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A CONCEPTUAL FRAMEWORK FOR CRITICAL THINKING-BASED IMPLEMENTATIONS¹

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Abstract

As definitions of thinking terms and their sub-components differ greatly, it is vital to border conceptual framework and set of definitions to be adopted within a scientific study in thinking fields. The present article aims to offer a conceptual framework for critical thinking-based implementations. The review article was carried out by two-stage content analysis. In the preliminary stage, Google, Google Scholar and Council of Higher Education Turkey National Thesis Center databases were scanned with “eleştirel düşünme” and “critical thinking” keywords. In the second stage, the review was deepened and extended. The results of the review indicated that critical thinking should be taught in all age groups both in course contents in an interdisciplinary way and as a separate thinking skills course; critical thinking studies should be comprehensive and longitudinal; they should target improving critical thinking directly. Such studies should also present activities and daily life examples of critical thinking directing learners to use principal terms of thinking to regulate their thinking processes. It is possible to make comparisons with previously known templates such as the taxonomy of learning objectives and the stages of scientific inquiry to support learners to understand critical thinking. It can be recommended that studies combine more than one higher order thinking skill such as critical thinking and creative thinking collectively as higher order thinking can be designed.

Keywords: critical thinking, higher order thinking, conceptual framework, biology education

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1. Introduction

Reflective thinking, problem-solving, creative thinking and critical thinking are commonly referred as Higher Order Thinking Skills (HOTS) (Tileston, 2005; Timucin, 2019). Critical thinking, creativity and problem-solving are mentioned by almost all of the eight prominent frameworks (Partnership for 21st-Century Skills (P21), EnGauge, Assessment and Teaching of 21st-Century Skills (ATCS), National Educational Technology Standards (NETS), Technological Literacy Framework for the 2012 National Assessment of Educational Progress (NAEP), 21st century skills and competencies for new millennium learners, Key competencies for lifelong learning, a European reference framework, ICT competency framework for teachers, a UNESCO initiative) for 21st-century competencies (Voogt and Roblin, 2012).

Thus, it can be said that members of the 21st-century society should possess HOTS (Dede, 2010; Paul, Binker, Jensen and Kreklau, 1990; Schleicher, 2008; Sector, 2004). Teachers of this society should master competencies on teaching and supporting HOTS (Ann, 2000; Facione, 1990; Paul and Elder, 2005; Thompson, 2011; Zepp, 2005). Critical thinking skills can help teachers meet demands in teaching like forming a habit of elaborately considering the pedagogical options and strategies (Low, Huive and Cai, 2017). Implementation of activities prepared by concerning critical thinking has the potential to affect student competencies. Studies in science and biology fields have shown that critical thinking-based educational innovations positively affected learners' critical thinking skills and dispositions (Arisoy, 2017; Collier, 2017; Hager, Sleet, Logan and Hooper, 2003; Long, Carlson, 2011; Yildirim, 2010) and course achievement (Timucin, 2019; Yoldas, 2009).

Since definitions are diverse in thinking-related fields (Ennis, 1992; Stein, Haynes and Unterstein, 2003), how the HOTS concepts and related assumptions are perceived has the potential to properly shape the settings, design and even results of the studies. Acceptable conceptualization of HOTS, which is hard to be precisely separated from each other, makes it possible to say what a particular higher order thinking skill is and what is not, which is equally important at times.

2. Purpose

The aim of the present study is to form a conceptual framework for critical thinking studies by defining terms and sub-components of critical thinking and highlighting potential key points of such studies. Along with this aim the following research inquiries were pursued:

- What are higher-order thinking skills?
- What is critical thinking?
- What are the subcomponents of critical thinking?
- What are the significant key points of designing critical thinking-based studies?

3. Method

The study is a review article. The literature is reviewed and the results are presented in a descriptive manner to bring critical points of the issue together from the point of view of the authors. The authors have been working in the field of critical thinking in biology education for fifteen years and prepared publications and a doctoral dissertation.

The target studies were determined and objected to content analysis in two stages. In the preliminary stage, Google, Google Scholar and Council of Higher Education Turkey (CoHE) Thesis Center databases were scanned with “eleştirel düşünme” and “critical thinking” keywords. 139 theses from the CoHE database (all hits with keywords: critical thinking existing in the database between the years 1999 and 2011) are summarized collectively on a single table, under the short summary, method, results and implications headings. Highly cited peer-reviewed journal articles, book chapters and symposium proceedings were reviewed by taking notes and quotations. As a result of this initial review, the basics of critical thinking and subtitles of interest were determined as; Higher Order Thinking, Basics of Critical Thinking, Teaching Critical Thinking, Critical Thinking Skills and Critical Thinking Dispositions.

In the second stage, along with the explained thematic base, the review was broadened and widened: with the queries taking the subtitles above as keywords on the same databases. Further reviews were conducted repeatedly on specific interest points such as; “critical thinking skills Bloom’s taxonomy” and “history of critical thinking”. The books were mainly reached to be reviewed at specific points, sections or chapters addressed by research articles. Additionally, with the aim of establishing the bridge between daily life / extracurricular activities and critical thinking some daily life media such as cartoons, serial movies and novels were also reviewed and referenced.

The notes and quotes taken during both lapses were thematically merged under the mentioned headings. This bulk text was reorganized, analyzed and paraphrased. Finally, the pieces of information referred to as relevant and eligible were presented under: Higher Order Thinking, Basics of Critical Thinking and Teaching Critical Thinking, Critical Thinking Skills and Critical Thinking Dispositions headings to assemble a conceptual framework. The study mostly combines the highlights of the literature descriptively from the perspective of the authors. Interpretations of the authors are predominantly detailed in the Conclusions, Discussion and Implications section.

4. Results

After reviewing more than two hundred resources based on the relevance to research questions, the results of the study were presented under the subsequent titles. The reviewed resources not referenced in relation to the present research questions directly provided insight directing and restricting the flow of the review.

4.1. Higher Order Thinking

Thinking, cognition and metacognition constitute fundamental concepts of higher order thinking (HOT). Thinking can be assumed as a cognitive act that facilitates long-term knowledge gained. Cognition is a comprehending ability having various sub-components to manage perception, learning, reasoning etc. Metacognition is, on the other hand, learners' consciousness of their own cognitive processes and sovereignty of controlling them (Presseisen, 1992: 3).

Lewis and Smith (1993) discussed higher order thinking (HOT) by comparing different types of thinking. They argued that HOT occurs when newly acquired knowledge is stored in memory and associated or rearranged and extended to reach a purpose or formulate acceptable answers (Lewis and Smith, 1993). Zohar and Dori (2003) cited a part of Resnick's (1987) definition with particular emphasis arguing HOT is non-algorithmic, complicated by nature, frequently causes multiple solutions, and requires the implementation of various criteria, uncertainty and autonomy.

Creative thinking, critical thinking, reflective thinking and problem-solving are referred to as HOT types in this paper (Tileston, 2005). Reflective thinking or reflection is thinking clearly and critically over what, how and why we do and directing our future thinking and behaviours accordingly. Although it sounds as if it is subjective, it requires to be done objectively. It has stages: experience, inquiry, thinking critically and planning future steps (Schon, 2017). Cimer and Cimer (2012) defined the teacher who questions her/his thoughts and tries to improve her/his implementations as the one who thinks reflectively.

Problem-solving is a complex process which involves using cognitive, affective and psychomotor skills collectively (Korkut, 2002). A problem is a probable daily-life case, attracting the attention of the solver due to being confusing, not having formulated solutions since it is faced for the first time and it can be solved by applying the related knowledge properly (Turnuklu and Yesildere, 2005). Although Mathematics has been the science branch most frequently dealing with problems and problem solving by nature, there have also been problem-solving studies in natural (Syafii and Yasin, 2013) and social sciences (Rubin and Krasnor, 2014; Korkut, 2002).

Major aspects of creative thinking are originality, innovation, realizing previously unrealized things, defining formerly undefined relations and daring differences (Yenilmez and Yolcu, 2007). Creative thinking has become one of the major skills in the present information society where algorithmic processes undertaken by artificial intelligence and solely individuals who can make creative syntheses are needed (Akgunduz et al., 2015).

Contrasting most commonly accepted HOTS; creative thinking and critical thinking can help concretise HOTS. Critical thinking is simply thinking over thinking with a cognitive discipline. A critical thinker intentionally focuses on three different dimensions of thinking; analyses the thought, evaluates it and improves her/his thinking accordingly. New and better thinking is the product of proper critical thinking (Paul and Elder, 2005). Critical thinking is linear, continuous, planned, realistic, analytical, target oriented, logical and objective. It is generally associated with the left-hemisphere tasks of the brain and the evaluation stage of Bloom's Taxonomy (Bloom, Englehart, Furst, Hill and Krathwohl, 1956). Creative thinking, on the other hand, is about replacing weak thoughts with stronger ones. It is assumed to be holistic, global, subjective and intuitional. It is mainly associated with the right-hemisphere tasks and synthesis stage of Bloom's Taxonomy (Bloom et al., 1956). Both critical and creative thinking are interdisciplinary, requiring experience and knowledge, asking proper questions and explaining them, distinguishing relevant and irrelevant facts and applying existing knowledge in newly encountered situations (Paul, 2005).

Thinking includes an intricate bunch of processes. As HOTS, it is also hard to isolate the components of thinking. Creativity or judiciousness of thinking (critical thinking) cannot really be sliced out from the overall thinking process. In the flow of daily life thinking they are compound (Paul and Elder, 2019). This suggests that referring to HOTS collectively can be another option in higher order thinking study fields.

4.2. Closer Look at Critical Thinking

Although critical thinking has been studied extensively for about seventy years, its roots date back to Ancient Greek. The etymological origin of the word is attributed to words "kriticos" (might of making correct decisions) and "kriterion" (criterion). Thus, it can be said that the concept means: the ability of making correct decisions based on certain criteria (Kaya, 1997). The word "critical" is commonly considered in a negative way as it is associated with the concepts "to criticize" or "to revile" in different cultures (Dolapci, 2009; Winn, 2004).

4.2.1. History

Throughout history, there have been mythic local heroes of wit in different cultures using at least one HOT: critical thinking. Till Eulenspiegel in German culture and Nasreddin Hodja in Turkish culture can be examples of such masters (Gulsen, 2012; Ozdemir, 2010). Long ago, as the sources of three monotheistic religions narrated, Prophet Abraham used critical reasoning in his parables (Ben-Ari, 2007; Kuzucular, 2016). Scientific resources, on the other hand, launch the critical thinking calendar with serial critical questions of Socrates (Socratic Questioning) in about 2500 B.C. and draw a course including the main characters contributing to critical thinking as Platon, Aristotle and Thomas Aquinas in medieval; Colet, Erasmus, Moore, Francis Bacon, Thomas Moore, and Descartes in Renaissance Europe; Machiavelli from Italian Renaissance; Hobbes, Robert Boyle and Isaac Newton from 16th to 18th century England; Bayle, Montesquieu, Voltaire and Diderot from French Enlightenment; and finally Adam Smith, Kant, Marx, Darwin, Freud and William Graham Sumner from modern age (The Foundation for Critical Thinking, n.d.).

4.2.2. Today

Day by day critical thinking has been getting into our daily life more intensively. Cartoons have been using the terms and concepts of critical thinking directly (Dinosaur Train Official, n.d.). Similarly, certain productions display the ways of regulating mental processes by presenting the stages of critical thinking such as; setting the problem situation, forming hypotheses and applying reasoning by using some critical thinking terms (TRT Cocuk (a) and (b), n.d.). Movies and serials frequently presenting the application of logic and thinking system terms such as; induction, hypothesis, reaching conclusions by eliminating the options etc. have been produced and followed by a large audience attentively (NBC, n.d; Warner Bros (a) and (b), n.d.). Most of these productions accept Arthur Conan Doyle, the creator of Sherlock Holmes as doyen and they make allusions to the novel (Doyle, 2007; Willingham, 2007).

4.2.3. Definition

De Bono (1995) likened critical thinking to the driving skills of an experienced driver, which implies that critical thinking properly directs the existing intelligence. No matter how good a car you have, if you do not know how to drive well, it is no use. Comparing the previous definitions, Kuhn (1999) noted that almost all critical thinking definitions seemed to have traces from the definition by Paul (1990): “the art of thinking about your thinking”. Willingham (2007) highlighted three distinctive key features of critical thinking as effectiveness, novelty, and self-direction. Good critical thinkers are innovative, analytical, communicative, insistent, sensitive, energetic, flexible, risk takers, knowledgeable, observers, intuitive, extra-ordinary, output-oriented, open-minded, flexible, and eager to improve and change (Ignatavicius, 2001).

Reviewing various critical thinking definitions made between 1986 and 1995, Huitt (1998) indicated that common weaknesses of many of the definitions were labelling all good thinking styles as critical thinking and degrading the significance of focusing on critical thinking and confusing dispositions towards critical thinking with thinking processes.

Similarly, a group of critical thinking resources explains the stages of the reasoning with the argumentation process, including setting up propositions as premises and conclusions and making an inference based on the relation between them. All the intentional or involuntary mistakes in the inferences of the argumentation process are called fallacies (Alatli, 2001; Bowell and Kemp, 2014).

Based on the related literature, we think, critical thinking can be defined as a feedback-looping cognitive process including an individual’s arranging own knowledge obtained by experiences to improve reliable reasoning capability; and therefore, systematically managing self-thinking process sensibly and intentionally; defining the relation among events correctly and ability to determine mismatched relations; -fallacies.

4.3. Teaching Critical Thinking

Kuhn (1999), who associated critical thinking education with an individual’s development, claimed that critical thinking is not directly improvable and defined certain cognitive processes increasing the probability of occurrence of critical thinking. Similarly, the mental actions that are named critical thinking are an extension of three types of thinking: reasoning, judgments/decisions and solving problems. Accordingly, judging to read a piece of writing is not critical thinking. However, evaluating the content and logical bonds presented to decide whether to believe the content of it is critical thinking (Willingham, 2007). The perception of the researchers with the view that critical thinking is not improvable can be explained by the “water arc” metaphor: metacognitive strategies are like water arcs and critical thinking is like the water flows in them. Having the best water arcs does not guarantee that you will have water in them, nor does the amount of water depend on the arcs (Kuhn, 1999; Willingham 2007). One can think more systematically by applying metacognitive strategies, which can be learned and improved, however, this does not mean that she/he will be able to think critically (Kuhn, 1999). On the other hand, metacognitive processes that can possibly support critical thinking are improvable for anyone and they must be distinguished from intelligence (Walsh and Paul 1988). Finally, critical thinking skills do not always depend on age (Lipman,

Sharp and Oscanyan, 1980); thus, they should be taught to all age groups. Critical thinking should be taught both as a separate course and embedded in the content of the other courses (Ennis 1989; Marzano 1992).

4.4. HOTS and Bloom's Taxonomy

By justifying or directly, several researchers have associated the upper three levels of Bloom's Taxonomy with HOTS (Bloom et al, 1956; Collier, 2017; Zohar and Dori, 2003). The revised version of the taxonomy was also included in the discussions (Krathwohl, 2002). Huitt (1998) argues that the evaluation stage, which can be accepted as the equivalent of critical thinking, focuses on making a conclusion based on certain expressions and propositions. The synthesis stage, which is supposed to be comparable to creative thinking, requires analysing the parts and relations and reproducing them in an authentic way (cited by Springer and Deutsch, 1998). However, the stages of the taxonomy are merely criteria for classifying the instructional purposes and attainments. Whereas HOTS such as critical and creative thinking are complicated processes including various behaviours, skills and dispositions that can be generalized to the whole daily life of an individual. Along with the same idea, Paul (1985) claimed that all activities in an educational environment require analysis, synthesis and evaluation and Bloom's Taxonomy (Bloom et al., 1956) is a unilateral hierarchy tormenting the complex structure of critical thinking. According to Paul (1985), applying Bloom's Taxonomy, which is quite useful in education fields, may have a restrictive effect while curricula supporting critical thinking are being developed. However, using certain templates such as Bloom's taxonomy and the stages of the scientific method to compare with critical thinking seems to be a need for groups newly learning about critical thinking to concretize the concept. In the same way, giving daily life examples for higher order, lower order, critical, creative, reflective thinking and problem-solving help learners comprehend critical thinking (Timucin, 2019).

4.5. Critical Thinking Skills

The review presented above has already indicated a variety of cognitive and affective sub-fragments of critical thinking over which there have been different points of view as well. Two of the most commonly applied critical thinking cognitive skill sets are suggested by Paul (1990) and Facione (1990).

Paul (1990) has referred to sub-components of critical thinking as 9 effective and 26 cognitive strategies. Paul (1990) explained that cognitive strategies were presented on macro and micro scales uniquely to provide insight into two levels of thinking. Micro-skills are the elementary critical thinking skills and macro-abilities are like the process of orchestrating those elementary skills. He explained the distinction of these skills by giving examples from some performance professions, sports and arts. A ballerina's practicing fundamental ballet movements at a practice bar, a surgeon's dissection and stitch practices on a cadaver or a tennis player's hitting the ball against the backboard provide them with the basic skills of the eventual performance. In that, they are like micro-skills. A critical learner should know the fundamentals of critical thinking such as; the meaning of assumption, implication, inference and conclusion, determining reasons, contradictions or vague sentences etc. On the other hand, a ballet performance, a surgical operation or a tennis match requires a combination of plenty of such skills. Using critical thinking in real-life cases is generally more complicated and it calls for the application of macro-level skills (Paul, 1990).

Based directly on critical thinking strategies by Paul (1990), Cimer, Timucin and Kokoc (2013) developed a survey (CTLOBICS) to determine the level of biology course environment fitting the critical thinking culture. The survey had 32 items and 5 factors (Affective CT Skills, General Thinking Skills, Basic CT Skills, Associating with Real Life, Reasoning Skills). Reed and Kromrey (2001) applied and experienced the whole framework by Paul in a history course.

The American Philosophy Association held a longitudinal project to state a multi-national expert agreement on critical thinking and related terms (Facione, 1990). 46 critical thinking experts took part in the six sessions of the study in 1988 and 1989. During the project, the volunteer experts debated and agreed on certain critical thinking issues by stating arguments and counter-arguments. The result of the study was called as Delphi Method. The method indicated certain key points about how to be a good critical thinker, how to instruct and assess critical thinking (Facione, 1990). The critical thinking cognitive skills determined (under the main titles: Interpretation Analysis, Evaluation, Inference, Explanation and Self-regulation) were adopted as a framework by various critical thinking studies (Paul, 2014).

Along with these widely accepted frameworks, a particular study may need to take a certain perspective or focus on certain sub-compartments of critical thinking. Alkin (2012), for example, developed the Critical Thinking Supportive Teacher Behaviors Inventory. The inventory consists of five dimensions: Open Mindedness (OM), Questioning of the Accuracy and Reliability of Information (QARI), Seeking Causes and Evidence (SCE), High-Level Questioning (HLQ), and Openness (O).

4.6. Critical Thinking Dispositions

Tendencies and dispositions towards critical thinking are also hard to differentiate from cognitive skills. Different methods may be needed to improve these separate sets of skills individually (Huitt, 1998). Critical

thinking dispositions were also framed by Paul (1990) and Facione (1990). Facione (1990) provided more detailed explanations whereas Paul (1990) used more general summarizations. Both lists underlined the faith, persistence and trust towards healthy reasoning, fair/open mindedness, understanding and analysing other people's thoughts and the background of these thoughts and insight into egocentricity or sociocentricity.

Ennis (1996) is another widely accepted source for defining critical thinking dispositions. According to Ennis (1996) critical thinkers are disposed to:

1. Care that their own beliefs are true and that their decisions are required to be justified (seeking and being open to alternative hypotheses, conclusions etc.; keeping a position justified by sound information; being well-informed; considering other people's perspectives seriously),
2. Present themselves in a clear and honest way (being clear, being focused on the conclusion, seeking and offering reasons, considering the total situation, being aware of own basic beliefs),
3. Concerning the dignity and worth of every person. (Discovering and listening, caring feelings and level of understanding, being concerned about others' welfare).

5. Conclusions, Discussion and Implications

Although critical thinking is a large area with plenty of brand-new details, this study is expected to form a map of critical thinking fundamental lines, especially for the ones who start thinking over critical thinking. We believe that the choice of definitions presented in this study can make a solid framework for HOT studies, particularly critical thinking studies. The paper combines studies in different languages and it is a portent to provide a different point of view on the issue.

Even the authors accepting critical thinking as an unimprovable trait, admit that applying strategies to support critical thinking is possible. Thus, it sounds like it is possible to devise studies developing and presenting critical thinking-based instructional innovations to improve students' certain aspects like critical thinking skills, dispositions and their course achievement level etc.

During critical thinking implementations, the definition, borders and sub-components of critical thinking should be clearly defined in the first place. In order to be able to reach valid results, defining what is not critical thinking is as crucial as defining critical thinking. The concept "critical" should be considered in its comprehensive frame without being narrowed to "revile". In critical thinking studies in education fields, all the elements such as assessment tools, activities, and plans should be developed one to one in accordance with the intended learning outcomes that critical thinking skills and dispositions of the adopted conceptual framework indicate (Timucin, 2019).

Concerning the fact that individual HOTS as critical or creative thinking operate coherently in real life and can be isolated only artificially, studies that aim to determine or evaluate HOTS collectively can be conducted. Separate HOTS can be discussed in further stages as sub-components or factors of assessment tools etc. (Wechsler et al., 2018).

Critical thinking should be taught at all levels within each course and as a separate thinking skills course (Ennis 1989; Marzano 1992). Successful critical thinking education or critical thinking-based instructions require to have certain characteristics. Only the curricula targeting to improve critical thinking skills directly can help students gain intended critical thinking outcomes (Tan, Koh, Lee, Ponnusamy and Tan, 2017). Another fundamental feature of critical thinking competencies is that the change does not happen instantly but appears over time (Kuhn, 1991; Tiruneh, De Cock and Elen, 2018; Zohar and Nemet, 2002). Therefore, critical thinking studies should consider these two points collectively and they should target critical thinking directly with consistent and long-term planning. The coverage of such studies should also be extended so as to consider more than a single lesson, to create a classroom culture or a school culture where applicable.

While critical thinking is presented to learners, it can be useful to use comparisons with templates such as Bloom's taxonomy and stages of the scientific method. However, it should be kept in mind that they are simplifications as it is made when photosynthesis or ATP synthesis is explained to secondary school students. Activities comparing real life examples of HOT and lower order thinking can also help learners understand types of thinking better and organize their own thinking (Timucin, 2019). The argumentation process, which has been presented as the core of critical thinking by various studies (Alatli, 2001; Bowell and Kemp, 2014), can be included in studies to facilitate learner comprehension of critical thinking. Similarly, setting arguments can be used as an instrument to help students regulate their thinking processes. There have been studies venturing argumentation-based instruction and activity types including critical thinking elements, higher and lower order thinking examples (Giri and Paily, 2020; Timucin, 2019; Zohar and Nemet, 2002).

Members of contemporary and future information society should be able to evaluate arguments multilaterally in terms of reason result relationships they include. Advancing critical thinking and other HOTS is not uniquely the responsibility of scientists and educators; the whole society should cope coherently (Paul *et al.*, 1990; Schleicher, 2008; Sector, 2004). So, artists, content producers of the internet, books, broadcasting and entertainment media of all kinds should reconsider their creations in terms of HOT, as well as stakeholders of education on school curricula and instruction. Parents and guardians should consider the issue in their acts, as well.

The components of the HOT started to be detailed in the 1990s and further studies mainly set up these frameworks. Hopefully, with the improvements in educational neuroscience and other science fields we will have much less controversial but empirical data about the components of thinking and how we use them for educational purposes.

Compliance with Research and Publication Ethics

The article is original and was not previously published. Through the research process, international and the journal's Ethical Principles and Publication Policies were followed. The citations were presented with proper references with respect to conventions. As the paper is a review article the approval of the ethics committee is not needed and not provided.

Contribution Rate of the Researchers

Both authors equally contributed to the whole research and documentation process.

Conflict of Interest Statement

Both authors declare that they have no conflicts of interest.

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