomized controlled trial, a prospective correlational study and a retrospective (case-control) study. Argument analysis abilities require an understanding of the concepts of argument, premiss, assumption, conclusion and counter-consideration. Additional critical thinking concepts are proposed by Bailin et al. (1999b: 293), Fisher & Scriven (1997: 105–106), Black (2012), and Blair (2021).

According to Glaser (1941: 25), ability to think critically requires knowledge of the methods of logical inquiry and reasoning. If we review the list of abilities in the preceding section, however, we can see that some of them can be acquired and exercised merely through practice, possibly guided in an educational setting, followed by feedback. Searching intelligently for a causal explanation of some phenomenon or event requires that one consider a full range of possible causal contributors, but it seems more important that one implements this principle in one's practice than that one is able to articulate it. What is important is "operational knowledge" of the standards and principles of good thinking (Bailin et al. 1999b: 291–293). But the development of such critical thinking abilities as designing an experiment or constructing an operational definition can benefit from learning their underlying theory. Further, explicit knowledge of quirks of human thinking seems useful as a cautionary guide. Human memory is not just fallible about details, as people learn from their own experiences of misremembering, but is so malleable that a detailed, clear and vivid recollection of an event can be a total fabrication (Loftus 2017). People seek or interpret evidence in ways that are partial to their existing beliefs and expectations, often unconscious of their "confirmation bias" (Nickerson 1998). Not only are people subject to this and other cognitive biases (Kahneman 2011), of which they are typically unaware, but it may be counter-productive for one to make oneself aware of them and try consciously to counteract them or to counteract social biases such as racial or sexual stereotypes (Kenyon & Beaulac 2014). It is helpful to be aware of these facts and of the superior effectiveness of blocking the operation of biases—for example, by making an immediate record of one's observations, refraining from forming a preliminary explanatory hypothesis, blind refereeing, double-blind randomized trials, and blind grading of students' work. It is also helpful

to be aware of the prevalence of “noise” (unwanted unsystematic variability of judgments), of how to detect noise (through a noise audit), and of how to reduce noise: make accuracy the goal, think statistically, break a process of arriving at a judgment into independent tasks, resist premature intuitions, in a group get independent judgments first, favour comparative judgments and scales (Kahneman, Sibony, & Sunstein 2021). It is helpful as well to be aware of the concept of “bounded rationality” in decision-making and of the related distinction between “satisficing” and optimizing (Simon 1956; Gigerenzer 2001).

Critical thinking about an issue requires substantive knowledge of the domain to which the issue belongs. Critical thinking abilities are not a magic elixir that can be applied to any issue whatever by somebody who has no knowledge of the facts relevant to exploring that issue. For example, the student in Bubbles needed to know that gases do not penetrate solid objects like a glass, that air expands when heated, that the volume of an enclosed gas varies directly with its temperature and inversely with its pressure, and that hot objects will spontaneously cool down to the ambient temperature of their surroundings unless kept hot by insulation or a source of heat. Critical thinkers thus need a rich fund of subject-matter knowledge relevant to the variety of situations they encounter. This fact is recognized in the inclusion among critical thinking dispositions of a concern to become and remain generally well informed.