



Comprehension View about Critical Thinking - Narrative Review

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Author's contribution

This work was carried out in collaboration between both authors. Both authors designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

The critical thinking literature emphasizes the continuous need of understanding the meaning of a complex concept as critical thinking. Previous research provides multiple theoretical approaches on critical thinking, including different theoretical and operational definition, methods for developing critical thinking and measurements tools within formal educations. In this study, we focus on reviewing the main insights from previous studies with the specific aim of proposing a structured overview of how critical thinking can be defined, developed and measured according to multiple approaches (i.e., philosophical, psychological, educational). Results of this study showed the development of the critical thinking concept, consisting of a broad perspective of multiple approaches of critical thinking. This further enables an overview of critical thinking particularities.

Keywords: Critical thinking; narrative review; philosophical approach; psychological approach; educational approach.

1. INTRODUCTION

Critical thinking (CT) is considered the 5th in a top ten demanding skills for 2022 [1]. Thus far, CT

was linked to other key skills of the 21st century in students' learning process and daily life. Franco et al., [2] showed that people who master a "good thinking" experience more professional,

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academic and daily life opportunities. In addition, research has a continuous focus on the CT concept [3]. Nonetheless, less research focused on providing a qualitative overview of the concept of CT [4]. There is a specific need of understanding what does CT mean, which domains does it cover and how is it mainly studied. The aim of the study consists of exploring the different literature that focuses on CT. The specific objective involves enabling an overview of the CT concept in different research fields such as philosophy, psychology and education, with taxonomies, frameworks, developing programs and assessment methods.

Over the years research fields such as philosophy, psychology and educational sciences tried to master the CT concept [5]. As a result, every field concluded by giving a particular definition and approach to CT. Building on three approaches (i.e., philosophical, psychological, educational) this study enables a complex overview on the CT concept. Each approach debates the CT, bringing different insights that must be considered in further studies. Therefore, we further present an overview of the main approaches that studied CT. We begin with an overall matrix of thinking skills to have a broad view over the thinking concept, and we will further continue with presenting a proposed taxonomy and the working definitions for each approaches (i.e., philosophy, psychology and education). Lastly, we outline a historical junction for the CT concept.

CT, as a unit concept, comprises the association of two words (i.e., critical and thinking) that can be interpreted as a specific state of mind (i.e., being *critical*) and the psychological *thinking* processes. Firstly, we mention Gubbins's work materializing in a synthetic Matrix of Thinking Skills that outlines the beginning of research in the field of thinking. Gubbins's contribution consist of providing an understanding of the theoretical and practical instrument used in the assessment of the thinking skills [6]. The matrix is divided into six operationalized skills in sections that consist of problem solving, decision making, inferences (i.e., inductive and deductive thinking skills), divergent thinking skills, evaluative thinking skills, philosophy and reasoning. Table 1 outlines each skill introduced by Gubbins and its respective operationalization consisting of the steps of each skill.

2. CONCEPTUALIZATION

2.1 Philosophical Approach

Philosophy considers CT in terms of attitudes or dispositions of an *ideal critical thinker* [6,7]. CT definition involves thinking that meets standards or certain criteria of accuracy and adequacy [8]. The limitation of this approach consists of a lack of consideration of the process of thinking.

Moreover, Robert Ennis proposed a philosophical taxonomy for CT starting from the idea that CT results from the interaction of a dispositional set and some abilities for CT [9]. The dispositions set include seekingness of a clear statement; the pursuit reasons; the state of being well-informed; maintaining its relevance. The desire and motivation to think critically are considered here are the premises for these dispositions. Table 2 highlights Ennis taxonomy of the CT abilities and their operationalizations. The taxonomy unfolds from elementary clarification to taxonomy and tactics.

Analyzing the evolution of the definition of CT according to the philosophical approach, we observe that CT concept has initially been defined as a reflective and reasonable thinking, a skillful and responsible, a self-directed and goal-directed thinking, a reflective judging and a reflective skepticism skill. Over the years the attributes associated with CT are reflective, purposeful, disciplined and goal directed (see Table 3). This demonstrated the continuous interest in studying this concept and the permanent need of improving it.

2.2 Psychological Approach

On the opposite side the *psychological* approach defines CT in terms of metacognitive processes or in terms of skills, focusing on *how people really think* [16]. Metacognitive phrase/ system was used because of its simple meaning of "thinking about thinking" [17]. Moreover, metacognition was considered as an instrument able to measure the quality of CT [18]. Over the years, the CT concept was used interchangeably along with metacognition, higher cognitive skills, creative thinking, reasoning or problem solving [19,20]. Likewise, CT was defined in terms of a specific behavior that a critical thinker can have. The limitation of the psychological approach consists of reducing CT to tested skills performance mostly done in laboratory and without generalization to the daily life performance of the assessed people [6].

Table 1. Gubbins's matrix of thinking skills [6]

| SKILLS | OPERATIONALIZATION | | | | |
|-------------------------------|--|---------------------------|---|---------------------------|--|
| 1. Problem Solving | identifying general problem clarifying general problem formulating hypothesis formulating appropriate questions generating related ideas formulating alternative solutions choosing best solution applying the solution monitoring acceptance of the solution drawing conclusions | | | | |
| 2. Decision Making | stating desired goal / condition stating obstacles to goal / condition identifying alternatives examining alternatives ranking alternatives choosing best alternative evaluating actions | | | | |
| 3. Inferences | <table border="0"> <tr> <td style="vertical-align: top;">inductive thinking skills</td> <td style="vertical-align: top;">determining cause and effect analyzing open-ended problems reasoning by analogy making inferences determining relevant information recognizing relationships solving insight problems</td> </tr> <tr> <td style="vertical-align: top;">deductive thinking skills</td> <td style="vertical-align: top;">using logic spotting contradictory statements analyzing syllogisms solving spatial problems</td> </tr> </table> | inductive thinking skills | determining cause and effect analyzing open-ended problems reasoning by analogy making inferences determining relevant information recognizing relationships solving insight problems | deductive thinking skills | using logic spotting contradictory statements analyzing syllogisms solving spatial problems |
| inductive thinking skills | determining cause and effect analyzing open-ended problems reasoning by analogy making inferences determining relevant information recognizing relationships solving insight problems | | | | |
| deductive thinking skills | using logic spotting contradictory statements analyzing syllogisms solving spatial problems | | | | |
| 4. Divergent Thinking skills | listing attributes of objects / situation generating multiple ideas (fluency) generating different ideas (flexibility) generating unique ideas (originality) generating detailed ideas (elaboration) synthesizing information | | | | |
| 5. Evaluative Thinking Skills | distinguishing between facts and opinions judging credibility of a source observing and judging observation reports identifying central issues and problems recognizing underlying assumptions detecting bias, stereotypes, cliches recognizing loaded language evaluating hypotheses classifying data predicting consequences demonstrating sequential synthesis of information planning alternative strategies recognizing inconsistencies in information identifying stated and unstated reasons comparing similarities and differences evaluating arguments | | | | |
| 6. Philosophy And Reasoning | using dialogical / dialectical approaches | | | | |

Note. Reprinted from "Critical Thinking: Its Mature, Measurement, and Improvement.", by E. J. Gubbins, 1985 as cited in Sternberg, [6], Washington, DC: National Inst. of Education, p. 33-35

Table 2. Ennis taxonomy of CT abilities [6]

| No. | Abilities | Operationalization of abilities |
|-----|--------------------------|---|
| 1. | Elementary clarification | focusing on a question analyzing arguments asking / answering questions / clarification / challenge |
| 2. | Basic support | judging the source credibility observing judging observation reports |
| 3. | Inference | deducing and judging deductions inducing and judging inductions making and judging the value of judgments |
| 4. | Advanced clarification | defining terms judging definition identifying assumptions |
| 5. | Strategy and tactics | deciding on an action interacting with others |

Table 3. Definition of CT for philosophical approach

| Author name | Definition | Key word of the dispositions |
|---------------------|--|---|
| Ennis, [10] | - reflective and reasonable thinking engage to state what should believe or do; | reflectiveness |
| Lipman, [11] | - skillful and responsible thinking that sustain good judgment based on criteria, sensible to context and self-correcting; | responsibleness (responsibility) self-correctness |
| Paul, [12] | - disciplined and self-directed thinking representing the perfections of thinking that aimed to form a judgment; | self-directedness |
| Bailin et al., [13] | - goal-directed and purposive thinking that meet adequacy and accuracy standards; | goal-directedness |
| Facione, [14] | - reflective judging what to do or believe. | reflectiveness |
| McPeck, [15] | - the skill and predilection to start an activity with reflective skepticism; | reflective skepticism |

Sternberg [6] developed a psychological taxonomy of skills involved in CT, which derives from a psychological analysis of CT where skills are divided in *meta-components*, *performance components* and *knowledge-acquisition components*. Table 4 presents this taxonomy with skills components proposed in the reverse order of complexity, from low to high processes, respecting the same structure. The *knowledge-acquisition* components (i.e., selective encoding, combination and comparison) represent the low processes required to learn procedures or concepts. The middle order *performance* components are non-executive processes used to provide feedback for the meta-components instructions. The higher order executive processes are occupied by the *meta-components* that are involved in planning, monitoring and evaluating things to do.

Halpern [21] proposed another taxonomy of CT skills with an added instrument to measure this

concept. Its taxonomy consists of guidelines for improving the CT skills through instruction. Such instructions must be valid and easy to communicate to students or the general public. Table 5 presents the improved skills and their descriptions.

As it can be seen in Table 6 the definition of the CT from the psychological approach is based on mental processes or cognitive skills, emphasizing the description of those skills. The focus of the psychological approach involves the assessment of the CT skills while the CT concept represents more than just the sum of its parts [22]. Also, the cognitive scientists define CT as reasoning, making judgments, taking decisions and problem solving [23]. We can conclude that over the years the definition provided by the psychological approach evolved in the following order mental process or activity; a cognitive skills or strategy; a more particular concrete or practical skills such as problem solving, drawing conclusions and

openness to new evidence that disconfirm the thinker's ideas.

2.3 Educational Approach

Besides the philosophical and psychological approaches, the educational approach proposes a perspective based on Bloom's Taxonomy of the Cognitive Domain (as shown in Table 7). This taxonomy comprises different levels of educational objectives on the cognitive domain. Within the taxonomy, the last four levels (application, analysis, synthesis and evaluation) are recognized to be equal to CT. Bloom considered more appropriate to use the phrase *intellectual abilities and skills* instead of CT. According to him, abilities were defined as the sum of the art of skills and knowledge [24,25]. Here, various researchers argue that *evaluation* level from Bloom's taxonomy can be equivalent to CT because it makes a judgment, or an assessment based on the analysis of a proposition or statement [26].

The educational field concentrates on studying CT in a dynamic way, following its outcomes or utility and does not concentrate on defining the CT. As a result, Glaser considered to be the first researcher who used the exact notion of CT, conducted the very first experiment in the educational area, testing the feasibility of

teaching CT to high school students [27]. He considered that CT is made up of three components as *disposition* to perceive life experiences in a thoughtful way and *skills* to apply *knowledge* of the logical inquiry. Thus far, educational theorists defined CT based on classroom observations and experiences, texts and process analysis of thinking in the observed classes. The limitations of this approach are represented by the lack of measurement tests such as the psychological or philosophical approaches and the lack of clarity on the epistemological side [6].

And yet, despite of the lack of a theoretical model for CT shared by practitioners there was a specific interest for a consensual definition of CT shared within the experts that were working with CT in different domains [28]. Under these circumstances the American Philosophical Association gathered 46 educators, researchers, employers and policy makers with various fields of expertise, under the name of *Delphi Research Project* (1988-1989), and after six rounds of meetings, they agreed on the definition of CT in terms of affective dispositions and cognitive skills. According to this project, CT was defined as a purposeful and self-regulatory judgment, resulting in components such as interpretation, analysis, evaluation, inference and explanation of the evidential considerations that the judgment

Table 4. Sternberg taxonomy of skills involved in CT [6]

| No. | Skills' components | Operationalization of skills ' components |
|-----|-----------------------|--|
| 1. | Knowledge-acquisition | used to learn concepts or procedures selective encoding from irrelevant information selective combination by putting together the relevant information in an organized way selective comparison by relating old information to new (to be learned) |
| 2. | Performance | information used for instruction execution and feedback for the meta-components e.g.: performance components of induction - encoding, comparing, inferring relations between stimuli, mapping relations, applying relations from one domain to another, explain potential responses and responding |
| 3. | Meta-components | used for plans what someone will do monitor what someone will do evaluate the plan done recognize the existence of a problem define the nature of the problem monitor the solving process order the steps into a strategy shape the form for mental representation of information allocate time and resources for solving a problem use feedback after problem was solved decide the steps for solving the problem |

Table 5. Halpern taxonomy of CT skills [21]

| The improved skills | Description of each skill |
|-------------------------------------|---|
| verbal reasoning | comprehend and defend against everyday persuasive language |
| argument analysis | analyze the stated or unstated assumptions and irrelevant information |
| thinking as hypothesis testing | explain, predict and control events; generalize, accurate assessment and validity |
| likelihood and uncertainty | use correctly the cumulative, exclusive and contingent probabilities |
| decision-making and problem solving | selecting and generating alternatives and restate goals and problems |

Table 6. Definition of CT for psychological approach

| Author name | Definitions | Key skills identified in the provided definitions |
|------------------|--|---|
| Sternberg, [6] | - mental processes, strategies and representations use to solve problems, make decisions and learn concepts; | problem solving, decisions-making |
| Halpern, [21] | - cognitive skills or strategies use to increase desirable outcomes; | reasoning, analysis, evaluation, judgment, and decision-making |
| Huitt, [21] | - disciplined mental activity that's evaluating propositions or arguments and makes judgments that guide the development of beliefs and actions; | evaluation of arguments, judgment |
| Willingham, [23] | - solving problems, deducing and inferring conclusions from valid facts, demanding for claims to be backed by support and evidence, seeing the issue in both sides or being open to new evidence that disconfirm your ideas. | problem solving, deduct and infer conclusions, openness to different perspectives |

Table 7. Bloom's hierarchical taxonomy of educational objectives for cognitive information processing [24]

| No. | Objective levels | Particularities of each level |
|-----|----------------------|---|
| 1. | Knowledge (lowest) | accumulates as much information, knowledge |
| 2. | Comprehension | goes beyond knowledge understands what one knows |
| 3. | Application (higher) | applies what one comprehends |
| 4. | Analysis | appraises what one comprehends and applies |
| 5. | Synthesis | puts together the knowledge one has analyzed |
| 6. | Evaluation | appraises the analyzed and synthesized knowledge |

was based upon. Moreover, CT comprised *cognitive skills (6)*, *sub-skills (16)*, *general affective dispositions (12)* and *general affective dispositions (7)*. All these cognitive skills, sub-skills and affective dispositions offered a much precise view about the complexity of the CT concept. Table 8 presents the list of these skills and their respective sub-skills.

After Delphi Research Project the CT literature was improved by the work of Thomas & Lok (2015) "Operational Framework" for teaching CT by merging the philosophical, psychological and

educational approach (see Table 9). By being interrelated, all the three components form the CT attributes.

The previous definitions of CT highlight different aspects of this concept. First, CT is the sum of characteristics or personality dispositions held by an ideal critical thinker (philosophical approach). Second, CT is defined in terms of skills, behavior that a critical thinker can have (psychological approach) and third, CT is defined regarding the operational objectives of the cognitive domain (educational approach). These approaches and

insights on CT allowed us to develop and propose the following overall definition of CT: *an umbrella concept that gathered under his spectrum personality dispositions and cognitive skills all mixed and applied to daily life knowledge*. This definition facilitates a deeper understanding of the CT concept by taking into account all the previous approaches.

Table 8. List of skills and sub-skills and affective dispositions of CT according to the delphi research project [29]

| No. | Cognitive core skills | No. | Sub-skills |
|--|--|---|--|
| 1. | Interpretation | 1. | categorization |
| | | 2. | decoding significance |
| | | 3. | clarifying meaning |
| 2. | Analysis | 4. | examining ideas |
| | | 5. | identifying arguments |
| | | 6. | analyzing arguments |
| 3. | Evaluation | 7. | assessing claims |
| | | 8. | assessing arguments |
| 4. | Inference | 9. | querying evidence |
| | | 10. | conjecturing alternatives |
| | | 11. | drawing conclusions |
| 5. | Explanation | 12. | stating results |
| | | 13. | justifying procedures |
| | | 14. | presenting arguments |
| 6. | Self-regulation | 15. | self-examination |
| | | 16. | self-correction |
| Affective dispositions | | | |
| Approaches to life and living in general | | Approaches to specific issues, questions, or problems | |
| 1. | inquisitiveness with regard to a wide range of issues | 1. | clarity in stating the question or concern |
| 2. | concern to become and remain generally well-informed | 2. | orderliness in working with complexity |
| 3. | alertness to opportunities to use CT | 3. | diligence in seeking relevant information |
| 4. | trust in the processes of reasoned inquiry | 4. | reasonableness in selecting and applying criteria |
| 5. | self-confidence in one's own ability to reason | 5. | care in focusing attention on the concern at hand |
| 6. | open-mindedness regarding divergent world views | 6. | persistence though difficulties are encountered |
| 7. | flexibility in considering alternatives and opinions | 7. | precision to the degree permitted by subject and circumstances |
| 8. | understanding of the opinions of other people | | |
| 9. | fair-mindedness in appraising reasoning | | |
| 10. | honesty in facing one's own biases, prejudices, stereotypes, egocentric or sociocentric tendencies | | |
| 11. | prudence in suspending, making or altering judgments | | |
| 12. | willingness to reconsider and revise views where honest reflection suggests that change is warranted | | |

Note. Reprinted from "A statement of expert consensus for purposes of educational assessment and instruction. Research findings and recommendations", by P. A. Facione [29], Millbrae, CA: The California Academic Press, p. 15, p. 28. Copyright [29] by P. A. Facione

Table 9. The operational framework of Thomas & Lok (2015, p. 98)

| Approach | Philosophical | Psychological | Educational |
|------------|----------------------|-------------------------------|---|
| level | personal disposition | skills | knowledge |
| components | attitudes | evaluation | general information and basic facts |
| | intellectual virtues | reasoning | experience (intellectual development and knowledge from work and life experience) |
| | habits of mind | reflection or self-regulation | specific content-based knowledge |

3. PROGRAMS TO IMPROVE AND FOSTER CRITICAL THINKING

If there were a multitude of approaches in defining CT, the same domains presented different programs for improving CT. From the philosophical side, Lipman [30] proposed a training program for thinking skills in the context of daily lives of children: "Philosophy for Children". Within the program, students are provided with explicit situations (i.e., daily life situations encountered by children) to figure out the bridge between CT skills and the daily use of CT. Another philosophically based program for secondary college level was Copi's courses in logic, used as tool for teaching CT (see Table 10). It deals, in particular, with situations and problems applicable for methods of logic even if not all life's problems lead to formal logical analysis (Copi, 1978; as cited in Sternberg, [6], p.23).

On the other hand, the psychological approach, Bransford and Stein [31], presents the "i.d.e.a.l. problem solver" (*I*dentifying the problem, *D*efining and representing the problem, *E*xploring possible strategies, *A*cting on the strategies, *L*ooking back and evaluating the effects of other activities), a program that uses practical

examples linked to psychological theories and researches. This program presents demonstrated techniques exemplified in everyday examples and readers are stimulated to apply those techniques to their personal problems. It is structured in eight parts where it presents: 1) the importance of problem solving; 2) a model to improving the problem solving, 3) improving memory skills; 4) understanding learning; 5) intelligent criticism; 6) creativity; 7) effective communication; and 8) concluding remarks. Generally speaking, the IDEAL program was designed more for individual approach.

The educational approach was proposed by Elen and collaborators in an educational protocol based upon Delphi Research Project outputs (definition of CT) to promote and guide the development of CT in European Higher Education Institutions at a macro-level from the institutional level, to teaching program which follows the course level that had inside the central concept of CT [32].

If we consider CT developing context a stratifying one, we should have *CT level* as core, surrounded by *course level*, which fit to a *teaching program level* and the first layer will be the *institutional level* [32].

Table 10. Copi's logic course as cited in Sternberg, [6]

| No. | Course part | Course chapter |
|-----|--------------------------|--|
| | | Definition |
| | | Introductory chapter on the nature of logic |
| 1. | Use of language in logic | Categorical propositions |
| | | Uses of language in logical thinking |
| | | Informal fallacies |
| | | Categorical syllogisms |
| | | Arguments in ordinary language |
| 2. | Deduction | Methods of deduction |
| | | Quantification theory |
| | | Analogy and probable inference |
| 3. | Induction | Philosophy of science and hypothesis testing |
| | | Probability theory |
| | | Causal arguments |

Table 11. Programs for developing CT in different contexts

| Approach | Authors | Program's name | Applicability on the following level of education |
|------------------------------|--|--|---|
| Philosophical | Lipman [30] Copi (1978) | Philosophy for children Copi's course in logic | primary school college |
| Psychological Educational | Bransford & Stein [31] Elen et al. [32] | The i.d.e.a.l problem solver Promoting CT in European Higher Education Institution: toward an educational protocol | daily learning bachelor's |

As we have seen in the different approaches of CT, the educational field was the one that focused on studying CT in a dynamic way, based on experiences spent in the classroom and observation. Thus, the usefulness of this concept in educating students was emphasized.

We presented the CT developing programs from the three main fields (see Table 11) and we can conclude that we covered all the learning levels starting with primary school level and Lipman's program [30] "Philosophy for children" where CT skills were taught through some children's characters. Copi's course in logic was the program that proposed to develop CT at college level through formal logic analysis applicable in problems and situations. The psychological approaches were represented by Bransford and Stein [31] and their "Ideal problem solver" for life level. Here the readers were taught through everyday life examples how to identify a problem, to define and represent that problem, to explore all the possible strategies that occur, and to act on the strategies. In the end the reader was taught to look back and evaluate the effects of other activities. For the educational approach we presented what Elen and colleagues [32] proposed; one educational protocol that promotes and guides the development of CT in European Higher Education Institutions. This development was thought in layers from the institutional level and organizational climate to the exterior level, going inward to teaching program expressed in the curriculum level, resources and materials. Further we found the course level where content, aim and objectives had the purpose to foster the CT as the main concept.

4. MEASUREMENT OF CRITICAL THINKING

From the entire areal of instruments that measure CT, we considered the main ones that

were used in various research and translated in multiple languages. The philosophical approach prefers to measure reasoning in the verbal context by proposing tests with highly verbally load and it can be associated with several instruments such as Watson Glaser CT Appraisal (WGCTA), or The Cornell CT Test (CCTT) [6].

In WGCTA the concept of CT is defined as being disposed or to have an attitude to consider the subjects and problems in a thoughtful way; to have knowledge of the logical inquiry and reasoning methods; and skills to apply the above methods. Also, is a test that maximizes reasoning skills and at the same time it minimizes the importance of content. It contains 80 multiple choice items grouped under five subtests that measures different CT skills. The items are related to relatively short passages that reveal some situations. Even it has no time limited for administration 30 minutes are recommended as an optimal time [33]. The test is recommended for students starting to 9th grade level (high school) and above. The five subtests are: (i) Inference, (ii) Recognition of Assumptions, (iii) Deduction, (iv) Interpretation, and (v) Evaluation of Arguments [34].

The CCTT was designed after Ennis definition of CT as a reflective and reasonable thinking engage to state what should believe or do. It has two levels X and Z. Level X appropriate for secondary school (five grades) has 71 items and contains four sections: (1) Induction (judging conclusions), (2) Deduction, (3) Credibility, (4) Identification of Assumptions. Z level is designed for college students, has 52 multiple-choice items and contains seven sections, four as X level and three more: (5) Semantics, (6) Definition and Assumption Identification, (7) Prediction in Planning (or Induction - planning experiments). Both forms (X, Z) had 50 minutes as time limit [35].

Table 12. Instruments that measure CT

| Approach | Specific characteristics | Specific instruments |
|-----------------|---|---|
| Philosophical | measure reasoning in the verbal context by proposing tests with highly verbal load; it has time limitation | Watson Glaser CT Appraisal (WGCTA) The Cornell CT Test (CCTT) |
| Psychological | assess reasoning with less demands upon student's knowledge base; contains both verbal and nonverbal items; no time limit | Halpern Critical Thinking Assessment using Everyday Situations (HCTAES) |
| Educational | measure reasoning in a comprehensive way; no time limit | Testo de Pensamento Critico e Creativo (TPCC) PENTRASAL (Pensamiento, Transfer, Salamanca) |

The psychologically based tests assess reasoning with less demand upon student's knowledge base and contain both verbal and nonverbal items. One example is Halpern Critical Thinking Assessment using Everyday Situations (HCTAES) that deals with similar daily situations in 25 open-ended scenarios and closed-ended items format [36]. The double format questions allow to assess if the respondent manifests the spontaneous use of a particular CT skill or if he/she is using the skill just when he/she receives indications that it is necessary for that situation. According to the test, the five CT skills assessed are: (1) evaluating hypotheses, (2) verbal reasoning, (3) analysis of arguments, (4) probability and uncertainty and (5) decision making and problem solving. The scoring is between 0 and 2 and the maximum answering time is 120 minutes.

On the educational field we can associate the Critical and Creative Thinking Test (Testo de Pensamento Critico e Creativo TPCC) that assess the competence of creative and CT in a comprehensive way, based on Bloom's revised taxonomy, the Delphi Research Project and Guilford general intellectual processes (from the divergent production, creativity) [37,29,38]. The test offers real-life situations and six question related that require open answers, with many possible solutions. TPCC assesses CT competence as (1) interpretation, (2) analysis, (3) explanation, (4) evaluation,(5) synthesis, (6) production creation. The scoring is between 0 and 3 points, just the flexibility dimension from the production creation is scored between 0 and 2. The mean answering time for this test was 30 minutes.

Another test captured our attention because it aims to measure the transfer of CT skills to

different domains as a measure of efficiency is PENTRASAL (Pensamiento, Transfer, Salamanca) [39]. The test deals with tasks which reflect different contexts problems (job-related, sports, politics, education, environment, or health problems). The main principles that stay at the base of this Transfer Test are: i) the items are daily life problems-based; ii) it respects the open-response format; iii) it proposes problems from different domains knowledge or picks; iv) the proposed problems had just one answer. The test contains 35 open answers items (problematic situations) disposed in five factors: (1) deductive reasoning, (2) inductive reasoning, (3) practical reasoning, (4) decision making, (5) problem solving. The scoring goes from 0 to 2 and the mean answering time is 55 minutes.

Each of the instruments presented above in Table 12, (WGCTA, CCTT, HCTAES, TPCC, PENTRASAL) is representative for one of the main approaches we took into discussion in this article, also there are validated tests, available on the assessment market [35,33] and on the actual literature research [36,38,39].

5. CONCLUSION

CT is one of the main concepts related to the students' learning process and its applicability in real life situations. According to World Economic Forum Center [1], CT is one of the most demanding key skills of the twenty-first century. This paper focused on reviewing the CT studies from the '80 to nowadays, covering research from philosophy, psychology and education. During the study, the focus was on the chronological timeline of definitions, taxonomies, training programs and measurement of CT.

Firstly, we provide a comprehensive overview of the initial approaches of CT. As a starting point, we reviewed the implications of Gubbins' Matrix in inventorying the thinking skills based on empirical research [6]. We continued by presenting the insights on CT from three fields: 1) philosophy, 2) psychology, and 3) education. For each field, we presented the main taxonomies, chronological definitions and the development of CT as research stream. In addition, we provide an overview of a critical event in the development of CT as concept. The Delphi Research Project created a gathering event that connected experts from several fields for providing a consensual definition, a set of skills and dispositions of CT (Facione, 1990). Based on insights provided because of this event, we presented a complex operational framework that connects the approaches from the three investigated fields (Thomas & Lok, 2015). After we internalized all these information, we proposed a definition for CT.

By investigating the Gubbins's Matrix of Thinking Skills (GMTS) that synthesizes all the theoretical and practical knowledge about the domain of thinking (1985) and the Delphi Research Project [29] about the consensual definition skills of CT, we were able to highlight interconnected insights. Both agreed on *Inference* as one of the skills of CT. However, GMTS divided Inference in *inductive* and *deductive thinking*, while Delphi Research Project divided in into sub-skills such as *query evidence*, *conjecture alternatives* and *draw conclusions*. Moreover, *Evaluative Thinking Skills* from GMTS described as *evaluating arguments* is like the *assessing arguments* sub-skill of *Evaluation* from Delphi Research Project. Similarly, *Decision Making* skill from GMTS with *evaluating actions level* can be considered equivalent to *assessing claims* sub-skill of *Evaluation* skill from Delphi Research Project.

Further, we observed that CT is a studied concept in adjacent fields such as philosophy, psychology, or education. Even those domains are part of social sciences, the concept was addressed distinctly. Despite the interest of all three fields for CT, the discussions and approaches of CT differ. In philosophy, the CT insight consists on dispositions or personality aptitudes of an *ideal critical thinker*. Here, the definition of CT developed in a chronological order from reasonable and reflective thinking [10], followed by responsible and skillful thinking [11], purposeful judgment, self-directed and disciplined thinking, [12]; purposive and goal-

directed thinking [13], reflective judgment [14] and reflective skepticism skill [15].

We can conclude that the keyword used in the philosophical approach is *reflective*. In psychology, the CT insight consists on *skills and behavior of a critical thinker*. The definitions of CT started from mental processes [6] to cognitive skills [21] followed by disciplined mental activity [26] and skills such as problem solving, drawing conclusions and openness to new proves against own initial ideas [23]. Here, the main keywords are *skills* and *behavior*. Notable here is the base skill of a critical thinker, i.e., the openness and acceptance having wrong ideas. No other approach has considered those aspects regarding self-ideas that are important in everyday life. We consider that the educational field approached CT in the most applicable way with educational objectives and direct observations of CT. Here, CT is a *jointing between knowledge and skills*. The main interest of specialists from education, consisted of the application, transfer and use of CT in real life. The main keyword here is applied *knowledge*. Before ending the part of conceptualization, we found necessary to add our point of view and propose an overall definition that presents CT as an umbrella concept that gathered personality disposition and cognitive skills both applied to knowledge used in daily life. We found this definition integrative and facilitative for a better understanding of CT concept.

We also brought into discussion, following the same triadic approach (philosophical, psychological, and educational), the proposed programs for improving CT. We considered here all the programs starting from primary school to university level and added insights about the lifelong learning.

The last phase of the review involved discussions on measurement of CT. Differences were observed between measurement of CT in each of the three fields. In philosophy, the proposed tests had time limit and right or wrong responses [35,34]. In psychology, we observed a preference for open-ended questions without time limit [36]. Similar types of tests, open-ended and without time limit, were observed for the specific view on CT in education approach [38].

In conclusion, this study provides a conceptual overview of CT from the three main domains interested in this concept. This involves a comprehensive and chronological view on

definitions, skills structure, proposed taxonomies, developing programs and measurement instruments. This approach facilitated our process of proposing the following research: What are the following phases that could facilitate our approach and development of CT in education field? To respond to this question, we propose a further review with specific focus on teaching methods and strategies of developing CT. In this way, we will further the overall understanding of what is and what are the methods to develop CT.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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