CONSIDERING SCIENCE TEACHERS’ CONCEPTIONS OF CRITICAL THINKING PEDAGOGY IN SEVERAL OF IRAN’S SPECIAL GIFTED SCHOOLS: A MULTI-PHASED STUDY

by

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Abstract

This research study examined Iranian science teachers’ conception(s) of critical thinking in gifted classrooms, in grades 7, 8, 9, and 10. Moreover, with the scope of a secondary science program, teachers’ instructional behavior in terms of critical thinking pedagogy were identified, observed, and assessed. The design was a multi-phased and mixed methods sequential design, including classroom observation (quantitative/qualitative); teachers’ survey questionnaire (quantitative); and in-depth interviews (qualitative). This research study took place in Iran during the 2012-2013 Winter Term 2.

Various dimensions of Iranian science teachers’ conceptualization of thinking critically were explored as well as the teachers’ perspectives of a careful and conscientious thinker. The context is four Iranian exclusive gifted schools seen through the lenses of a “4+1 classical elements” conceptual framework and a tension-based framework of inquiry. Despite the diversity of attitudes, applying the classical elements theory as a conceptual framework, this multi-phased mixed method study resulted in development of a pentagram of habits of mind. This study has the potential to contribute to gifted science programs and to frame recommendations for change, including historical approach to teaching science and simulating science history, problematizing public beliefs, real-life challenges in first-hand problem-oriented manner, inductive learning rather than deductive.
Preface

This dissertation is an original intellectual product of the author, Mehdi Ghahremani. The fieldwork reported in Chapters 3 to 5 was covered by UBC Ethics Certificate number H13-00072. As per UBC Okanagan Research Ethic Board guidelines, Dr. Philip Balcaen was designated as a Principal Investigator, and Mehdi Ghahremani was the UBO graduate students who completed this project for graduate requirements as per the UBC Master of Arts Program. Mehdi Ghahremani engaged in the data collection, in Iran, with thesis committee members’ guidance, consisting of:

- Dr. Philip Balcaen, UBC Associate Professor
- Dr. Carol Scarff, UBC Associate Professor
- Dr. Karen Ragoonaden, UBC Senior Instructor
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List of Symbols and Abbreviations

BREB: Behavioral Research Ethics Board

COS-R: The William and Mary Classroom Observation Scales – Revised

CT: Critical Thinking

TC2: The Critical Thinking Consortium

DMGT: The Differentiated Model of Gifted and Talented (Gagné’s model of giftedness)

IQ: Intelligence Quotient

MAKER: A framework of Methods, Awareness of students, Knowledge of the content, Ends for teaching, and Relationship with students

MI: Multiple Intelligence Theory

NODET: Iran’s National Organization for Development of Exceptional Talents

RLS: Renzulli Learning System

SAT: Scholastic Assessment Tests

SEM: Schoolwide Enrichment Model

SMPY: Mathematically Precocious Youth (A research at John Hopkins University)

WICS: Sternberg’s model of giftedness (Wisdom, Intelligence, Creativity, Synthesis)
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Dedication

This is dedicated to all science teachers in Iran’s National Organization for Development of Exceptional Talents (NODET), where I studied, worked, and grew up, and specifically to the founder of NODET, Dr. J. Ejei.

Dedicated to Dr. A. M. Ashtiani (احمد آقا), M. Naserzadeh (آقا ناصرى), Afshin Daneshnejad (دفتر سیسیل), and all my friends in the “Sicily Office” (حاج افشین)
Chapter 1: Introduction

1.1 Background

In the last two decades, one can see the widespread acceptance of the importance of teaching critical thinking as a 21st-century competency for all students from primary to graduate school (Bailin, 2002; Case, 2005; Ennis, 1993; Halpern, 2001; Lipman, 2003; Rotherham & Willingham, 2009; Scardamalia, Bransford, Kozma, & Quellmalz, 2012). As Scarff (2011) argues, curriculum without embedded critical thinking pedagogy poses a real threat of indoctrinating students.

Many educators believe that they have a good grasp of critical thinking, however, Paul, Elder and Bartell (1997) in their survey research of 140 college and university professors, found that although 89% of them asserted critical thinking (hereafter CT) as a main objective of their instruction, only 19% could clearly define critical thinking and explain where it appeared in their syllabus. In line with this study, Case (1992, 2005) concluded that students in regular classrooms are not being supported in developing good habits of thinking critically. One of the factors that perpetuate the problem is that despite widespread awareness of the importance of CT, different conceptual foundations and a lack of consensus on definition and instructional strategies cause problems in developing effective CT curriculum.

One of the main tensions is between philosophical and psychological understandings about CT. Philosophical approaches mainly highlight standards and qualities of thinking with regard to some criteria (Paul and Elder, 2006; Bailin, 2002). They inquire into the very nature of CT, that is, how does teaching look differently when CT is instilled within science lessons? Among other qualities, Lipman (1991) and Paul (1995) viewed a spirit of evaluation
and detailed analysis of fundamental ideas or beliefs as being at the heart of critical thinking. For example, Linn and Shore (2008) make the distinction between critical thinking and critical theory or critical pedagogy, and state that critical thinking is related to the evaluation of logical and empirical foundations of ideas. Moreover, they note that the origin of the word *criteria* is the Greek verb: *krinein* (*κρίνω*), which means “to separate, decide, and judge”. Thus, Linn and Shore add that a second component of thinking critically is the use of reason.

From a psychological perspective CT is taken up in other ways. For example, constructivism and multiple intelligences, as Fenstermacher & Soltis (2009) state, are two wholly separated notions, which are derived from cognitive psychology and attend to “how the mind processes experience” (p. 39). Cognitive constructivism assumes that children learn through actively constructing their own knowledge from their experience by making sense of it and connecting their experience to other information or mental frameworks that already exist, to build new cognitive structures (Boghossian, 2012; Fenstermacher & Soltis 2009; Lunenburg, 2011; Wang, Woo, & Zhao, 2009). For psychologists, thinking critically and cognitive constructivism are closely related, as CT is seen as having a key role in knowledge construction (Wang, Woo, & Zhao, 2009).

“Multiple Intelligences” is one of the theories that empower teachers’ capacity to become aware of their students’ differences as learners. Gardner initially (1983) in his work, *Frames of Mind*, proposed seven relatively independent intelligences: linguistic, logical-mathematical, spatial, musical, body-kinesthetic, interpersonal, and intrapersonal intelligence (Dai, 2010, Fenstermacher & Soltis, 2009). However, he later added naturalistic, spiritual, and existential intelligences as new candidates (Waterhouse, 2006; Gardner, 1998, 1999; as cited in Dai, 2010). Based on Renzulli’s (2005) description of Gardner’s MI theory, logical-
mathematical and intrapersonal intelligence are intelligences that related directly to thinking critically.

The tensions between these two approaches to understanding the role of CT in teaching and learning run throughout this thesis and are reviewed more thoroughly in the chapter two and implicated in the research and recommendations for future inquiry.

1.2 Giftedness and Critical Thinking
Gifted education provides the context for the study, where giftedness indicates an educational program for gifted children (Renzulli, 2005; Sternberg, et al., 2011) taking account of a commonality and affinity among the strategies and issues for high-ability students: Providing for a challenging curriculum, creative thinking, and critical thinking are common issues among scholars’ understandings of such gifted program (e.g., Callahan, C. M., & Hertberg-Davis H. L., 2013; Dai, 2010; Linn & Shore, 2008; Renzulli, 2005; Sternberg, Jarvin & Grigorenko, 2011; Renzulli & Reis, 2012; VanTassel-Baska, 2012). As the needs of gifted students are “complex and diverse”, having an appropriate gifted program is needed to satisfy these students’ demands and to achieve the outcomes of providing a good education (Gentry, 2009; Moon, 2009; Robinson, 2009; VanTassel-Baska, 2009).

Despite the consensus on the key role of critical thinking, as central to education in general and gifted education in particular, there is a lack of a general understanding about teaching CT in terms of effective pedagogical approaches (Bailin, et al., 1999; Case, 2005; Marin & Halpern, 2011). Although there are several pedagogical models offered to support teaching in general, and teaching critical thinking in regular classrooms, there is no well-defined program for gifted students in which gifted and talented students’ needs are specifically considered. This research finds that an identifiable approach to teaching critical thinking (CT) to gifted learners is nearly non-existent. For example, Linn and Shore (2008)
assert that “[r]ecent research in critical thinking … has not yet been applied to any great extent in the specific context of gifted education.” (p. 157)

Many factors seem to contribute to this problem. First, paralleling the problem of defining gifted education, there is no single definition of critical thinking. Lipman (2003) proposes that the word ‘critical’ is related to and a synonym for the term ‘criteria’. Therefore, to think critically is to think based on and in light of appropriate sets of criteria. Paul (1996) emphasizes Socratic questioning and accentuates that the critical mind is a questioning mind. Bailin (1987) highlights the mistaken view that creative and critical thinking are radically different; she asserts that this is a false dichotomy.

The second factor, that perpetuates the problem, is that people or particular groups hold informal/implicit theories that reflect their understanding of and experiences with gifted individuals (Miller, 2008, p.113). For example, among different groups of teachers there exists different implicit theories of giftedness coupled with varying perceptions of critical thinking creating a major limitation to developing efficacious learning programs for gifted students. Case (2005), based on their work with Canadian teachers in the TC$^2$, observes that in many classrooms the teaching of CT is broadly separated from the teaching the subject matter. He claims that, many teachers see CT divorced from curriculum and consequently address thinking skills only at the end of a term or a course. This separation problem and end of course strategy is also true for gifted students. The problems of defining and identifying an effective operational approach to teaching and embedding CT into the curriculum problem are shared within gifted education.

1.3 Gifted Education

The context of the research within the study is gifted education in Iran, making theories and tensions associated with gifted education important throughout the study as well. Dai (2010)
accentuated the deep changes in our understanding of key fundamental concepts such as intelligence, motivation, creativity, development, and context, which has been reinforced by advances in cognitive, affective, and developmental neurosciences. He compared and reconciled the traditional and emergent conceptions and approaches to gifted education by introducing a conceptual, analytical, and philosophical framework of consisting of three “essential tensions”:

- **Ontological** issues (how researchers conceptualize the concept of giftedness),
- **Epistemological** issues (how scholars identify and assess relevant subjects), and
- **Normative** issues (how educators should strive to develop exceptional competence).

With regard to the “gifted child versus talent development” tension, Dai (2010) and Renzulli (2005) discern four arguments as a rationale for gifted education that inform the conclusions of the study:

- **The cure for cancer** argument. This argument considers the future role of gifted children in improving human condition and solving urgent problems facing our world, as a reason for gifted education. In this “instrumental” view, gifted individuals are our “natural resources.”
- **The enhancing-social-capital** argument. This argument emphasizes the future leadership and integrity character.
- **The personal fulfillment** argument. Self-actualization and personal satisfactory are the main concerns in this argument.
- **The unique-needs** argument. From categorical approach view, unique educational needs are the main reason for gifted education. (Dai, 2010, pp. 159-161; Renzulli, 2005, p. 249)
From the “expertise versus creative” perspective, like Renzulli (2005), Dai (2010) states that most gifted programs are more focused on “expertise” (i.e. mastery of knowledge, academic lesson-learning abilities; proficiency), rather than “creativity” (i.e. thinking skills, problem-solving, exploring the unknown; innovation). Both categories are considered long-term objectives of gifted education. However, as Dai points out, many cognitive psychologists believe that procedures leading to creativity are not different from paths leading to expertise. Creative works involve knowledge mastery, as well as thought processes. Dai proposes interactive parameters upon which the developmental paths of creativity and expertise depend, namely, person’s characteristics, domain (content), and educational processes that are used in pedagogy and curriculum.

1.4 The Research Question
VanTassel-Baska (2012) asserts that, teachers’ instructional approaches in the classroom tremendously effect students’ learning level. This suggests that knowing teachers’ understanding of instructional strategies for promoting good thinking habits may play key roles in designing critical thinking pedagogy for gifted and talented individuals. Furthermore, “gifted and talented teacher behaviors are not systematically monitored” (VanTassel-Baska, 2012, p.43). Based on my understanding of teachers’ key roles affecting the degree that students learn subject matter, as well as developing CT skills and habits, I address the following question as the focus of this study:

*What are the characteristics of science teachers’ conceptions of CT in Iranian gifted schools? To what extent do science teachers in the Iranian gifted schools consider critical thinking in their programs and instruction, as viewed through the lens of TC²’s four-pronged conceptual framework?*
The research described in this thesis attempts to close a gap between theory and practice, providing suggestions for better embedding critical thinking pedagogy into gifted science education.

1.5 Context of the Study
The National Iranian School System operates under the jurisdiction of the Ministry of Education of Iran. The structure of the educational system is divided into the four cycles: pre-elementary school, elementary school, middle school, and high school. The one-year pre-elementary program is considered for five year old children, in which they are prepared to enter a five-year free and compulsory primary cycle (grade 1-5) where they receive general education to promote general reading and writing abilities.

The middle (or guidance) school three-year cycle (grade 6-8) provides students with opportunities to experience a variety of areas and familiarization with different bodies of knowledge such as astronomy, creative writing, biology, and arts. This cycle assists students in deciding and choosing the “branch”, in which they will pursue their study in the high school step. The four-year cycle (grade 9-12) is categorized into three main branches: (a) Academic (humanities, mathematics-physics, and experimental sciences), (b) fine arts, and (c) technical/vocational, which is particularly designed to train technicians for the labor market. Grade nine students choose their educational branch by the end of the first year of this cycle. This is a free choice.

Except for pre-elementary schools, students are required to take nation-wide exams at the end of each cycle. Those who pass these exams are qualified to proceed to the next cycle. Since the Iranian Islamic revolution in 1979, schools are mandated to be single gender. However, recently, some private schools which do not operate under the Ministry’s jurisdiction are implementing coeducational systems. The Ministry of Education defines four
kinds of school systems: public schools, private schools, schools for students with disabilities (intellectual disabilities, deaf, blind, physical disabilities, learning disabilities, mental illness, and multiple disabilities/needs), and gifted schools (approximately 3% of Iranian students are studying in these exclusive schools).

1.5.1 History and admission policy

“Houshmand”1 elementary school was the first Iranian gifted school and was established in 1967 in Tehran — a private school with only 14 students. In 1969, the Department of Children and Exceptional Students (under the jurisdiction of the Ministry of Education and Training) established the first public national school for gifted and talented children that was designated to train educated and skilled cabinet and dignitaries for the crown prince, under the Queen’s superintendence. In 1976, the Department of Children and Exceptional Students became an Organization for Development of Exceptional Talents under the jurisdiction of the Board of which Queen Farah was the head (Karami, 2013).

After Iran’s Revolution in 1979, the Organization for Development of Exceptional Talents was cancelled until 1987. In 1987, with the request of Vice-Prime Minister, Dr. J. Ejei, the “National Organization for Development of Exceptional Talents” (NODET, in short) was established. Since then, NODET developed and increased its schools and established schools in other cities. However, NODET does not involve pre-elementary and elementary schools. It is responsible for Iranian gifted middle and high schools. In terms of identification, every year, NODET holds two country-wide exams to identify pupils qualified to begin studying in grade six and grade nine in NODET’s middle and high schools.

Every student with a minimum GPA of 19 (out of 20) is eligible to take the exam. Both middle schools’ and high schools’ entrance exams have three stages: two paper-and-

1 /huːʃmænd/, which means intellect in Persian
pencil multiple-choice tests and an interview. A combination of intelligence, creativity, science (biology, chemistry, astronomy, and physics), and math are addressed in the multiple-choice tests. Approximately three percent of participating students are identified and designated separately for boys and girls at different schools (Karami, 2013). In terms of educational branches, gifted high schools only offer “academic” branches: mathematics-physics and experimental sciences.

The study is situated in four schools (two middle and two high schools) enrolling a total of 1085 boys and 924 girls.

1.6 Overview
In the following chapters the theoretical frameworks of CT found in the literature are reviewed, along with the historical background and conceptual frameworks of giftedness and gifted education, and the tensions within the different conceptualizations of thinking critically in Chapter Two. In Chapter Three I offer details of the context of the study, rationale for and description of the mixed methods research methodology, and details of research methods including:

- Classroom observation (quantitative/qualitative)
- Teachers’ survey questionnaire (quantitative)
- In-depth interviews (qualitative)

The design is a multi-phased and mixed methods sequential design (Creswell, 2012). Iran was chosen as the general location for my study as I am interested in informing educational change there. I chose Iran’s gifted schools as the specific site of my inquiry because this location is a familiar context based on my being a student in one of Iran’s gifted schools and having taught physics in one of these schools for 14 years.
This research focuses on characteristics of science teachers in four Iranian exclusive
gifted schools and examines the relationship(s) among variables, without testing statistical
(null) hypotheses. The study is a non-experimental design where mixed methods are used to
provide a better understanding of the science teachers’ conception(s) of critical thinking with
regard to their instructional behavior and their practical strategies. The application for ethical
approval was submitted to the RISE for “Human Ethics” in January 14, 2013. The Approval
was issued on behalf of the Behavioral Research Ethics Board (BREB) Okanagan, in
February 12, 2013 (ID: H13-00072; see Appendix A), as a “Minimal Risk” study.

1.6.1 The emergent lens used to interpret data
In Chapter Four I consider the data through both the emergent lens of a “4+1 classical
elements” conceptual framework and my tension-based inquiry framework. I examine the
dimensions of Iranian science teachers’ conceptions of thinking critically through my
empirical inquiry where I assess (N=27) Iranian science teachers’ instructional behavior in
terms of CT pedagogy. I examine (N=37) Iranian science teachers’ conception(s) of CT and
teaching critical thinking in grades 7, 8, 9, and 10 gifted classrooms, with regard to CT’s
related tensions. I also inquire into the relationship(s) between science teachers’ demographic
information, (such as gender, number of years of experience in Iranian gifted schools, their
educational background), and their quality of CT pedagogy.

Finally in Chapter Five, based on my findings and taking account of the emergent
pentagram of five elements of science teachers’ conception of thinking critically and my
reading of the literature, I offer several recommendations as possible improvements to
addressing how science educators might better address embedding CT pedagogy into their gifted education science teaching.
Chapter 2: Review of the Literature

In this chapter theoretical frameworks of CT development, historical background and conceptual frameworks of giftedness and gifted education, and tensions within the different conceptualizations of thinking critically will be presented. Moreover, tracing changes in different conceptualizations, connections between these two contested concepts, giftedness and critical thinking will be explored.

With regard to teaching approaches, using the MAKER framework (Methods, Awareness of students, Knowledge of the content, Ends for teaching, and Relationship with students), Fenstermacher and Soltis (2009) conceptualized approaches to the curriculum process and teaching in three models: the executive approach, the facilitator approach, and the liberationist approach. According to Fenstermacher and Soltis, critical thinking belongs to the liberationist way of instructing which is rooted in notions of liberal education, “wherein the goal is to liberate the mind to wonder, to know and understand, to imagine and create, using the full intellectual inheritance of civilized life” (p. 44). In general, the primary idea central to this approach is the notion of manner, which accentuates certain habits and disposition, as the way individuals’ “entire personality is made manifested in various contexts,” (p. 48) and focuses on characteristics such as fair-minded, witty, and being skeptical about claims.

2.1 Theoretical Frameworks of Critical Thinking Development

Based on my review of the literature in the field of critical thinking, this venerable contested concept is rooted academically and primarily in two streams and two different disciplines: philosophy and psychology. These two disciplines have contributed to many scholars’ understanding of thinking in general and critical thinking in particular (Lewis & Smith, 1993;
Paul, Elder, & Bartell, 1997; Yanchar, Slife, & Warne, 2008). The philosophical approach is more normative. In contrast, the psychological perspective is more descriptive. “Normative considerations have to do with what should or ought to be the case, rather than with what is believed to be the case”, in descriptive considerations (Fenstermacher & Soltis, 2009, p.32). According to Fenstermacher & Soltis (2009), normative considerations connected to the values, ideals and aims.

In addition to these two academic areas, there is a third wave within the field of education that focuses on a pedagogical perspective on thinking critically as a set of teachable behaviors (Atkinson, 1997; Sternberg, 1986). Below I review these three strands (philosophy, psychology, and education), with respect to their definitions, priorities and the different approaches are explored below.

2.1.1 Philosophical Perspective
Paul, Elder, and Bartell (1997) argued about CT’s philosophical rootedness in Socrates’ questioning method (Socratic Method):

   The intellectual roots of critical thinking are as ancient as its etymology, traceable, ultimately, to the teaching practice and vision of Socrates 2500 years ago who discovered by a method of probing questioning that people could not rationally justify their confident claims to knowledge. (p. 8)

Today, this practical conception is known as “Socratic Questioning” and as Paul and colleagues (1997) claim, this method is one of the best-known CT strategies. In addition to ancient classical philosophers (Socrates, Plato, and Aristotle) in more recent time, Robert Ennis, Matthew Lipman, Harvey Siegel, and Richard Paul provide an enlightenment-like philosophical approach to CT.
Based on philosophy’s dominant paradigm and theory of logic, philosophical approach focuses on argumentation, reasoning, and assessing logical structures of statements, in a relatively narrow and technical fashion. Paul (1997) characterized some of this approach’s characterization as:

- Developing theories of fallacies in thought
- Developing theories of informal logic
- Critique of formal logic
- Designing individual courses in CT

Therefore, based on Paul’s (1997) delineation, this individual-centered philosophical view focuses on characteristics of a hypothetical ideal person who performs high-quality critical thinking. Consequently, this theoretically broad idea involves ambitious use of terms, addresses the general lack of criteria to meet real-life problems and considers general, universal CT skills for all disciplines and domains.

For instance, in 1989 the American Philosophical Association’s Committee on Pre-College Philosophy, finally achieved a consensus on a definition of CT:

We understand critical thinking to be purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based. (Facione, 2011, p. 25)

The committee conceptualized CT as an inquiry tool, as an educational liberating force, individuals’ influential resource for personal and social life, and self-rectifying human phenomenon (Facione, 2011). In describing “the ideal thinker: the American Philosophical Association asserted that:
The ideal critical thinker is habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, be clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit. (p. 25)

Along with this definition, I want to emphasize Mogensen’s (1997) philosophical view and his four ‘perspectives’ of critical thought which emphasized intellectual traits or virtue-centered view. He argues that CT can be seen from four perspectives: an epistemological, a transformative, a dialectical, and a holistic perspective (p. 432). Mogensen defines these four perspectives as follow:

First, the epistemological perspective implies that “qualified thought has a form so that we can speak of critical thinking as involving a skill dimension or a definite mode of performing thought activity.” (p. 433) Epistemological perspective concerns “identifying factual as well as normative aspects of a problem”, “explaining and understanding these aspects in a historical and structural context”, and “assessing them with the aim of developing visions of possible action strategies, as appropriate.” (p. 433) This perspective emphasize on questioning in the "Socratic Questioning" manner. Epistemological perspective connected to understanding through “actively examining and questioning the world.”

Mogensen (1997) indicates that pupils, themselves, seek out and talk to those involved in a subject matter’s issues and listen to their arguments. He concluded that “through their actions the pupil can become wise to the mechanisms, phenomena, and barriers” that are connected with subject. Therefore, Mogensen’s epistemological perspective of critical thinking can shift
teaching approach from teacher-centered to learner-centered. Finally, this method has a positive and profound influence on “confidence in personal and communal action.” (p. 433)

Second, the **transformative perspective** is the central perspective in thinking critically. This characteristic points to the big picture of ‘transformation position’. As Miller (1990) presented, the tree major positions in the curriculum process are transmission, transaction, and transformation positions, “which helps one to perceive the linkage between curriculum practices and the philosophical, psychological, and social contexts that shape them.” (p. 5) Miller posed transformation position in this way:

It encompasses three specific orientation: teaching students skill that promote personal and social transformation (humanistic and social change orientations); a vision of social change as movement toward harmony with environment rather than as an effort to exert control over it, …in which the ecological system is viewed with respect and reverence (transpersonal orientation). The paradigm for the transformation position is an ecologically interdependent conception of nature that emphasizes the interrelatedness of phenomena. (p. 8)

The transformative perspective points to ‘inner’ dimensions of pupils, such as attitudes and values. Historically it is linked to the romantic educators’ notion that “education should allow the inner nature of the child to unfold with minimum interference” (Miller, 1990, p. 8). In this way, the transformation position transforms the relationship between curriculum and student: the curriculum and the student are seen to ‘interpenetrate’ each other.

Third, the **dialectical perspective** is a crucial characteristic of critical thinking. Mogensen’s (1997) dialectical perspective underlines two aspects of critical thinking. The first is ‘contextualization of information’, which means “critical thinking obliged the
individual to look at the case from several points of view, to listen to other people’s understandings, and treat them responsibly and fairly” (p. 434). The second aspect refers to dynamically and continuously challenging, querying, and criticizing. To maintain responsibly dialectic perspective, the critical thinker should have certain predispositions and ‘virtues’. In Mogensen argument, dialectical characteristic of critical thinking can develop qualities such as the following:

- The courage not to passively accept everything, but to actively participate in discussions and debates, i.e. a willingness to get involved.
- An ability to emphasize, to appreciate other people’s way of thinking and their ideas, as well as an ability to decentre one’s own views and see beyond one’s own narrow sphere of interests.
- The will to apply consistent criteria of assessment to oneself and others.
- An awareness of the limits of one’s own knowledge.
- The belief that arguing for a case can have positive effects.
- The will to persist despite great barriers and frustrations. (p. 434)

These virtues look like some “competency standards” for students to think critically in the Paul’s & Elder’s (2006) work.

Forth, the holistic perspective insists that thinking critically involves both feelings and reason. Mogensen (1997) poses that, thinking critically is “human rather than mechanical. Thus, critical thinking involves the integration of reason and feelings, a unity of cognition and emotion. These two human constituents of consciousness develop and support each other reciprocally. ” (p. 434) Mogensen’s holistic perspective of critical thinking was disregarded in the most cognitive-centered viewpoints. Person who disregards his/her
emotions is in danger of becoming “insipid, purely registering, external stimuli, bored and incapable of distinguishing between the significant and the insignificant” (p. 435).

Despite the lack of consensus over the years, five philosopher’s definitions have served as reference points for many (Daniel & Auriac, 2009): Robert Ennis, John McPeck, Matthew Lipman, Harvey Siegel, and Richard Paul. Below I consider Lipman’s conceptions of critical thinking as one of the key authorities in the philosophical field as a means of unpacking key understandings about this important concept.

2.1.1.1 Lipman: “skillful responsible thinking”

Lipman (1976) advanced the Philosophy for Children (P4C) approach to developing critical thinking in children through philosophical stories and dialogues (Daniel & Auriac, 2009). The basic assumption underlying P4C’s approach is that the use of understandable terms to state philosophical issues, rather than “the formal jargon of the professional philosophers”, results in children’s intrinsic interests in CT (Lewis & Smith, 1993). From a pragmatic point of view, Lipman (2003) emphasized that the meaning of an idea is to be found in the applicable consequences. He asserted that the outcome of thinking critically is judgment.

Lipman (1988) defined CT as “skillful responsible thinking that facilitates good judgment because it 1) relies upon criteria, 2) is self-correcting, and 3) is sensitive to context” (p. 39). In line with McPeck (1990), sensitivity to context in his definition implies domain-specificity in thinking critically. According to Lipman (1988), the word ‘critical’ is related to and a synonym for the term ‘criteria’. Therefore, to think critically is to think based on and in light of an appropriate set of criteria. Accordingly, he defined uncritical thinking as “flabby, amorphous, arbitrary, specious, haphazard, and unstructured” (Lipman, 2003, p. 212). Moreover, in his view use of warranted criteria provide a basis for comparisons.
Based on Lipman’s (2003) conception, the outcomes of critical thinking are judgments. He suggests that the present concern for critical thinking is rooted in and related to the ancient concern for wisdom, which is conceived to be ‘good’ judgment (pp. 209-210). However, in contrast to this traditional ‘technical’ manner of thinking, and under the influence of Vygotskian theory, he believes that the development of CT occurs in the individuals’ interactions with a community of peers, through verbal exchanges and philosophical dialogues to improve personal and social experiences (Daniel & Auriac, 2009). As Daniel and Auriac (2009) propose, the influence of Socrates, Dewey, and Vygotsky are at the root of Lipman’s perception of CT. In this view, Lipman introduced the notion of a “community of inquiry” approach as a social activity for schooling and instruction (Garrison, Anderson, & Archer, 2010). The approach highlights the effectiveness of a groups’ use of inquiry-based strategies in educational areas and the conversion of routine classrooms into communities of inquiry in which “students can generate and exchange ideas, clarify concepts, develop hypotheses, weigh possible consequences, and in general deliberate reasonably together” (Lipman, 2003, pp. 105-106). His model of CT does not separate the emotional from rational, that resonates with Gardner’s intrapersonal and interpersonal intelligences (Moseley D., et al., 2005).

Although Lipman’s (1988) conception address and accentuates several important characteristics of CT and issues such as judicious judgment, criteria, self-correction, sensitivity to context and the community of inquiry approach, his definition lacks clarity with regard to the term “responsible”. It is not clear to whom or what makes thinking critically responsible. Is it responsible to criteria, or society, or an individual’s own priorities? Besides, for Lipman issues such as reasoning and concept formation are involved
in all kinds of thinking, but he does not explore relationships between these issues in any
detail (Moseley D., et al., 2005). Furthermore, his perception does not involve essential
dispositions and/or habits of critical thoughts such as fair-minded, independent- and open-
-minded referred to as key aspects of CT by others (Case, 2005; Facione, 1990; Halpern,
1998).

2.1.1.2 Other definitions from philosophical perspective

Definitions that emerge from philosophical traditions include (as cited in Lai, 2011):

- “the propensity and skill to engage in an activity with reflective skepticism” (McPeck,
  1981, p. 8);
- “reflective and reasonable thinking that is focused on deciding what to believe or do”
  (Ennis, 1985, p. 45);
- “disciplined, self-directed thinking that exemplifies the perfections of thinking
  appropriate to a particular mode or domain of thought” (Paul, 1992, p. 9);
- “thinking aimed at forming a judgment,” where the thinking itself meets standards of
  adequacy and accuracy (Bailin et al., 1999b, p. 287); and
- “judging in a reflective way what to do or what to believe” (Facione, 2000, p. 61).

These definitions inform “CT’s areas for consensus” as discussed at the end of this chapter.

2.1.2 The Psychological Perspective

The philosophical approach is more normative in contrast to the psychological perspective
that is more descriptive. Whereas the philosophical normative perspective has developed
through discourse, rationality and logical argumentation, the psychological descriptive
approach has been elaborated and developed from within a research paradigm (Lewis &
Smith, 1993). The contributions of these two disciplines to what the psychologists call higher
order thinking are very different. Whereas the philosophical approach that links CT to “methodical doubt” (a skeptical way of exploring for certainty by systematically classifying and doubting everything) the psychological perspectives emphasize cognitive skills and problem-solving strategies within the actual mental process (Daniel & Auriac, 2009, Sternberg, 1986).

This second “wave”, as Paul (1997) refers to it, attempted to integrate critical thinking into instructional design. Particularly, the cognitive psychological perspective has focused on the experts’ manner of ‘thinking’ skills and ‘intelligence’. Exploring the relationships between thinking critically and emotion, media, problem-solving, cognitive psychology, and creative thinking are some of the concerns of this cognitive science strand (Paul, 1997). Paul claims that this second wave often lacks a philosophical foundation, clear instructional connections to the subject matter and involves an intellectual assessment of thinking. This approach offers several ‘practical’ suggestions which do not provide a coherent pedagogy for critical thinking and has resulted in disjointed, sometimes superficial, usually incompatible, and in some cases, arbitrary ideas (Paul, 1997). Paul refers to these superficial notions as the phenomena of ‘pseudo-critical thinking’ movement.

While philosophical schools of thought are fundamentally focused on logical reasoning and characterization of an “ideal” critical thinker, cognitive psychology is more concerned with individuals’ thinking procedure to make sense out of their experiences through meaning construction (Lewis & Smith, 1993). For example, Linn and Shore (2008) describe Stanovich’s (2004; as cited in Linn, & Shore, 2008) categorization of two separate minds supporting thinking procedures: “System 1” thinking or The Autonomous Set of Systems (TASS), which is “a set of systems that operate in an associative, parallel,
automatic, often modular way” (p. 156). It is what popularly is thought of as intuitive, holistic, spontaneous, and reflexive thinking. In contrast, “System 2” thinking, or Rational, or analytic thinking is characterized as a “rule-based, conscious, relatively slow, serial, resource-intensive, controlled and decontextualized” (pp. 155-156). System 2 then involves evaluation of evidence and arguments, choosing a course of action, evaluation of goals, and evaluating the evaluation. In cognitive psychology such rational thinking and critical thinking are used interchangeably (Linn and Shore, 2008).

A psychological approach is more descriptive and more interested in how human beings create and maintain their beliefs as a psychic phenomena (Halpern, 1998), rather than focusing on “deciding what to believe or do” (Ennis, 1993, p. 180).

In general, cognitive psychology’s conceptualization is a skill-based approach to thinking critically. Based on this cognitive skills-based approach, it is common to introduce lists and taxonomies of skills to categorize CT strategies. Probably the origin of this idea inception was Bloom’s (1956) taxonomy of educational objectives in which he classified learning objectives into three domains one of which is “higher order thinking.

Below I review Sternberg’s and Halpern’s conceptions of critical thinking as a means of illustrating key ideas in the psychological approach.

2.1.2.1 Sternberg: “analytical intelligence”
Cognitive psychologists primarily attend to how people actually think, rather than how they should or could think (Sternberg, 1986). This conception of critical thinking puts emphasis on skills and dispositions, as well as the transferability of CT skills (Halpern, 1998, 2001; Marin & Halpern, 2011). As Halpern (2007) states, Sternberg (1996) in his “tripartite model
of the thinking skills” proposed three categories of skills responsible for “successful intelligence”: critical thinking, creative thinking, and practical thinking.

For Sternberg, CT is different from creative thinking and involves analyzing, critiquing, judging, evaluating, comparing and contrasting (Klein, 2011). He summarized these components as “analytical thinking” and conceptualized CT as an analytical intelligence (Sternberg, Jarvin, & Grigorenko, 2010). From a problem-solving approach, Sternberg and colleagues (2010) noted that such an analytical intelligence focuses on evaluating the quality of ideas, as well as “skills and attitudes needed to recall and recognize but also to analyze, evaluate, and judge information” (p. 43).

Sternberg (1996) categorized thinking processes into three discrete thinking skill functions: creative thinking in generating ideas, critical thinking in evaluating these ideas, practical thinking in implementing the ideas, and wisdom to ensure that the decisions are used for a common good (Sternberg, Jarvin, & Grigorenko, 2010). He exemplifies a psychological model of thought, which views thinking as separate steps, strategies, or skills. Bailin (2002) criticizes this model as a problematic misconception that characterizes CT in terms of separate mental processes or cognitive skills. She argues, “a justifiable conception of critical thinking must be explicitly normative, focusing on the adherence to criteria and standards” (Bailin, 2002, p. 368).

2.1.2.2 Halpern: “cognitive skills or strategies”

A cognitive-skills approach usually addresses CT as “higher-order” and trans-contextual thinking abilities. Halpern (1998, 2007) defines “the term critical thinking as use of those cognitive skills or strategies that increase the probability of a desirable outcome”. He characterized CT as “purposeful, reasoned, and goal directed – the kind of thinking involved
in solving problems formulating inferences, calculating likelihoods, and making decisions,”
by using thoughtful and effective “higher order cognitive skills” (Halpern, 1998, p. 450;
Halpern, 2007, p. 6). To enhance CT, Halpern (1998) introduced a four-part model that
consists of:

(a) a dispositional or attitudinal component that consisted of modeling critical
thinking and actively encouraging thoughtful responding; (b) instruction in and
practice with critical thinking skills; (c) structure training activities designed to
facilitate transfer across contexts, which was accomplished by deliberately noting
how specific thinking skills apply with very different topics; and (d) a metacognitive
component, which included having students discuss the process of thinking. (p. 4)

Some of the psychological perspective’s primary concerns are reflected in Halpern’s (1998,
2007) four-part model: (1) emphasis on thinker attitudes to use of CT skills, (2) emphasis on
skills and their improvement in training activities, (3) emphasis on the procedure of thinking
suggested similarly a problematic 10-category taxonomy of CT skills.

To sum up, the two notions of Halpern’s conception of CT are problematic ideas in
the CT field. First, his ideas are based on the assumption that, “there are clearly identifiable
and definable critical thinking skills”, leading him to argue that CT can be taught and applied
explicitly in educational system (Klein, 2011). Second, his taxonomy of CT skills involves
some different groups of skills from philosophical view such as implicating the “The
Relationship between Thought and Language”, “Likelihood and Uncertainty”, and “Creative
Thinking” as aspects of CT (Halpern, 2007).
2.1.3 Pedagogical Perspective

Despite the consensus on the key role of critical thinking as a central goal to education (Bailin, 2002; Case, 2005; Ennis, 1993; Halpern, 2001; Lipman, 2003; Rotherham & Willingham, 2009; Scardamalia, et al., 2012), there is a lack of agreement about teaching CT in terms of pedagogical approaches and instructional strategies (Bailin, et al., 1999; Case, 2005; Marin & Halpern, 2011). A pedagogical perspective attempts to provide a practical instructional framework to facilitate teaching critical thinking to students.

The third pedagogical approach emerged recently from an examination and recognition of the strengths and weaknesses of the first two approaches. Paul asserts that the field of teaching and learning needs a comprehensive integrated framework of its own for teaching critical thinking with a clear set of intellectual domain-specific and context-specific standards, which has enough “space” for emotion, intuition, imagination, and values in thinking. Moreover, he posits a rigorous and comprehensive theory of developing effective assessment tools and identifying pseudo-critical thinking models of this third wave’s characteristics.

2.1.3.1 TC²'s Conception of CT


The TC² conception disputes the perception that critical thinking consists of a generic set of skills or processes, which are separate from content and context. Moreover, as Case (2005), the executive director asserted, TC² believes addressing CT as an add-on to the regular instruction is not an effective method; rather he espouses an embedded approach to teaching CT. To promote thinking critically in students, TC² propose a four-pronged framework (Balcaen, 2008; Bailin, Case, Coombs & Daniels, 1999; Case, 2005; Case & Daniels, 2002) involving:

- Providing critical challenges within the curriculum as invitations to CT. This prong focuses on providing students with problematic situations as opportunities to think critically, nurturing a thinking classroom environment, supporting thinking classroom environment by providing students with ongoing opportunities to engage them in cooperative dialogues, and modeling ‘good’ thinking.
- Developing the intellectual resources to nurture high-quality CT. This prong focuses on teaching five types of intellectual tools supporting critical thinking.
- Evaluating and assessing tools and students’ overhaul competence. This prong focuses on summative assessment of five types of the tools of thinking to see how students exhibit quality thinking.
- Building a community of thinkers within the classroom/school. This prong focuses on infusing critical challenges throughout the subject matter, where criteria for judgment are required.
TC² states that “critical thinking involves thinking through problematic situations about what to believe or how to act where the thinker makes reasoned judgment that embodies the qualities of a competent thinker” (Case & Daniels, 2002, p.1). As high-quality CT plays a central role in TC²’s conceptualization, they introduce five types of intellectual tools and resources to help students become habituated to thinking critically: (1) background knowledge, (2) criteria for judgment, (3) critical thinking vocabulary, (4) thinking strategies, and (5) habits of mind (Balcaen, 2008; Case, 2005; Bailin, Case, Coombs & Daniels, 1999). As mentioned earlier, each of TC²’s intellectual tools is the main concern and priority in different schools of thought (Case, 2005). TC² consolidates multiple conceptualizations in the history of critical thought and their four pronged approach is used to frame the research design outlined in Chapter Three.

2.2 Giftedness and Gifted Education
The “Gifted” student population is one of the key groups that require opportunities to acquire and develop CT skills and habits of mind (Linn & Shore, 2008). Like others, it is my position that, in our rapidly changing globalized world, those nations not aware of their gifted students and gifted education are taking the serious risk of falling behind other countries (Sternberg, Jarvin & Grigorenko, 2010; Renzulli, 2004). Sternberg and colleagues (2010) note that countries that make great strides in scientific research have definite gifted programs.

Like critical thinking, the multi-faceted terms “giftedness” and “gifted” are fluid concepts in the history of educational thought, which never have been more elusive and challenging than they are today (Dai, 2010). There is probably no conception of giftedness that can capture all facets of this contested concept (Renzulli, 2005; Sternberg, 2005). To compare different paradigms in the gifted education area, Dai (2010) attempts to provide a
meta-level philosophical framework. He categorized major themes into three parts and in each identifies three conflict-like thoughts and tensions in the field.

Those speaking from a variety of perspectives, propose many different understandings of these terms such as psychometrically defined abilities, cognitive approaches, indicators of academic achievement, and aspects of creativity, to name a few. Miller (2008) states that the conceptions of giftedness are central to gifted education. She summarizes major theorists such as Terman, Sternberg, Gardner, and Renzulli offering brief descriptions of their definitions, work and of the substantial questions the raise in the field. She mentions empirical support for and limitations of research on each conceptions of giftedness. Furthermore, she generally categorizes theories of giftedness as formal or informal in the following ways:

- Formal/explicit theory of giftedness. An explicit theory results from combination of scholar’s research in the field and her/his personal conception(s) of giftedness and/or intelligence.

- Informal/implicit theory of giftedness. An implicit theory is people’s personal conception(s) of giftedness and/or intelligence that resides in people’s mind, based on her/his experiences with gifted education/individuals.

With regard to implicit theory, Sternberg (1995) summarized people’s implicit theories or folk beliefs about giftedness in his “pentagonal theory” for identifying the gifted individual. He suggests that giftedness can be understood in terms of five criteria:

1. Excellence. This criterion states that “the individual is superior in some dimensions relative to peer.”
2. Rarity. The rarity criterion states that “to be labeled as gifted, an individual must poses a high level of an attribute that is rare relative to peers.”

3. Productivity. This criterion states that, “the dimension(s) along which the individual is evaluated as superior must lead to, or potentially lead to, productivity.”

4. Demonstrability. The demonstrability criterion states that “the superiority of the individual on the dimension(s) that determine giftedness must be demonstrable through one or more tests that are valid assessments.”

5. Value. The value criterion states that “for a person to be labeled as gifted, the person must show superior performance in one or more dimensions that is valued for that person by his or her society.” (Sternberg, Jarvin & Grigorenko 2011, pp. 2-7)

I find this helpful with the exception of the productivity criterion which I find vague. The authors did not give enough detailed information and criteria. It’s unclear what they mean by the term “potential” productivity, “productive work”, and how one can measure or identify the possibility of potential productivity. Moreover, in the statement on the demonstrability criterion, they claim that, “[d]otting i’s is not an acceptable measure of intelligence” (Sternberg, Jarvin & Grigorenko 2011, p. 6). However, they did not give any objective criteria for “acceptable measure of intelligence” and how they reject dotting i’s, as a kind of measurement. Furthermore, why did they consider that excellent performance necessarily is a sign of giftedness? It can be a sign of experience and merely being a “veteran.”

Sternberg’s (1995, 2011) assumptions in his “pentagonal theory” and five criteria was challenged by Dai (2010) for considering non-technical language, arbitrary standards, and the way that public discourse is shaped as criteria in the Sternberg’s pentagonal theory. Sternberg
and colleagues (2011) emphasize that the giftedness conception is a “relative” one and socio-culturally constructed noting that a gifted individual might be viewed differently in different cultural contexts.

2.2.1 Theoretical Background and Conceptual Frameworks
As early as 2200 B.C., an elaborate system of competitive identifications had been developed by the Chinese to select high-ability individuals for government positions (DuBios, 1970; as cited in Renzulli, 2005). Down through the ages “almost every culture has had a special fascination for people who have made notable contributions to their respective areas of interest and involvement” (Renzulli, 2005, p. 246). For more ancient and historical around-the-world review see Davis & Rimm (1998), and Colangelo & Davis (2003).

Dai (2010) makes problematic challenging various viewpoints on defining what is meant by “gifted” and how researchers and scholars use this concept in their work from a historical perspective contrasting the “essentialist” and “developmentalist” conceptions. He clearly delineates a brief history of essential tensions around the gradual evolution of the giftedness as a concept and its circuitous route from “initial conceptions of general intelligence as a basis for identification” to the later “recognition of a plentitude of manifestations of talents.” (Dai, 2010, p. 23) He stated that scholars’ conception of giftedness has evolved from an accent on giftedness as a natural quality that someone has to the consciousness of a developmental process involving contextual factors. He also considered giftedness from the methodological views of an objectivist perspective that considers gifted child as a “natural” category of children to the subjectivist standpoint that perceive giftedness as being constructed.
Sternberg, Jarvin & Grigorenko (2011) conceptualize conceptions of giftedness in three categories (Sternberg, Jarvin & Grigorenko 2011, pp. 14-35):

1. IQ-based framework and $g$-based abilities. This conception states that giftedness is measured well by traditional measures, such as IQ tests, SATs, or other $g$-based assessments.

2. Beyond intelligence and ‘IQ-plus-other-qualities’ models. This understanding and approach to giftedness asserts that the IQ-based tests cannot measure all of what is relevant to giftedness.

3. No conception. This perspective argues that the superfluous and outdated concept of giftedness is a social invention that has no constructive purpose.

In Miller’s (2008) words, the second conceptualization involves inclusive theories of giftedness. Inclusive theories move “beyond a one-dimensional conception of giftedness (i.e., high IQ) to include multiple elements” (Miller, 2008, p. 108), such as different aspects of intelligence, personality traits, social factors, and creativity. Changing assumptions and concerns in the technical context of psychological and educational research, and conceptual evolution of related concepts, such as intelligence, creativity, motivation, and development have shaped the third understanding and conceptualization of giftedness (Dai, 2010, pp. 26-34). Dai (2011) deeply probed the philosophical foundation and underlying assumptions on which the history of giftedness is rooted.

2.2.1.1 IQ-based Framework and Domain-general g-based Approaches

This conceptions state that giftedness is measured well by traditional measures such as IQ tests, SATs, or other $g$-based assessments. This approach, particularly within the work and studies by Frances Galton, Alfred Binet, Lewis Terman, and Leta Hollingworth formed the
germinal seed in the first wave of scientific thought of understanding the conception of
Genius*, is considered as a beginning of systematic study of individual differences and the
grandfather of gifted-child movement, with regard to conceptions of intelligence (Colangelo & Davis, 2003). Impressed by Charles Darwin’s *Origin of the Species*, he emphasizes
hereditary factors and genetically inherited intelligence. This, according to Morelock (1996),
is how “gifted children” were first made.

At the turn of the 20th century Alfred Binet and colleagues, who worked on the
identification of children with learning difficulties, introduced a mental scale and the concept
of mental age to identify typical student ability at various ages (Davis & Rimm, 1998). Based
on Galton’s and Binet’s study, Lewis Terman a Stanford psychologist made three
“historically significant contributions to gifted education, which earned him the title of the
‘father of the gifted education’ movement” (Colangelo & Davis, 2003, p. 6). First, he adapted
Binet’s scale and created The Stanford-Binet Intelligence scale, one of the first intelligence
tests used to identify gifted individuals. Secondly, he adapted Galton’s theory of the nature
of genius, created a classification scheme for students based on IQ score, and “viewed
giftedness as a single entity, equating giftedness with a high IQ” (Kaufman & Sternberg,
2008, p. 73). And finally, Terman’s third contribution was his identification and longitudinal
project (1925-1959), *genetic studies on genius*, study of 1,528 “gifted children” (856 boys,
672 girls), that “have been the most studied group of gifted individuals in the world”
(Colangelo & Davis, 2003, p. 6). The impact of this first generation results in
interconnectedness and a relationship between giftedness and intelligence. As Dai (2010)
asserts, “[t]he gifted-child movement has a close historical tie with intelligence testing” (p.
Dai distinguishes Terman’s time convictions, which characterized Terman’s legacy of essentialism. Dai claims that an essentialist or realistic tradition of giftedness definition and identification were started by Terman, which are characterized as:

- Intelligence is a general human quality that is largely genetically determined.
- A hierarchy of intellectually superior, mediocre, inferior individuals can be established in society.
- Intelligence, as a general personal quality can be measured objectively with the intelligence tests.

Sternberg and his co-authors (2011) mention that, in 1968, Sternberg and Detterman asked 24 well-known cognitive psychologists the question: What do they believe intelligence is? Varied responses involved three themes: capacity to learn from experience, ability to adapt surrounding environment, and people’s understanding and control of their own thinking process: meta-cognition. Furthermore, they strongly emphasized the key role of culture and real-world context. Important to this thesis is their finding that human intelligence as ‘highly malleable’ and that it can be shaped and improved by involvement in various kinds of activities—including educational experience.

This IQ-based viewpoint and the nature of general intelligence still underlie some scholars’ perception of giftedness (Kaufman & Sternberg, 2008; Sternberg, Jarvin & Grigorenko 2011). For instance, Robinson (2005), based on a factor-analytic conception of g (giftedness) as a basic guide, strongly defends the psychometric approach to definition of academic giftedness. According to Miller (2013), several researchers such as those involved in the Genetics of High Cognitive Abilities (CHCA) and the Study of Mathematically Precocious Youth (SMPY) at John Hopkins University continue working on this perspective
to this day. Sternberg and colleagues (2011), from their IQ-based category identify 15 adequate and passable reasons to show why measures of IQ and psychometric g scores play such a great important role in contemporary identification procedure (see Sternberg, Jarvin & Grigorenko, 2011, pp. 17-24). Based on my review of the literature, I believe in a “supplementary” role of psychometric IQ- and g-based assessment models of identification.

2.2.1.2 “No-conception” Framework
Historically, from cultural points of view and with regard to social values various societies have used the concept of giftedness as a label to recognize special people who perform exceptionally and make notable contributions in one or more domain valued within their respective society (Pfeiffer, 2012, Renzulli, 2005). Therefore, from their view, what constitutes giftedness varies from culture to culture. From this perspective, Pfeiffer (2012) argues that gifted and non-gifted as a two distinct mutually exclusive groups is a false dichotomy and that there is no scientific basis for this arbitrary division.

In contrast with psychometric g-based approaches, the non-conception perspective argues that the superfluous and outdated concept of giftedness is a social invention that has no constructive purpose. Borland (2005, 2009a) argues that giftedness in school contexts is a “chimera”; the concept of giftedness is a social invention to create arbitrary divisions in society and that this division is superfluous and outdated. They take the position that education would proceed better if we dispensed with a concept of giftedness all together. In Borland’s view, the current situation of gifted education perpetuates social injustice and discrimination. He claims that the concept of the gifted student is “incoherent and untenable” in contemporary society (Borland, 2005, p. 2). He argues first that it is a social construct of questionable validity, second that it is largely ineffective and third that it results in
inequitable allocation of educational resources in his study context of America. Dai (2010) notes that,

In essence, Borland argues that the way we define giftedness as an essential quality that sets some children apart from the rest is scientifically unwarranted and practically harmful (particularly for minority, underprivileged students). (p. 15)

Pfeiffer (2012) contradicts IQ-based approach pointing out that giftedness as high IQ is presently embraced by very few experts in the field although many schools, educators, supervisors, and practicing psychologists still hold to this historical belief. “Once gifted, always gifted” is related to this “Mystery” model of giftedness (Matthews & Foster, 2009). Matthews & Foster (2009) focus on moving away from a mystery model identification of “gifted” labeling, and emphasize diagnostic assessment in which there is no need for formal labeling because of a natural match between students’ developmental level and their education.

By presenting hypothetical stories, parents’ and students’ mixed feelings, confusion, questions, and concerns about the term “gifted”, Matthews & Foster (2009) describe and compared the significant elements of “Mastery” versus “Mystery” models of identification. They compare these two models based on ten factors such as origin, duration, competence domains, and identification measures (see Matthews & Foster, 2009, pp. 5-10). Their description of the mystery model not surprisingly implies characteristics of an IQ-based framework. Furthermore, the authors address possible problems in one-time-only identification procedures facing children in many jurisdictions. Besides, interviewing parents and children about their reaction to the gifted label they also made a list of “benefits” and “problems” identified by families.
Based on my experience with gifted students and as a student in an exclusive gifted school for seven years, as well as being a physics teacher in that school for 14 years, Matthews’ & Foster’s (2009) hypothetical stories seem somewhat biased. Their accounts do not fit well with my own experiences and therefore raise some questions and concerns for me. Although the parents seem to exaggerate the impact of and the extent of their “mystery” model’s circumstances; they developed general and reasonable recommendations such as use of multiple measures, assessment as an ongoing process, a diagnostic emphasis, and labeling the services—not the child. I want to emphasize that these are important contributions and should not be dismissed entirely just because the stories come from a different contexts with a different history do not fit well with mine.

Matthews’ & Foster’s (2009) model, Mystery vs. Mastery, illustrates the two extreme ends on the continuum of viewpoints and conceptions of giftedness. In my view, Renzulli’s Schoolwide Enrichment Model (Renzulli, 2012) offers a more moderate approach to gifted education and related issues that resonate with my experience.

2.2.1.3 Domain-specific Perspectives

Using factor analytic studies, Charles Spearman concluded the general factor that he labeled “g” is the key to understanding intelligence and thus the gifted person is one who excels in general intelligence (Sternberg, Jarvin & Grigorenko, 2011). In contrast to Spearman, Louis Thurstone concluded that seven statistically independent primary mental abilities constitute the core of intelligence: verbal comprehension, verbal fluency, inductive reasoning, spatial visualization, number, memory, and perceptual speed (Kaufman & Sternberg, 2008; Sternberg, Jarvin & Grigorenko 2011).
In an early model of general intelligence, Horn and Cattel (1966; as cited in Kaufman & Sternberg, 2008) proposed that it comprises two major parts: fluid intelligence/ability \( (g_f) \) (speed and accuracy of abstract reasoning, which is dependent on efficient functioning of the central nervous system), and crystallized intelligence/ability \( (g_c) \) (accumulated knowledge and vocabulary, which is more dependent on experience and cultural contexts (Kaufman & Sternberg, 2008; Sternberg, Jarvin & Grigorenko 2011).

More recently, based on an analysis of more than 460 data sets (more than 130,000 people), a hierarchical model of intelligence was proposed by Carroll (1993), in which he assumes three strata: Stratum I or lower-order stratum, which includes 50 to 60 or more narrow linearly independent abilities (for e.g., spelling ability, speed of reasoning); Stratum II or middle-order stratum, which comprise 8 to 10 or more linearly independent broad abilities (for e.g., fluid intelligence, crystallized intelligence); and Stratum III or higher level stratum, which implies a single general intelligence, much like Spearman’s \( g \) (Carroll, 2003, p. 3). Kaufman and Sternberg (2008) argue that Carroll’s (1993) three-stratum theory gained the widest acceptance in the psychometric community.

Finally, the domain-specific perspective was expanded by Howard Gardner’s Multiple Intelligence’s theory. Gardner initially (1983) in his work, *Frames of Mind*, proposed seven relatively independent intelligences: linguistic, logical-mathematical, spatial, musical, body-kinesthetic, interpersonal, and intrapersonal intelligence (Dai, 2010, Fenstermacher & Soltis, 2009; Renzulli, 2005). However, he later added naturalistic, spiritual, and existential intelligences as new candidates (Waterhouse, 2006; Gardner, 1998, 1999; as cited in Dai, 2010). “He views each ability as a separate intelligence, not as a part of a single whole” (Sternberg, Jarvin & Grigorenko 2011, p. 75). Pedagogically, MI theory
provides teachers with a more flexible approach to learning and instruction that acknowledges that students have various ‘learning styles’, making room for different kinds of “smart” pupils such as ‘body smart’ or ‘music smart’.

Although in some experts’ views (Dai, 2010, pp. 15-27; Kaufman & Sternberg, 2008, p.75) the theory of Multiple Intelligences is one of the theories that have completely changed the way giftedness is conceptualized, various criticism have been proposed (for e.g., see Klein, 1997; White, 2004). The cutting-edge idea that underlying this theory is that intelligence is not necessarily tied to IQ-based intelligences (logico-mathematical and linguistic). For me, it seems that Gardner’s MI theory is based on reviewing literature and there is a lack of evidence to support this categorization. It’s not clear why MI conceptualizes intelligence in just eight or ten categories, and how the theory can justify it? Moreover, what are the criteria that one should meet and satisfy to be considered as a, for example, ‘smart body’ candidate?

2.2.1.4 “Systems” Approaches

The “third wave” of studies on a conception of giftedness, Kaufman and Sternberg (2008) describe views giftedness as a system – the total operation and synthesis of psychological processes operating together. According to Kaufman and Sternberg (2008), Renzulli’s Three-Ring Conception of giftedness and Sternberg’s WICS model of giftedness are both significant systems models.

2.2.1.4.1 Renzulli’s Three-ring Conception of Giftedness

One of the well-known models in the contemporary gifted education is Renzulli’s (1984, 1997, 2005; Renzulli & Reis, 2012) Three-Ring Conception of Giftedness (Davis & Rimm, 1998; Miller, 2008; Sternberg, Jarvin & Grigorenko 2011). Despite Borland’s (2005) claim,
Renzulli (2005) believes that giftedness is an age-old issue. In a very general sense he states that the field of gifted education focuses on two major questions: (1) “what makes giftedness?”, and (2) “how can we developed giftedness in young people and adults?” (p. 246). The second question implies that his theory views giftedness as something we can develop in individuals as he puts emphasis on “gifted behavior”, rather than using “gifted” as a noun. Moreover, he highlights the search for the meaning of giftedness “there must be a purpose for defining this concept” (Renzulli, 2005, p. 248). In this light, the purpose of Renzulli’s Three-Ring Conception of Giftedness and his Enrichment Triad Model program is promoting creative-productive giftedness (Sternberg, Jarvin & Grigorenko 2011).

Renzulli (2005, 2013; also Renzulli & Reis, 2012), defines two kinds of giftedness: First, schoolhouse or high-achieving giftedness, which refers to typically test-taking or lesson-learning gifted students who are visible to teachers (Sternberg, Jarvin & Grigorenko 2011), easily identified by IQ or other cognitive ability tests and/or achievement measures, that are most valued in traditional schooling system to select students for special programs (Renzulli, 2005, 2013). He asserts that “it can be identified through standardized assessment techniques” (2013, p. 38), and generally remains stable over time.

Second, creative-productive giftedness which is in line with current Western definitions of creativity (see Renzulli, 2005, pp. 254-255) refers to those aspects of human activity “where a premium is placed on the development of original material and products that are purposefully designed to have an impact one or more target audiences” (Renzulli & Reis, 2012, p. 21). To promote creative-productivity, he elaborates on an application of content and thinking processes in an integrated, inductive, and real-world-problem oriented manner. However, he emphasizes that both types are important and usually interact with each
other. Although the second kind can be found in students’ project work, I disagree and think these two kinds “do not” correspond with each other. For example, in adulthood people are seen as gifted because of their creative-productive trait(s) whereas in childhood they are considered as gifted as a result of their high-achieving giftedness.

With regard to necessity of gifted education, from both individual and social points of view, Renzulli (2005, 2013) discerns two arguments as a rationale for gifted education:

- Providing students with maximum opportunities to present their potential and for self-fulfillment through the development of one or combination of performance areas.
- Increasing society’s supply of individuals who will help to solve contemporary civilization’s challenges by producing knowledge.

The Three-Ring Conception of Giftedness is a research-based theory that evolved over 30 years and is based on three clusters of human traits:

1. Well-above-average ability. This cluster is defined in two ways: General abilities (e.g., general intelligence), which consist of

   [t]he capacity to process information, to integrate experiences that result in appropriate and adaptive responses to new situations, and the capacity to engage in abstract thinking. Examples of general ability are verbal and numerical reasoning, spatial relations, memory, and word fluency. (Renzulli, 2005, p. 259)

Renzulli maintains that tests of general aptitudes or intelligence can measure these across-all-domains abilities. Special abilities, in same line with Gardner’s MI theory, refer to the capacity of acquiring skills and ability to perform in one or more real-life
activities and/or situations, such as musical composition, mathematics, and photography.

2. Task commitment. The second cluster of traits refers to a form of motivation, related to both intrinsic and extrinsic motivation, which represents the “energy brought to bear on a particular problem (task) or specific performance area” (p. 263), and can be described in terms of perseverance, endurance, hard work, dedicated practice, and self-confidence. Renzulli notes that task commitment is clearly indicated in both Galton’s and Terman’s conception of giftedness as an important part of gifted person’s personality.

3. Creativity. The third cluster characterizes creative trait(s) of gifted individual in some dimensions, such as originality of thinking and freshness of approaches to the problems, constructive ingenuity, and ability to refuse established conventions when appropriate. He argues that in the literature, the words gifted, genius, eminent creators, and highly creative persons are used synonymously.

Based on these traits, Renzulli defines gifted behavior as traits and aptitudes that reflect the interaction among these three basic clusters of general human traits (Renzulli, 2013, p. 267). It is important to note that no single cluster makes giftedness. As Renzulli clarifies, this conception portrays the main dimensions of humankind potential for creative productivity. From a product-oriented view, he accentuates some educational factors such as inductive learning, real-problem-oriented manner, and firsthand inquiry. Translating theory into practice, Renzulli (2005) describes practical strategies for identifying all potentially gifted students from a “talent pool of students” in the Renzulli Identification System, which includes six steps.
Renzulli’s Three-ring conception is the “systems” approach to giftedness in which the total operation and synthesis of the three aforementioned human traits operating together considerably and positively attempts to widen the circle of definitions and gifted-services which effects my perception of gifted programs and education. However, he does not provide a rationale and establish criteria for selecting these three particular clusters of traits among other traits. Moreover, he does not explain why these clusters are the main dimensions of creative-productivity? Finally, his descriptions of the clusters are not clear in relation to a definition of creativity.

2.2.1.4.2 Sternberg’s WICS model of giftedness.

Sternberg’s (2003, 2005, and 2011) WICS model is the other significant system model (Kaufman & Sternberg, 2008), in which giftedness is conceptualized as a synthesis of intelligence, creativity, and wisdom. The model is an expansion of Sternberg’s model of leadership, which proposes that, intelligence, creativity, and wisdom are essential and indispensable attributes for ‘future gifted leaders’ (Sternberg, 2003). Therefore, the WICS – an acronym standing for wisdom, intelligence, creativity, synthesized – as a model of giftedness, emphasizes the future role of talented individuals as gifted leaders. In general, this model argues that giftedness is:

a function of creativity in generating ideas, analytical intelligence in evaluating the quality of these ideas, practical intelligence in implementing the ideas and convincing others to value and follow the ideas, and wisdom to ensure that the decisions and their implementation are for the common good of all stakeholders. (Sternberg, Jarvin & Grigorenko, 2011, p. 34)
Sternberg (2003) proposes five main characteristics for a model of giftedness. The model has to (1) encompass the attributes that constitute giftedness, (2) be conceptually coherent, (3) be psychologically defensible (4) be operationalizable, and finally (5) the model should not embrace the attributes that “do not” constitute giftedness. In the WICS model, he mapped more than 50 attributes which were sought after by scholarship programs. Sternberg (2009; also Sternberg, Jarvin & Grigorenko, 2011) notes that as intelligence, creativity, and wisdom are modifiable and individuals can develop these attributes one is “not born” gifted.

As Sternberg (2003, 2005) asserts, there are many definition of intelligence, although it is typically defined as the ability to adapt to surrounding environments and has the capacity to learn from experiences. In the Triarchic theory of successful intelligence that underlies the WICS Sternberg proposes there is a somewhat more elaborate definition of intelligence. He posits three kinds of intelligence. First, analytic or academic intelligence (IQ) that refers to conventional notion of intelligence and intellectually gifted people, in term of analyzing and judging information, and evaluating the qualities of ideas (Sternberg, 2005; Sternberg, Jarvin & Grigorenko, 2011). Second, synthetic or creative intelligence, which is related to characteristics such as, insightfulness, intuitive, creativity, and ability to cope with novel situations (Sternberg; 1996, Sternberg & Grigorenko, 2004). Third, practical intelligence which is a “set of skills and attitudes to solve everyday problems by utilizing knowledge gained from experience to purposefully adapt to, shape, and select environments” (Sternberg & Grigorenko, 2004, Sternberg, 2009; Sternberg, Jarvin & Grigorenko, 2011). In the WICS, as Sternberg and colleagues clarify, the emphasis is on practical intelligence. Sternberg (2009) maintains that different combination of intellectual skills results in different types of
giftedness. For more details and discussions on Triarchic theory of successful intelligence, see Sternberg (1996), and Sternberg & Grigorenko (2004).

The second foundation of the WICS’s model is creativity in generating ideas as a confluence of skills and attitudes. Based on Sternberg’s conception of creativity individuals need enough of the following 10 elements and particular characteristics to “translate their potential gifts to actualized ones”: (1) problem redefinition, (2) problem analysis, (3) recognizing that creative ideas do not sell themselves, (4) realizing how knowledge can be both help and hinder, (5) willingness to take sensible risks, (6) willingness to surmount obstacles, (7) belief in one’s ability to accomplish the task at hand, (8) willingness to tolerate ambiguity, (9) willingness to find extrinsic rewards for the things one is intrinsically motivated to do, and (10) continuing to grow intellectually rather than to stagnate (Sternberg, 2003, 2005, 2009; Sternberg, Jarvin & Grigorenko, 2011). Sternberg highlights that, “to a large extent, people decide to be creative. Creativity is in large part attitudinal” (2009, p. 2).

Moreover, Sternberg and colleagues (2011) introduce eight types of creative ideas (see Sternberg, Jarvin & Grigorenko, 2011). However, in both cases, 10 elements for creative attitudes and eight types of creative ideas, they do not adequately provide evidence from other studies or literature for their arguments and categorization. However, there is a lack of references and evidence to support statements and claims made in this part of the theory.

An additional distinct and relatively recent quality added to this theory is wisdom which is an essential and significant quality in the WICS model of giftedness. As they assert “giftedness in wisdom is a matter of balance” (p. 50); balancing one’s own various self-interests (intra-personal), others’ interests (inter-personal), and interests of other aspects of the context such as environment (extra-personal), to use one’s creativity, intelligence, and
knowledge for a common good. Wisdom implies skillful balance; balancing of the various interests over the short and long term, in making decisions (Sternberg, 2009).

In addition to balancing these three types of possible interests, Sternberg (2005) appends and enlarges the circle of balancing to three kinds of actions; adaptation to environments, shaping of environments, and selection of alternative environments. Although gifted people can be intelligent and creative in various ways; it does not promise that they are wise (Sternberg, 2009; Sternberg, Jarvin & Grigorenko, 2011). However, Sternberg Jarvin & Grigorenko (2011) do not provide any definitions or criteria for common good and how to balance intra-personal, inter-personal, and extra-personal interests with regard to the common good. In my understanding, this element of WICS model basically addresses normative critical thinking.

Reviewing literature, Sternberg (2003) discusses different aspects and sets of components for wisdom as found in different studies. Examples include:

- Exceptional understanding, judgment and communication skills, general competence, interpersonal skills, and social unobtrusiveness (Holliday and Chandler, 1986; as cited in Sternberg, 2003).

- Reasoning ability, sagacity, learning from ideas and environment, judgment, expeditious use of information, and perspicacity. (Sternberg 1990a, as cited in Sternberg, 2003).

- Practical problem-solving ability, verbal ability, intellectual balance and integration, goal orientation and attainment, contextual intelligence, and fluid thought (Sternberg, 2003).
• Extension of Piagetian intelligence and formal operations, in term of thinking reflectively and/or dialectically (Sternberg, 2003).

Finally, gifted people as gifted leaders require combinations of each of the elements of WICS model to make a positive, meaningful, durable difference to the world. Based on this model, no single element makes for giftedness. Giftedness is a synthesis of creativity skills used to confront novel situations and to come up with new ideas; a high level of intelligence and academic skills and attitudes, to evaluate ideas, make decisions, and implementation; and the wisdom-based skills and attitudes to contemplate the common good. Any country needs leaders, and “WICS provides a model for developing leadership in its young” (Sternberg, Jarvin & Grigorenko, 2011, p. 53).

2.2.1.5 Developmental theories.

Historically, Dai (2010) expresses an evolutionary “dialectical cycle of construction, deconstruction, and reconstruction of giftedness” (p. 12). From a deconstructed view of giftedness, he categorized criticism on intelligence testing in two categories: (1) Critique from social constructivist perspective, and (2) Critique from an expertise perspective. Finally, Dai argues that reconstruction of giftedness has been promoted by two pragmatic movements. First, the Study of Mathematically Precocious Youth (SMPY) at Johns Hopkins University in 1971 and second, the developmental of enrichment models for gifted education by Rezulli in 1977 which led to the following new understandings and conceptions of giftedness: Developmentalism. To sum up, “natural abilities” as an objective reality which appear to be measured, turn out to be a dependent and relative idea; they depend on many factors such as genetic, socio-economic, developmental, technical, and environmental factors. Dai (2010) states that, intelligence is now seen as a dynamic, effective functional
state; rather than static personal traits. Furthermore, in addition to addressing factors, other than personal trait, that contribute to creativity, he describes a developmental view on giftedness, as well as context as a key component of giftedness.

In addition to taking numerous ideas from IQ-based approaches, domain-specific conceptions, and system models, developmental conceptualizations broaden the view on giftedness, even wider than the system models’ conception, by emphasizing external and environmental variables, such as the school, family and peers, as well as individuals’ internal factors, continuously changing and dynamic nature of giftedness (Kaufman & Sternberg, 2008). Renzulli (2012) asserts that, “giftedness is developed over time and that culture, abilities, environment, gender, opportunities and chance contribute to the development of gifts and talents.” (p. 21)


The Differentiated Model of Giftedness and Talent (DMGT) presents the talent development process (P) as the transformation of outstanding natural abilities, or gifts (G), into outstanding systematically developed skills which define expertise, or talent (T) in a particular occupational field. This developmental sequence constitutes the heart of the DMGT. Three types of catalysts help or hinder that process: (a) interpersonal (I) catalysts, like personal traits and self-management processes; (b) environmental (E) catalysts, like socio-demographic factors, psychological influences (e.g., from parents, teachers, or peers), or special talent development facilities and programs; and (c) chance (C). (p. 119)
Gagné (2005, 2013) states that the field of gifted education has been shaped around two special “non-normal”, individuals’ abilities: giftedness and talent. He makes a distinction between the concept of giftedness as outstanding natural abilities (gifts) and aptitudes in at least one field of human abilities and the concept of talent as outstanding mastery of “systematically developed” knowledge and skills which are called competencies in at least one ability domain (Gagné, 2004, 2005, and 2013). The DMGT includes ‘top 10 per cent’ threshold for both gifted and talented. According to Gagné’s (2004, 2005, 2013) conceptualization, the DMGT model depicts talent development procedure as the progressive transformation of gifted individual into talented one; and, from gifted inputs to talented outputs. It particularly highlights the dynamic nature of the development of gifts towards talents. However, in my understanding, the DMGT’s process could apply to all students to some degree.

Other theorists, such as Abraham Tannenbaum, David Henry Feldman, and John Feldhusen formulate different developmental models involving different dimensions. All of these researchers attempt to clarify transition from inherited natural abilities to the specific developed talents.

As a most relevant and contemporary example of gifted programming, Renzulli and Reis (2012) present a high-level Internet-based enrichment program based on high-end learning theory, in which creative productivity and firsthand investigations are the main focuses. The Renzulli Learning System (RLS) developed the pedagogy of Schoolwide Enrichment Model (SEM). The Three-ring Conception of Giftedness, Enrichment Triad Model of inductive learning, and high-end learning theory underpin school-wide enrichment and is based on their 30-years experience of field-testing.
They characterize this model using three requirements: First, is that students must personalize the issue or problem. Second, using methods of investigation, the students act like professionals. Third, the student’s work usually involves a product or services that “perform” to particular audience. Moreover, they offer the following principles to help define the “high-end learning” concept:

- Each learner is unique, in terms of abilities, interests, and learning styles.
- Enjoyment, as a goal, should be considered in constructing learning experience.
- Content and process should involve real-world and present problems.
- The major goal of this approach is that students “construction” replaces passive learning with engaged active learning.

They define high-end learning as “applying relevant knowledge, research skills, creative and critical thinking skills, and interpersonal skills to the solution of real problem” (p. 27).

Furthermore, the four-step procedure of the Renzulli Learning System, an Internet-based enrichment program, is described as a computer-based assessment to create each student’s profile of academic knowledge, interests, and learning styles is the first step. In step 2, the differentiation search engine matches each student profile to an enrichment database of 17,000 activities. In Step 3 “the Wizard Project Maker” focuses on providing meta-cognitive skills for students to help them work on their investigative projects. Automatic ongoing storage of all individual activities into a Total Talent Portfolio is the last step in the RLS.

To sum up, RLS is a designed internet-based tool to help teachers for effective differentiation that promote engaged inductive high-end learning. The inductive learning model and high-end learning theory broadened my knowledge about learning, and I will consider these two issues in my future teaching. However, the tool’s limitation is that the
RLS is based on use of the internet and technology; therefore, it is inapplicable to economically disadvantaged societies and students who have no access to computers and internet in their schools.

2.3 Tensions and Critiques of CT
Therefore, providing an instructional framework for developing CT requires that educators deal with several difficulties and challenges in planning appropriate and efficacious pedagogy. These tensions are presented below:

- **Generality versus Domain Specificity.** Most of the conceptions imply that CT is a domain-specific thinking (e.g., McPeck, 1990; Bailin et al., 1999; Case 2005). In contrast, generic abilities and generalist’s view supported by Siegel (1988) and Ennis (1989).

- **Embedded versus Explicit Approach to Curriculum.** Some of the authorities in the field believe in a curriculum-embedded approach to CT (McPeck, 1981; Paul & Elder, 2006; Case, 2005). For example, Case (2005) argues that “content-process” is a false dichotomy. However, some recent studies found that explicit modes of teaching CT are more effective (Marin & Halpern, 2011). Moreover, Lipman (2003) and Siegel (1988) supported both approaches.

- **Skills versus Habits.** Psychological perspective, such as Halpern (1998, 2007), is a descriptive skill-centered approach to CT. In contrast, philosophical conception, such as Siegel (1988) and TC², accentuate virtues and habits of mind.

- **Critical versus Creative Thinking.** As Bailin (1987) mentioned, standard view and some “theorists such as Edward de Bono believe that there is a tension between critical and creative thinking” (p. 167). However, she claimed that it is a false dichotomy and there is a close interconnection between these two types of thinking.
• Constructivism versus Critical Thinking. Although some studies stated that thinking critically and cognitive constructivism are closely related, as CT has a key role in knowledge construction (Wang, Woo, & Zhao, 2009), Boghossian (2012) argued that there is a tension between constructivism and CT in that “constructivist epistemological presuppositions, actively thwarts the critical thinking process” (p. 73).

• Critiques of Thinking Critically. Thinking critically involves thinking with regard to application of criteria in order to evaluation and to designate criteria we should be critical. So, it looks like a circular argument. Furthermore, Case (2005) discussed three reasons that relegate CT to a sideshow: proliferation of thinking skills, the ranking of thinking skills, and the separation of skills from content.

2.4 CT’s Areas for Consensus

Despite the lack of consensus on the definition of CT and differences among the three perspectives on critical thinking, one can see areas for agreement. The TC²’s conception of CT pedagogy has consolidated many of these areas of agreement:

1. Background Knowledge. Among researchers in different approaches to CT, there is an agreement on the importance of the background knowledge, as an essential condition to think critically (e.g. See Bailin, Case, Coombs & Daniels, 1999; Case, 2005; Facione, 1990; Halpern, 1998; McPeck, 1990).

2. Dispositions. Most researchers working on the CT area agree that there exists a set of dispositions or habits of mind, with regard to quality thinking. The most commonly habits of critical thinker include: open-mindedness, fair-mindedness, full-mindedness, flexibility, and inquisitiveness (Bailin, Case, Coombs & Daniels, 1999; Ennis, 1985; Halpern, 1998; Facione, 1990).
3. Thinking Strategies. Among different approaches to CT there exists an agreement on
the importance role of intellectual tools and thinking strategies. However, different
perspectives put the emphasis on the different tools/strategies; for instance, analyzing
arguments/claims (Ennis, 1985; Facione, 1990, Halpern, 1998; Paul, 2006), and
making inferences, making decision, and solving problems (Ennis, 1985; Facione,
1990; Willingham, 2008).

4. Judgment. From different points of view assessment, judgment, and using warranted
criteria is central to thinking critically (e.g. See Case & Daniels, 2002; Facione, 2011;
Lipman, 2003; Ennis, 1993; Sternberg 2003)

Furthermore, from diverse conceptualizations’ view, critical thinking and judgment is
at the core of theories of giftedness education:

- IQ-based Framework: Alfred Binet, one of the first authorities in the field of gifted
education, and in the IQ-based conceptualization of giftedness puts emphasis on the
role of judgment. “In Binet’s view, judgment is the key to intelligence.” (Sternberg,
Jarvin & Grigorenko, 2011, p. 57)

- Domain-specific Perspectives: Louis Thurstone’s primary mental abilities constitute
inductive reasoning as the core of intelligence (Kaufman & Sternberg, 2008;
Sternberg, Jarvin & Grigorenko 2011). Moreover, Carroll’s (1993) hierarchical model
of intelligence in his three strata includes reasoning and judgment as well.

Furthermore, based on Renzulli’s (2005) description of Gardner’s MI theory, logical-
mathematical and intrapersonal intelligence are intelligences that related directly to
thinking critically and making decisions.
• Renzulli’s Three-ring Conception of Giftedness: Renzulli and Reis (2012) define high-end learning as “applying relevant knowledge, research skills, creative and critical thinking skills, and interpersonal skills to the solution of real problem” (p. 27).

• Sternberg’s WICS Model of Giftedness: this model argues that giftedness is:
  a function of creativity in generating ideas, analytical intelligence in evaluating the quality of these ideas, practical intelligence in implementing the ideas and convincing others to value and follow the ideas, and wisdom to ensure that the decisions and their implementation are for the common good of all stakeholders. (Sternberg, Jarvin & Grigorenko, 2011, p. 34)

Therefore, despite the lack of consensus on the definition of CT among the three perspectives on critical thinking, as well as conceptions of giftedness, one can see areas of intersections and agreements. Hence, this research study, based on these areas of consensus, defines critical thinking as when a person is attempting to assess or judge the merits of possible options in light of relevant factors or criteria while using the tools of a good thinker. To promote thinking critically in students, TC² propose a four-pronged conceptual framework that encompasses many areas of agreement, involving (Balcaen, 2008; Case, 2005):

• Providing critical challenges within the curriculum as invitations to CT, problematizing background knowledge

• Developing the intellectual resources to nurture high-quality CT, such as use of criteria to make judgments, use of critical thinking concepts (vocabulary), use of thinking strategies, and developing the habits of good thinkers

• Evaluating and assessing for the tools and students’ overhaul competence
• Building a *community of thinkers* within the classroom/school

This study applies TC²’s conceptualization to explore Iranian science teachers’ instructional behavior.

### 2.5 Teachers’ Implicit Theories and Conception(s) of CT

The second factor that perpetuates the problem is that people or particular groups hold informal/implicit theories that reflect their understanding of and experiences with gifted individuals (Miller, 2008, p.113). Among different groups, teachers’ perceptions of critical thinking, as well as their implicit theories of giftedness-relative issues is a major determinant of efficacious learning programs. For example, Case (2005), based on their work with Canadian teachers in the TC² observes that in many classrooms the teaching of CT is broadly separated from the teaching of the subject matter. He claims that many teachers see CT divorced from curriculum and consequently address teaching thinking only at the end of a term or a course.

In the educational field, probably every educator believes that they have a good grasp of critical thinking. However, Paul, Elder, and Bartell (1997) in their survey research on 140 college and university professors found that although 89% of them asserted critical thinking as a main objective of their instruction, only 19% of them could clearly define critical thinking. In line with this study, Case (1992) concluded that students in regular classrooms are not typically being supported in developing good habits of thinking critically. It is this problem that I take up in my study of Iranian gifted school educators over the following chapters.

Teachers’ perceptions of critical thinking, as well as their implicit theories of giftedness-relative issues are one of the major determinants of efficacious learning programs. Teachers’ instructional approaches in the classroom tremendously affect students’ learning
level (VanTassel-Baska, 2012). This suggests that knowing teachers’ understanding of instructional strategies for promoting good thinking habits plays key role in designing critical thinking pedagogy for talented individuals. Furthermore, “gifted and talented teacher behaviors are not systematically monitored” (VanTassel-Baska, 2012, p.43). Based on my passion for science and physics education, and my background in gifted education, and based on my understanding of teachers’ key roles as models affecting the degree that students learn subject matter as well as critical thinking skills and habits, I explored dimensions of science teachers’ conceptions of promoting critical thinking in the context of Iranian exclusive gifted education system (NODET\(^3\)).

Furthermore, taking a pragmatic stance in this study to give a “more detailed and balanced picture” of the phenomena being studied, and to capture a more complete picture of these science teachers’ teaching characteristics and their conceptions of CT, a mixed methods approach was applied (Altrichter et al., 2007; Lodico, M. G., Spaulding, D. T., & Voegtle, K. H., 2010). According to Cohen, Manion & Morrison (2000), such multi-phased mixed methods research is “an attempt to map out, or explain more fully the richness and complexity of” teachers’ conceptions and instructional “behavior by studying it from more than one standpoint and, in so doing, making use of both quantitative and qualitative data” (p. 112). Contemporary wisdom (Cohen, Manion & Morrison, 2000) suggests that more than one data collection technique is typically included in research studies to validate results. These different multi-method approaches are later compared and contrasted in a procedure called triangulation (Altrichter et al., 2007; Lodico, Spaulding, & Voegtle, 2010). In this view, this research study includes three phases that I outline in Chapter Three.

\(^3\) Abbreviation for National Organization for Development of Exceptional Talents
Chapter 3: Research Design and Methodology

In the following chapter I offer details of the context of the study, a rationale for and description of the research methodology, outline methods including classroom observations, teachers’ survey questionnaires, in-depth interviews, and the conceptual framework emerging from my analysis of the data.

3.1 Background
I chose Iran as the general location for my study as I am interested in informing educational change in my homeland. I chose Iran’s gifted schools as the specific site of my inquiry because this location is a familiar context based on being a student in one of Iran’s gifted schools and having taught physics in one of these schools for 14 years. I have considerable inside knowledge of this part of the school system as I was responsible for the Physics Department from 2004 until leaving in 2011. In addition to providing a deep understanding of the cultural context of these institutions this experience provided for access to two gifted middle schools and two gifted high schools, allowing me the opportunity to follow up my questions in a highly familiar context. Additionally, there have been some critiques of the gifted education system within Iran suggesting that changes are needed. Parallel to Dai (2010), these critiques assert that Iran’s gifted programs are more focused on mastery of knowledge, academic lesson-learning abilities, and proficiency, rather than thinking skills, creativity, problem-solving, exploring the unknown, and innovation.

3.2 Rationale for the study
A recent study of Westinghouse Science Talent Search finalists and winners asserts the necessity for deepening the learning experience of gifted students within the ages of 11-22
(VanTassel-Baska and MacFarlane, 2008). This study puts an emphasis on science education for gifted students during the critical years of middle school and early high school (grades 7-10). At the same time, a focus on teaching critical thinking has emerged as part of a renewed focus on rigor within 21 Century learning environments across the globe. Thus, my research plan focuses on grades 7 and 8 in two Iranian gifted middle schools, and grades 9 and 10 in two Iranian gifted high schools, with a focus on teaching critical thinking in an attempt to address these concerns.

### 3.3 Research Question

VanTassel-Baska (2012) asserts that, teachers’ instructional approaches in the classroom tremendously affect students’ learning level. This suggests that knowing teachers’ understanding of instructional strategies for promoting good thinking habits plays key role in designing critical thinking pedagogy for talented individuals. Furthermore, “gifted and talented teacher behaviors are not systematically monitored” (VanTassel-Baska, 2012, p.43). Based on my understanding of teachers’ key roles as models affecting the degree that students learn subject matter as well as critical thinking skills and habits, I address the following question throughout the study:

*What are the characteristics of science teachers’ conceptions of CT in Iranian gifted schools? Using TC²’s conception of critical thinking as a framework, I ask to what extent do science teachers in the Iranian gifted schools consider CT in their programs and instructions?*
Through this research, I offer recommendation about how to close the gap between theory and practice by providing suggestions for improving how critical thinking pedagogy is embedded into gifted science education in Iranian schools.

3.3.1.1 Objectives

Through my empirical inquiry I:

- Assess Iranian science teachers’ instructional behavior, in terms of CT pedagogy, based on TC²’s four-front conception of CT.
- Examine Iranian science teachers’ conception(s) of CT and teaching critical thinking in gifted classrooms, grades 7, 8, 9, and 10, with regard to CT’s tension.
- Inquire into the relationship(s) between science teachers’ demographic information, (such as gender, number of years of experience in Iranian gifted schools, their educational background), and their quality of CT pedagogy.

3.4 Research Methodology & Rationale

The study is a non-experimental design using a mixed methods approach to support the research questions (Gay, Mills, & Airasian, 2012). Both quantitative (Likert scales) and qualitative (interviews and classroom observations) data were gathered in this three-step study. This research focuses on characteristics of science teachers in these Iranian special gifted schools and examines the relationship(s) among variables, without testing statistical (null) hypotheses (Suter, 2012). The research can be viewed as small-scale evaluation research, for the purpose of improvement and/or decision making among science teachers teaching gifted students in Iran. According to Suter (2012), such non-experimental design involves examining teachers’ instructional characteristics while searching for relationship(s) without intervention, treatment, changing conditions, or planned interaction within the setting.
where data is collected. However, I do recognize that my direct observations might have affected the teachers’ behaviors in limited ways and address this concern in the chapter four.

3.4.1 Taking a pragmatic stance

One of the conceptual and philosophical frameworks that underlie the design of this study is pragmatism resulting in a pragmatic framework (Creswell, 2012). As Lodico, Spaulding, and Voegtle (2010) state, usually pragmatic researchers apply mixed methods approaches to their research, focusing on the immediate reality of problems that are posed to educational realism while striving to find better solution(s) for some challenges. According to Lodico, Spaulding, and Voegtle (2010), pragmatic researchers should “collaborate with participants to fully understand what works” (p. 11), using any method that accurately and appropriately describes the phenomenon. Pragmatism is concerned with identifying “what works,” rather than whether research assumes either an objective reality or a socially constructed world (Lodico, Spaulding, & Voegtle, 2010, p. 9). They argue that, in this way, theories and hypotheses provide for a useful approach to improving education — one of the goals of the study.

Furthermore, a scientific realism framework underlies phase I and II of this study where a mixed-method approach to the research involved producing numerical data, as well as gathering qualitative data. From a scientific realists’ view, these phases are non-experimental endeavors used to examine relationship(s) among variables and involving direct observational methods (Cohen, Manion, & Morrison, 2007). In this study the variables are teachers’ characteristics (e.g. age, years of experience with gifted schools, teaching area such as biology, chemistry, and physics), and instructional behavior (e.g. “encouraged students to express their thoughts”, “encouraged multiple interpretations of events and situations”) in the
classroom, especially in terms of their conception(s) of thinking critically and teaching strategies employed to promote CT in high-ability students. From a post-positivist view, the first assumption that is made implicitly is that there is an objective reality (Cohen, Manion, & Morrison, 2007; Lodico, Spaulding, & Voegtle, 2010), such as “science teachers’ perception(s) of teaching critical thinking in gifted classrooms” and “science teachers’ instructional behavior, in terms of CT pedagogy” that can be described through the research and where research can proceed by “gradual approximation to the truth” (Cohen, Manion, & Morrison, 2007, p. 11).

As Creswell (2012) clarifies, “[w]ith quantitative research now accepted by educational researchers, and with quantitative research being long established as an approach, mixed methods research has become popular as the newest development in research methods” (p. 534). Mixing quantitative and qualitative data to integrate and cover multiple databases makes this type of design “an advanced” methods procedures (p. 535).

In this study, mixed methods were used to provide a better understanding of science teachers’ conception(s) of critical thinking with regard to their instructional behavior and their practical strategies. While I believe that defining contested conceptions of CT is not easy even for experts (Case, 2005), we worked on this together through conversation.

By asking teachers to explain their understanding of CT-related issues and their use of criterion-based teaching strategies allowed me to document, rank and assess both their perception(s) of CT and teaching methods. Noting that teachers might apply various methods in their classes to address CT, while being unfamiliar with the “term” critical thinking, and therefore not having a way to name it.
To address this problem and to help elaborate on teachers’ perceptions and methods, I used follow-up interviews and classroom observations to provide supplementary data to complement and elaborate upon the survey questionnaire and to provide opportunities to develop a thorough grasp of science teachers’ understanding of, and strategies for developing critical thought in their classrooms. Additionally, direct observations of classroom practice provided me an opportunity to examine the actuality of teachers’ day-to-day instruction—what they really do in teaching rather than what they say or believe. This is important as it is possible that a teacher has a productive and clear understanding of CT but s/he does not address thinking skills in her/his teaching. Therefore one type of approach, pure qualitative or pure quantitative, is insufficient to address, explore, and elaborate on this phenomenon. So, assessing both quantitative and qualitative outcomes of the study helped develop a more in-depth understanding of “complex” real picture of their practices (Creswell, 2012; Gay, Mills, & Airasian, 2012).

3.5 The Design
The design is a multi-phased and mixed methods sequential design (Creswell, 2012). My research methodology involves three sequential phases:

1. Classroom observations to assess teachers’ use of strategies, critical thinking concepts, criteria for judgment, background knowledge and habits of mind that support critical thinking pedagogy (quantitative/qualitative) (see Appendix B1)
2. Survey questionnaires to assess teachers attitudes about use of strategies, critical thinking concepts, criteria for judgment, background knowledge and habits of mind that support teaching critical thinking (quantitative) (see Appendix B2 & B3)
3. Follow-up interviews to help triangulate on other data about teachers’ use of use of strategies, critical thinking concepts, criteria for judgment, background knowledge and habits of mind (qualitative) (see Appendix B4)

Collecting, integrating, and converging three kinds of data on the same study improves this inquiry by blending the strengths of different methods to neutralize the weaknesses found in others. Although both quantitative and qualitative data were gathered to complement each other in understanding the phenomena and discussing variables there is a greater emphasis on qualitative data. This means that this study employed a QUAL-quan model in which qualitative data are more heavily weighted than quantitative data (Creswell, 2012; Gay, Mills, & Airasian, 2012). Moreover, in phases I and II the Likert scales for both classroom observation and survey questionnaire were prioritized. Likert scale is an inexpensive and ordinal “measurement” of attitudes and beliefs that easily can be understood. This scale’s responses easily can be quantified. Besides, since this type of measure does not require participants to provide a concrete yes-no answer through the black-and-white view, it makes answering easier to respondent, and allows them to respond quickly and efficiently in a degree of agree/disagree spectrum. It can present neutral and undecided feelings as well. These two steps were followed by semi-structured interviews to collect qualitative data used to help triangulate the data from phases I and II.

3.6 Ethics
The application for ethic approval was submitted to the RISe (http://rise.ubc.ca/rise) for “Human Ethics” in January 14, 2013. The Approval was issued on behalf of the Behavioral Research Ethics Board (BREB) Okanagan, in February 12, 2013 (ID: H13-00072; see Appendix A1), as a “Minimal Risk” study. The study was completed as planned with minor
changes in timing and methods. As per UBC Okanagan Research Ethic Board guidelines, Dr. Philip Balcaen was designated as a Principal Investigator, and Mehdi Ghahremani was the UBC-O graduate students who completed this project for graduate requirements as per the UBC-O Master of Arts Program.

3.7 Procedure
After receiving institutional permission for access the context of the study and ethical approval, I traveled to Tehran, Iran to begin the research’s data gathering, on February 15, 2013. There, I met with and provided participants with a description of the proposed study and invited interested subjects to participate. Based on information provided about the study, I received consent from the volunteer subjects including the schools' principals and teachers (see informed consent documents in Appendix A). Before participating, the teachers/subjects were clearly informed by the researcher (Mehdi Ghahremani) about the purpose of study, the research procedure and their benefits and responsibility and the fact that they may stop participating in the study at any time without any repercussions. Consent was considered as an ongoing process. This means the initial signature on the consent form permitted researcher to proceed with the study but the researcher added information as he felt needed and then reconfirmed consent throughout the inquiry.

My research methods involve three sequential phases: (1) Classroom observation (quantitative/qualitative), (2) survey questionnaire (quantitative), and (3) follow-up interviews (qualitative). As noted earlier, doing the survey questionnaire (described in detail below) in the first step might have affected teachers’ instruction for the observation part and they might have changed their teaching methods, because of their awareness of the subject. Thus, to avoid “precautionary” changes in teachers’ behavior as participants, the first phase,
classroom observations were conducted before the phase II survey questionnaire. Based on these two first phases, seven science teachers were selected for the next and final step – interviews based on the following criteria: a) their instructional behavior and scores in the classroom observation scale of the first phase, b) including experienced and expert teachers, and c) including both female and male teachers.

Phases I and II were related to increase reliability. The classroom observation scale’s item and survey questionnaire’s items are correspondingly related. The third phase focused on chosen teachers’ conception of CT and their strategies to promote CT in the science curriculum for gifted students through in-depth interviews. Figure 3.1 summarizes the procedure for the data collection aspect of the study.

3.7.1 Phase I: classroom observation
According to Creswell (2012) and Springer (2010), observation is a process of gathering first-hand information as it occurs in a research setting to help study “actual” behavior. To access the actual instructional experiences, classroom observations in educational settings provides the best opportunity to observe how teachers behave in the classroom. For rich details, direct observation is an unparalleled assessment tool and source of information (Borland & Wright, 1994, p. 25). The type of design in this observational phase is nonparticipant observation where the observer is an ‘outsider’ who visits a site and records notes without interacting with participants and becoming involved in the activities (Creswell, 2012; Springer, 2010). However, it is worthy of note that based on my acquaintance with the context of the study (Iranian gifted schools) I am not completely an ‘outsider’ and I had to be conscious of this throughout the research.
3.7.1.1 Participants

Iranian middle and high school teachers’ instruction in the science classes (grades 7, 8, 9, and 10) were observed. The population of this phase of the study was science teachers in Iran’s two middle schools (one for boys and one for girls), and two high schools (again one for boys and one for girls). N=27 science teachers’ instruction (15 male and 12 female) were observed, two times (altogether 54 observations), in February and March 2013. In the observation part, the population was science classes, grades 7, 8, 9, and 10, in two middle and two high schools of Iran’s special and exclusive gifted schools system.

3.7.1.2 Instruments

I designed a 7-point Likert classroom observation scale, as a mean for recording descriptive field-notes during observations. By permission, I used Balcaen’s version of the TC² (2008) Likert scale for self-assessment of critical thinking pedagogy in combination with parts of The William and Mary Classroom Observation Scales – COS-R for short, (VanTassel-Baska et al., 2003, VanTassel-Baska et al., 2008; VanTassel-Baska, 2012 ) to design the observational scale for this research.

COS-R focuses on general teaching behavior and critical thinking as an instrument. COS-R is a 4-item uni-dimensional Likert scaling method, in which teachers’ behavior is measured using a Likert scale 0-3 (0=Not Observed, 1=Ineffective, 2=Somewhat Effective, 3=Effective). In terms of technical adequacy, VanTassel-Baska (2012) stated that the analyses in three studies showed that the COS-R scale was highly reliable: $\alpha=0.91$ to 0.93. Moreover, “based on content-validity assessment by four scholars in gifted education, the scale achieved an intra-class correlation coefficient of 0.98” (p. 47).
Figure 3.1 The Procedure for the Data Collection

1. Traveling to Tehran, Iran
   Contact & Invite Interested subjects to participate
2. Obtaining Informed Consent from Teachers & Schools’ Principal
3. Applying Stratified Random Sampling to Choose Science Teachers
4. Preparing Persian Version of Teachers’ Survey
5. Checking Persian Version with Three Experts in Language
6. Phase I: Observing Science Classes in Iranian Gifted Schools
7. Phase II: Conducting Teachers’ Survey Questionnaire
   - Simple Statistical Analysis of Findings in Phase I & II to choose teachers for Follow-up Interviews (Expert Sampling)
8. Phase III: Conducting In-depth Interviews
9. Data Analysis
   - Transcripts Returned to Participants for Feedback
   - Transcribing Interviews
Balcaen’s (2008) 7-point Likert scale involves three subgroups: providing critical challenges for classroom environment, teaching intellectual tools for thinking critically, and assessing for critical thinking. As mentioned earlier, these three items are main concerns in TC²’s conception of critical thinking. These studies and scales are validated and I used the scale in somewhat the same methods as the aforementioned researchers. The critical thinking items have been validated by Professor Roland Case, director of The Critical Thinking Consortium and his research team (U of T, SFU, and UBC).

Based on these two validated scales, a revised scale is designed for classroom observation. The revised version consists of five subgroups (See scale in Appendix B1):

1. General teaching behavior (formative assessment).

2. Nurturing a thinking classroom environment. Items 6-14 of the scale assess teachers’ instructional features in terms of the TC²’s concern on building a community of thinkers within the classroom, supporting thinking classroom environment by providing students with ongoing opportunities to engage them in cooperative dialogues, and modeling ‘good’ thinking (Balcaen, 2008; Bailin, Case, Coombs & Daniels, 1999; Case, 2005).

3. Teaching intellectual tools supporting critical thinking (as per TC²’s model). Items 15-23 of the scale explore teachers’ instructional characteristics in terms of the TC²’s emphasis on the five types of tools of thinking, including background knowledge, criteria for judgment, critical thinking vocabulary, thinking strategies, and habits of mind (Balcaen, 2008; Bailin, Case, Coombs & Daniels, 1999; Case, 2005).

4. Providing critical challenges and opportunities for critical thinking. Items 24-31 of the scale examine teachers’ instructional strategies in terms of the TC²’s concern for
infusing critical challenges throughout the subject matter, where criteria for judgment are required (Balcaen, 2008; Bailin, Case, Coombs & Daniels, 1999; Case, 2005).

5. Summative assessment of critical thinking. Items 32-38 of the scale examine teachers’ assessment of CT in terms of the TC’s view on assessing for the five types of the tools of thinking to see how students exhibit quality thinking (Balcaen, 2008; Bailin, Case, Coombs & Daniels, 1999; Case, 2005).

Observations in this study were semi-structured (Cohen, Manion, and Morrison, 2007), which enables the researcher to generate quantitative and numerical data, using an observational scale. In addition to structured and descriptive field-notes reflective field-notes (see sample in Appendix C1) were also recorded to collect qualitative data and to compare and contrast views as I examined teachers’ instructional behaviors.

3.7.1.3 The Data Collection Sample
Stratified random sampling was used to choose 27 science teachers in 4 grades (7-10): 12 middle school teachers (4 physics, 4 chemistry, and 4 biology), and 15 high school teachers (5 physics, 5 chemistry, and 5 biology) providing samples from both middle school and high school. This also provides the study with samples of each science areas (biology, chemistry, and physics). Using stratified random sampling for this study introduces more precision into the sampling design (Andres, 2012) and allows for comparison of subgroups or strata. The subgroups involve 12 strata including two gender categories, three instructional areas (biology, chemistry, physics), and two middle/high school categories.

According to Andres (2012), in terms of gender, a disproportionate stratification or unequal probability of selection process was employed, because “some strata are likely to be under-represented due to their small size” (p. 106) for instance female physics teachers. The
size of the population (number of science teachers in these four schools) is approximately 110 teachers. For this research, 27 science teachers were selected out of 110 possible participants in four Iranian gifted schools. Therefore, the selected sample can appropriately represent the population (~24% of the population).

3.7.2 Phase II: survey questionnaire
In the second phase, a paper-and-pencil survey questionnaire was given to participants. I met all participants in their school and gave them the survey questionnaire. A cross-sectional survey design was applied, in which quantitative data were collected at one point in time, rather than studying over time (Creswell, 2012; Gay, Mills, & Airasian, 2012). As Creswell (2012) state, “[a] cross-sectional study can examine current attitudes, beliefs, opinions, or practices” (p. 377). Thus, for this step, a 7 point Likert scale is designed to investigate science teachers’ current conceptions of critical thinking with regard to tensions in CT, (see Appendix B.2), and to assess their instructional strategies to promote CT (based on TC²’s conception). Such a cross-sectional survey has the advantage of providing data relatively quickly. However, a limitation of this design is that it is not effective in helping understand trends or developments over time (Gay, Mills, & Airasian, 2012).

As in phase I, participants in phase II were Iranian middle and high school science teachers (grades 7, 8, 9, and 10) who were observed in the first phase of the study. The population of this phase was science teachers in Iran’s two middle and two high schools. In addition to the 27 science teachers from the observational phase 10 subjects/teachers consented to participate just in phase II. This resulted in a participant group of 37 science teachers in the second phase of this study, in March 2013. As in the observation phase, the total population was approximately 110 science teachers, in grades 7, 8, 9, and 10, in two middle schools (one for boys and one for girls) and two high schools (again one for boys and
one for girls) of Iran’s special and exclusive gifted schools system. Hence, once again the selected sample can appropriately represent the population (~33% of the population).

3.7.2.1 The Likert Instrument

As described earlier, a 7-point Likert scale was designed as the teachers’ survey questionnaire (See Appendix B.2). On the first page, I note that participants “are free to not answer any question that they are not comfortable answering and they are free to withdraw from the study at any time without any negative consequence.” The questionnaire involves four subscales:

1. Background and demographic questions, such as gender, age, teaching area, field of educational study, and years of experience with gifted schools.

2. Agree/disagree Likert scale to examine science teachers’ perception with regard to CT’s aforementioned tensions, which includes statements on CT’s characteristics from different viewpoints. The statements reflect different aspects of CT-related issues from various schools of thought. Latent traits and themes in the teachers’ survey questionnaire for the pedagogy of CT involve: Approaches to CT (philosophical, psychological, and pedagogical), generality vs. domain-specificity tension, skills vs. habits/dispositions tension, nature vs. nurture/environment tension, creative vs. critical tension, and CT for gifted learners.

3. Likert scale, based on my literature review and the classroom observation scale were applied. This part involves items for kinds of self-assessment of CT pedagogy, according to TC²’s four-pronged framework. This part asks participants to respond to questions like “How often do the following issues happen in your instruction and/or in your classroom?” Most of the items in this section are exactly the same as the
classroom observation scale’s items. For instance, item 43 of the questionnaire and item 20 of the scale both address “employing brainstorming techniques.” Hence, it provides the researcher with opportunities to compare and contrast teachers’ perceptions of their instructional behavior and what they really do in their classrooms.

4. The 7 point rating scale related to three approaches to CT (philosophical, psychological, and pedagogical) and ‘skills vs. dispositions’ tension. This include several skills and habits of mind from three different perspectives, and asks teachers such questions as “based on your experience with gifted education, to what extent are the following skills and habits important in thinking critically.”

The participants needed approximately one hour to complete the survey questionnaire.

3.7.3 Phase III: follow-up interviews
Interviewing is one of the qualitative research methods helping the researcher learn from the qualities of experiences, look for broad trends or deep insights and/or interpret for meaning through purposefully conducted interviews and attentive listening (Mears, 2012). This third phase focused on seven chosen teachers’ conceptions of CT and their strategies to promote CT in science curriculum for gifted students. They were chosen based on the following criteria: a) their instructional behavior and scores in the classroom observation scale of the first phase, b) including experienced and expert teachers, and c) including both female and male teachers. Semi-structured interviews were conducted to examine these “expert” teachers’ understanding of CT and their approaches to promote thinking critically within science education in gifted classrooms/schools. (See interview protocol in Appendix B.4.)
3.7.3.1 Phase III Data Collection

In the third phase, the population was 37 science teachers in Iran’s two middle and two high schools, who have participated in phases I and II. Using expert sampling, 7 out of 37 science teachers from phases I and II, were selected for in-depth and semi-structured interviews to gather qualitative data on their perception(s) of CT and strategies used to cultivate CT in their high-ability students.

These interviews were one-on-one interviews using semi-structured and open-ended questions to allow participants to create their responses without being forced into predetermined possibilities (Creswell, 2012). The interviews were conducted in March and April, 2013. Five interviews took place in a public café and a hotel lobby with a quiet and comfortable atmosphere and the other two took place in schools at the teacher’s requests. However, the hotel lobby venue was more comfortable and appropriate rather than the schools. Table 3.1 demonstrates interviewees’ demographic data.

Table 3.1 Interviewees’ Demographic Data

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Alias</th>
<th>Gender</th>
<th>Age</th>
<th>Years of Experience in Gifted Schools</th>
<th>Type of School(s)</th>
<th>Alumni of Gifted Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>Mr. Kerem</td>
<td>M</td>
<td>44</td>
<td>15</td>
<td>High School</td>
<td>No</td>
</tr>
<tr>
<td>#2</td>
<td>Ms. Yasi</td>
<td>F</td>
<td>50</td>
<td>25</td>
<td>High School</td>
<td>No</td>
</tr>
<tr>
<td>#3</td>
<td>Mr. Xaki</td>
<td>M</td>
<td>41</td>
<td>22</td>
<td>High School</td>
<td>Yes*</td>
</tr>
<tr>
<td>#4</td>
<td>Ms. Sabz</td>
<td>F</td>
<td>30</td>
<td>10</td>
<td>Middle School</td>
<td>Yes</td>
</tr>
<tr>
<td>#5</td>
<td>Mr. Abi</td>
<td>M</td>
<td>34</td>
<td>16</td>
<td>Middle School</td>
<td>Yes</td>
</tr>
<tr>
<td>#6</td>
<td>Ms. Zard</td>
<td>F</td>
<td>48</td>
<td>13</td>
<td>Middle School</td>
<td>No</td>
</tr>
<tr>
<td>#7</td>
<td>Mr. Sourati</td>
<td>M</td>
<td>33</td>
<td>8</td>
<td>Middle School</td>
<td>No</td>
</tr>
</tbody>
</table>

* Teachers who were students in the Iranian exclusive gifted schools.

3.8 Data Analysis

The goal of these data analysis is to delineate the gifted science teachers’ educational view in terms of their conception of CT. The purpose of this analysis is to construct the human meanings and an attempt to understand teachers’ conceptualization and its essences helping
to reveal aspects of these educational settings. After completion of gathering data, I followed
the steps outlined below to analyze both the quantitative and qualitative data from classroom
observations, survey questionnaires, and interviews.

3.8.1 Quantitative Data Analysis
Before analyzing the quantitative data, I had to teach myself how to use the SPSS software to
analyze the data. I learned to follow the following steps:

Step 1: Data preparation. This step involves checking the questionnaire’s and scale’s data,
using SPSS to record data and Microsoft Excel to create codebooks.

Step 2: Descriptive statistics. It involves producing tables of frequencies, calculating measure
of central tendency (mean, median, and mode), producing graphical forms, such as bar-chart
and histogram. These were then used to summarize samples’ and measures’ of various
features and to do perform descriptive analysis (see Appendix C.2).

Step 3: Bivariate nonparametric analysis. This step involved two levels:

- Looking at the relationship between two variables. As the Likert scales produce
  ordinal variables, Spearman’s rho rank-order correlation coefficients were calculated
to find (significant) relationship between ordinal variables.

- Comparing two and more than two groups. Different statistical methods were
  employed to compare between groups: (a) doing cross-tabulation, Mann-Whitney U
test, and calculating Pearson chi squared in SPSS to compare between two groups
(nominal variables; for e.g. comparing teachers’ attitudes in terms of their
‘female/male’, ‘middle/high’ school, ‘alumni/non-alumni’ demographic data), (b)
using analysis of variance to compare more than two groups, and to examine
differences (for e.g. among three areas of teaching, age categories, etc.), by applying
nonparametric statistical tests in SPSS, such as Friedman test, Kendall’s W test, , and
Kruskal Wallis one-way analysis of variance. For instance, the differences between two measures in the first phase (observation) and second phase (questionnaire) were analyzed.

3.8.2 Qualitative Data Analysis

After each day of classroom observation, I reviewed my observational field-notes to add details that I had not recorded such as details of activities, thinking opportunities and classroom atmosphere, while the observations were fresh in my mind. In the same way, after each interview I attentively listened to the tapes not to analysis the data but rather to develop a general sense of ‘what was going on’, address how I could conduct my interviews more effectively and to realize my own weaknesses and strengths in interviewing.. This procedure helped me improve my interviews as time passed. For example, teachers were not comfortable with item 6 of interview protocol, and I omitted it from the protocol.

I used “traditional gradual reduction” methods (Saldaña, 2011) to analyze qualitative data from phase I & III, as follows:

Step 1: Transcribed interviews; detailed transcript of all recorded interviews. It normally took 8 to 10 hours to transcribe a 2-hour recorded interview. It led to about 140 pages of interview transcripts.

Step 2: copied transcripts; scanned each transcript and sent a PDF format to the interviewees for feedback.

Step 3: Read through all observational field-notes and interviews; marked with brackets the passages and divided them into meaning units.

Step 4: Cut and pasted meaning units to the colored A5 papers using a pair of scissors. I used different colors for each interviewee (seven different colors) and made a folder for each interviewee’s meaning units.
Step 5: Coded each meaning unit with a colored circle, and label them with a coded phrase (for e.g. gold-painted circle with a phrase ‘social & cultural’).

Step 6: Grouped these color-coded units into distinct categories reflecting semi-structured interview’s question guide.

Step 7: Read and analyzed collection of excerpts for sub themes; reduced all different teachers’ statement into 5-6 sentences/items that summarize these themes.

Step 8: Applied the themes as the basis for writing chapter four and its conceptual framework. Some of the emergent themes are significantly broad and out of the scope of this study (For instance, parental issues, social and cultural factors). I did not involve these themes in my findings and discussions.

3.8.3 Triangulation

Contemporary wisdom (Cohen, Manion & Morrison, 2000) suggest that more than one data collection technique is typically included in research studies to validate results. These different multi-method approaches are later compared and contrasted in a procedure called triangulation through which a researcher attempts to give a “more detailed and balanced picture” of the phenomena being studies (Altrichter et al., 2007; Lodico, M. G., Spaulding, D. T., & Voegtle, K. H., 2010). According to Cohen, Manion & Morrison (2000), in such multi-phased mixed methods research triangulation is “an attempt to map out, or explain more fully the richness and complexity of” teachers’ instructional “behavior by studying it from more than one standpoint and, in so doing, making use of both quantitative and qualitative data” (p. 112).

In this study, methodological triangulations were applied. One rationale is to capture a more complete picture of the science teachers’ teaching characteristics and their conceptions of CT, to increase validity and reliability while cross-checking information in
the sequence outlined in Fig 3.2. For example, in chapter four you will see how triangulation will give a more detailed and balanced picture of the teachers’ attitudes towards *generality of CT abilities*. As another example, science teachers’ complexity of understanding of open-mindedness will be more fully explained. Furthermore, making use of both quantitative and qualitative data in phase I and III will represent differences between teachers’ beliefs and their instructional behavior with regard to providing opportunities for students to generalize from concrete data to the abstract — what they think and what they really do.

![Research's Timeline]

**3.8.4 Confidentiality**

The participants’ identities were kept strictly confidential, as well as the school’s names and locations. Teachers’ confidentiality was and will be respected at all times by the researcher.
Computer data is password protected and all assessments, scales for classroom observation, survey questionnaire, and other documents related to the study will be kept in a locked filing cabinet at the researcher's residence, and after the study is complete, data will be kept in a locked filing cabinet in Dr. Balcaen’s office (EME Building # 3173) at UBC-O, for a period of five years. When those five years are past, all documents and assessments will be destroyed. Electronic records will be destroyed as well. Teachers will not be identified by name as they will be assigned a number for observational and questionnaire steps and a pseudonym for interview phase. Participants/teachers were provided with the draft of the study data and research’s findings for their comments and feedback. Figure 3.2 summarizes the research schedule.

3.9 Conceptual Framework
The conceptual framework operates as the theoretical glue that provides the “skeletal lumber” for the whole study (Saldaña, 2011). It acts as the network/link between the literature, the methodology, and the results. The conceptual framework delineates the key factors, interlinked concepts, variables, and relationship among them, based on researcher’s worldviews – the lens of belief system through which she or he constantly filters phenomena (Jabareen, 2009). A theoretical framework adds depth to research studies. At a more personal level, as Saldaña (2011) contends, according to individual’s own personal experiences, values, position, and attitudes towards a research question/topic the conceptual frameworks may vary from person to person.

In terms of the conceptual framework helping explain the data found here, I did not consciously pre-plan a framework. Conventionally, this study started from an inductive position. My framework gradually evolved and emerged as the study and my data analysis proceeded (Vaughan, 2008). Particularly, it evolved from a tension-based skeleton to a “4+1
elements’’ structure. Initially, reading Dai’s (2010) influential work, I planned to adopt a similar philosophical approach. He sets out a theoretical framework of nine essential tensions in gifted studies, such as being vs. becoming, and excellence vs. equity. However, piece by piece as my literature review, technical knowledge and my background in physics fused, I found the early ancient five elements of philosophical patterns offered a congruent conceptual framework that seem to match the emergent variables and building blocks of the study. Hence, I borrow classical elements theory from philosophy/physics field to frame the research’s findings. However, I also incorporate some parts of my initial tension-based approach.

3.9.1 ‘Four + one’ classical elements

The meaning and origin of physics always embraced the ever-lasting question: What is the nature of the matter that the universe is made from? Initial inquiries about these challenging questions were guided by an intellectually deep and aesthetically simple principle: “Entities, which at first glance appear quit different, may actually be alternate manifestations of the same essence” (Padamsee, 2003, p. 15). Despite the diversity, classical elements theory attempts to unify the universe, and to reduce multiplicity to a less puzzling scheme (Ball, 2004) something I hoped to do with my research data.

For instance, according to Padamsee (2003) and based on the following rationale, Thales chose water as a fundamental substance that he saw as the basis of everything:

Thales chose water because of abundance, universal presence, and….Water embodies two of the most fundamental attributes of nature: change and motion….Water can assume all the three distinct forms for matter: solid, liquid, and gas. (p. 15)
Some chose air (Anaximenes), earth (Xenophanes), or fire (Heraclitus). And some early philosophers challenged the idea that only one element could be the essence of a variety of substances in the universe.

Plato and Aristotle also postulated Empedocles’ notion. In Empedocles’ (about 440 B.C.) view there were four elements: earth, water, air, and fire (Ball, 2004; Kingsley, 1994). He introduced these fourfold “Roots”, as Gods (Kingsley, 1994). The so-called Aristotelian quartet theory advocated that all substances are composed of these four elemental statuses. In addition to the four earthly elements, Aristotle believed that the heavenly bodies are composed of another element, other than the four mundane earthly elements, namely aether (Hahm, 1982). According to Hahm (1982), in Aristotle’s doctrine, this celestial and unchangeable element had been associated with fire. This elemental theory anchors Hinduism, Buddhism, Chinese, Japanese, and Greek philosophy (Ball, 2004; Ferrey, 2012).

Even, Habashi (2000) and Kingsley (1995) claimed that the origin of the five-element cosmology seems to have Persian origins (Zoroastrian; about 600 B.C.). And this is important to me, because it contributes substantially to my identity as a Persian, as well as my lifelong passion for physics and philosophy.

I apply this five-part conceptual lens as a framework to present and interpret the essential elements in the aforementioned science teachers’ perceptions of thinking critically, as the emergent themes in my data analysis involve five themes or elements. The elements involve some characteristics, similar to the ancient ‘4+1’ classical elements that are discussed in chapter four.

3.10 Considering Reliability and Validity
As a philosophical (conceptual) framework, scientific realism underlies the quantitative aspects of this study which emphasizes objectivity. In contrast, social constructivism
underlies the qualitative aspects of this research which highlights subjective realities (Creswell, 2008). Thus, as Lodico, Spaulding, and Voegtle (2010) state, because “these two approaches include some contradictory assumptions about the nature of the real world, questions about the validity of combining these approaches [in mixed methods design] were raised” (p. 283). However, I believe that some aspects of educational phenomena have objective realities (for e.g. content of classroom discussion), whereas other aspects might be viewed more subjectively (for e.g. teachers’ perception of CT). Recognizing these characteristics of educational settings, one can consciously and cautiously use both frameworks in a mixed-methods pragmatic approach to deepen understanding of phenomena under study.

With regard to a mixed-method approach, *triangulation* of quantitative and qualitative data in different phases of the design has the potential to improve the reliability and validity of the study (Lodico, Spaulding, & Voegtle, 2010; Creswell, 2012). In order to ensure that the content of this research’s instruments is as valid as possible, it is noteworthy to mention that this multi-phased study is underpinned by two rigorous and extensive background researchers’; Balcaen’s (2008) work, and VanTassel-Baska’s and her colleagues’ (2003, 2008, and 2012) studies, that increase content validity of the study. Additionally, such interconnected multiple measures allow for more in-depth exploration of constructs (Andres, 2012).

In the first phase, a series of Cronbach's alphas are calculated for the designed scale (based on two validated scales), which allowed me to examine for internal consistency reliability. In terms of technical adequacy, I used the Cronbach's alpha of .94 for the entire set (38 items; \( \alpha = 0.94 \)). Therefore the new scale is highly reliable. The same analyzes are
employed for the survey questionnaire of the second phase of the research. The Cronbach's alpha for the entire set is .90 (83 items; $\alpha=0.90$) showing that the questionnaire is internally reliable and consistence.

In terms of external validity, this study’s sample is representative and can be generalized beyond the study sample to its population of Iranian science teachers in special gifted schools. However, the research findings probably cannot be simply generalized to all other contexts and science teachers. Claims of external validity and generalizability are considered as a simplistic idea and “not an adequate or accurate description of reality,” by quantitative, feminist, and post-structuralist researchers (Andres, 2012, p. 119).

Finally, validity and reliability are statistical indicators that have been attached to the quantitative tradition (Johnson, B., & Christensen, L. 2012). Validity refers to the accuracy of a measurement, or appropriateness of the instrument applied for the measurement. However, this study employed a QUAL-quan model, in which qualitative data are more heavily weighted than quantitative data (Creswell, 2012; Gay, Mills, & Airasian, 2012). Hence, statistical criteria are not as germane here. Fundamentally, in traditional philosophy, as Carspecken (1996) states, “validity refers to the soundness of arguments …claims that the analysis performed on the data was conducted correctly, and …the conceptual basis of the analytic techniques used is sound.” (p. 55-57) Therefore, the veracity of the claims can be examined in terms of soundness of the arguments, the data analysis’ methods – conformity and adherence to the truth. I, as a researcher, have a responsibility to ensure that the data analysis, discussions, and interpretations are accurate as possible. As the standard in qualitative research, according to Toma (2011), one of the criteria of assessing veracity is
“the consequence of applying the conclusion, interpretations, and recommendations of the work” (p. 270), the subject of Chapters four and five.
Chapter 4: Discussion of Findings

In this chapter, I apply the “4+1 classical elements” framework to interpret each aspect of my tension-based inquiry into the characteristics of science teachers’ conceptions of CT, in Iranian gifted schools. I take up TC²’s focus on intellectual tools supporting good thinking to help examine the extent of which science teachers in the Iranian gifted schools (grades 7, 8, 9, and 10) consider CT in their programs and instruction. In order to assist in closing the gap between theory and practice I also offer instructional suggestions for improving how critical thinking pedagogy might be better embedded into gifted science education in Iranian schools.

Within the discussion of findings, different multi-method approaches are compared and contrasted in a triangulation procedure (Lodico, M. G., Spaulding, D. T., & Voegtle, K. H., 2010). The triangulation involves use of “traditional gradual reduction” methods to analyze qualitative data from phase I & III and to identify emergent themes as well as applying nonparametric statistical analysis to examine relationship(s) between science teachers’ demographic information, (such as gender, number of years of experience in Iranian gifted schools, their educational background), and their quality of CT pedagogy.

4.1 The Domain-general vs. Domain-specific aspect
All seven participants in the interview phase indicate that critical thinking involves basic elements, features and characteristics that can be generalized across different contexts and domains. Ms. Sabz (interviewee #4), who has more than 10 years experience in teaching both physics and creative writing claims that we need the same CT abilities in both physics and writing courses. With regard to physical and natural science (biology, chemistry, physics, astronomy, and geophysics), teachers believe that these areas involve more general skills and
intellectual bases in common because of applying the scientific method. However, they were all aware that the knowledge and information about specific domains (e.g. History) and topics are required for well-informed reflection and thoughtful judgment. Moreover, two interviewees agree with Willingham’s (2008) statement that we can promote this type of thought even in three-year-old children and that experienced scientists can fail in attempts at good thinking.

According to my questionnaire, three items (8, 27, and 70) address the generality of critical thought and three items (11, 16, and 26) focus on domain-specificity aspects. Analyzes of these items reveals that science teachers in phase II of the study advocate for
Critical thinking skills can be generalized across different contexts and domains and can thus be taught in a generic way.

Table 4.1 Critical thinking skills can be generalized across different contexts and domains and can thus be taught in a generic way.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>1</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Disagree Somewhat</td>
<td>1</td>
<td>2.7</td>
<td>2.7</td>
<td>5.4</td>
</tr>
<tr>
<td>Neutral</td>
<td>4</td>
<td>10.8</td>
<td>10.8</td>
<td>16.2</td>
</tr>
<tr>
<td>Agree Somewhat</td>
<td>10</td>
<td>27.0</td>
<td>27.0</td>
<td>43.2</td>
</tr>
<tr>
<td>Agree</td>
<td>13</td>
<td>35.1</td>
<td>35.1</td>
<td>78.4</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>8</td>
<td>21.6</td>
<td>21.6</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

In support of her position Ms. Yasi (interviewee #2) states that, although in my understanding of good thinking, students who think effectively in math, physics and chemistry, logically must be able to generalize these types of thinking into other contexts of life, but the fact is they fail even in simple challenges in history or in their social life…. It seems that there is a separation between our schooling system and students’ everyday lives. (Ms. Lilac, personal communication, March 16, 2013)

Like Ms. Yasi, 75.7% of participants have the same opinion that students may exhibit CT and related abilities in one domain or context, but fail to do so in another (see Figure 4.2.). Ms. Yasi speaks of academic and real-life skills being different. She argues that this separation happens because of specialization saying that “our gifted students do not play by different rules and do not have different responsibilities in their lives” (personal communication, March 16, 2013). In her view, in comparison with her generation students
have less experience in different areas of life. Her comment implicitly addresses developmental theories in giftedness, such as Gagné’s (2004, 2005, 2011, and 2013) differentiated model of Gifted and Talented (DMGT), education which recommends mastery of “systematically developed” knowledge and skills in at least one ability domain for gifted education and transition from inherited natural abilities to the specific developed talents. For example, the Iranian gifted system cultivates students who are talented especially in numeracy or literacy. Although these talented individuals achieve outstanding successes this “specificity” based on her experience with talented learners causes the “separation” that Ms. Yasi (interviewee #2) addressed. Consequently, this specificity and “one-dimensionality” aspect may narrow talented students’ open-mindedness and attenuate their ability to think

![Figure 4.2 Item #11 of the Questionnaire](image-url)

**Figure 4.2** Item #11 of the Questionnaire
critically and effectively in different contexts/domains.

4.1.1 Degrees of freedom in Science and Humanities

Similarly to generality of CT abilities, Mr. Xaki (interviewee #3) and Mr. Abi (interviewee #5) indicate Ms. Sabz notion that thinking critically in both science and arts require general abilities. However they state that these disciplines require different means and instruments. Mr. Abi states that, “scientists apply laboratory equipment to measure the physical world’s properties and in the humanities they conduct questionnaires to ‘measure’ people’s understanding of something. I believe that both science and humanities use similar techniques”. (Personal communication, March 26, 2013)

Moreover, Mr. Xaki proposes the idea of “degrees of freedom” from statistical physics to express the differences between science and humanities. The degrees of freedom of a problem, system, or situation is the number of coordinates and/or parameters that are necessary to describe that case and may vary independently (Greiner, 2010). Mr. Xaki proposes that while there are similarities in both disciplines there are also marked contrasts. First, he argues that intrinsically degrees of freedom in humanities are more qualitative and in science more quantitative. He continues suggesting that “evaluation in science is qualitative. For example, you know if a value is 17.24±0.02. In science, an individuals’ curiosity can be easily satisfied” (Mr. Xaki, personal communication, April 19, 2013).

Second, the wide scope of degrees of freedom in humanities, rather than formal problems in science and engineering, suggests that CT is more appropriate for arts and humanities. He notes that, “in some cases in humanities the degrees of freedom are equal to the number of people related to that problem or even the number of people who live in our
This notion reminds us of the subjective vs. objective tension and the notion of different points of views. Arts and humanities involve personal and subjective points of view. While in contrast scientific facts are considered as objective realities. I believe that the more a challenge has degrees of freedom the more it is able to engage individuals critically. Despite the contrasts between these two disciplines (science and humanities) in the case of these teachers’ views on the fields of natural science students require same abilities to think critically in both biology and physics field (see Figure 4.3).

4.1.2 Domain-general g-based Approach
To analyze and justify Iranian science teachers’ perceptions of CT’s domain-generality it is helpful to recall g-based domain-general approaches to giftedness. Measures of IQ and
psychometric \( g \) scores still play an indispensable role in contemporary identification procedures of giftedness (see Sternberg, Jarvin & Grigorenko, 2011, pp. 17-24). As we see in the ‘nature vs. nurture’ tension, teachers have the general attitude that intelligence (high-IQ) as a natural and intrinsic factor playing a key role in thinking critically (fig. D.9 App. D.).

Responses to items 81 and 83 of questionnaire indicate that respondents agree with Sternberg and his co-authors (2011) and view critical thinking as a kind of intelligence. Sternberg, Jarvin and Grigorenko (2011) present three themes in 24 well-known cognitive psychologists’ beliefs about intelligence: capacity to learn from experience, ability to adapt surrounding environment and people’s understanding and control of their own thinking process: meta-cognition. However, these components are not what an IQ score practically indicates. These science teachers, based on their experience within gifted education, ranked “ability to adapt to the surrounding environment” and “learning from ideas and environment” as important abilities to think critically leading me to conclude that they see CT as a type of intelligence (high-IQ) and they have domain-general approaches to giftedness and intelligence. Therefore, from these science teachers’ point of view CT involves domain-general characteristics and abilities. To sum up, Figure 4.4 represents teachers’ attitudes (in phase II) towards the generality vs. domain-specificity tension by combining correspondingly related items in the questionnaire.

An examination of relationship(s) between science teachers’ demographic information (such as gender, their school type, area of educational background) and their conceptions of CT’s generality vs. specificity, bivariate analysis and cross-tabulation in SPSS (looking at the relationship between nominal and ordinal variables) shows that there is no statistical significance difference in this population. Chi square tests do not show a
significant level of difference in the response of female and male teachers to the items 8, 11, 26, ‘Generality’, and ‘Domain Specificity’ using the 0.05 cut-off point. However, a significant difference was found in the response of middle and high school teachers towards ‘Generality’ (Pearson chi square = 19.820, df = 11, p = 0.048). The results show a tendency towards general aspects of CT among high school science teachers compared to middle school teachers. The effect size for the chi square test, \( \phi = 0.732 \), suggests a strong relationship.

4.2 Five Elements of Iranian Science Teachers’ Conception of CT
With regard to the aforementioned findings that participants advocate generality of CT’s abilities rather than a domain-specificity view, science teachers participating in phase III of
the study were asked to describe and account for general abilities which are, in their opinion, central to thinking critically. Qualitative analysis, coding, categorizing, and developing hierarchical categories of emergent themes in these in-depth interviews reveals five crucial elements in these Iranian science teachers’ perception of CT and a critical thinker’s general competences. These are (I) Inquisitive & questioning mind, (II) Connections, (III) Probability of other possibilities, (IV) Intellectual courageous manner, (V) Conversation & interactions.

From these Iranian science teachers’ perspectives the five elements are common aspects of critical thinking. Below, the classical elements that were once believed as the essential constituents of all nature and matter are used metaphorically to picture these common aspects as competencies required for critical thinking. The elements which reflect ancient Persian, Chinese, Japanese, and Greek philosophy are Earth, Water, Air, Fire, and a fifth special element – the quintessential element ether. Each classical element is associated with one of CT’s general abilities in these teachers’ context of thinking. These elements offer educators an intellectual and instructional GPS to facilitate appropriate effective teaching strategies for developing thinking critically in all students and to enrich all classes.

4.2.1 Earth: Inquisitive & Questioning Mind
Five out of seven interviewees in the phase III of this study see this habit/disposition as a sub-structural component of a critical thinkers’ mindset. Curiosity and a questioning mind are central to some key conceptualization of CT, such as TC²’s framework (Case, R. & Daniels, L., 2005), Paul’s competencies (Paul, R., & Elder, L., 2006; Paul, R., Elder, L., & Bartell, T., 1997), and Mogensen’s (1997) epistemological perspective, which recall Socratic questioning methods. In addition to interviewees, 86.5% of science teachers participating in
the questionnaire phase consider ‘curiosity and inquisitiveness’ item as ‘very important’ and ‘extremely important’ disposition in thinking critically (see Figure 4.5).

Moreover, by calculating Spearman’s rho, the moderate level of correlation was found between two ordinal variables: item 8 of the questionnaire (Critical thinking skills can be generalized across different contexts and …), and item 67 (Curiosity and inquisitiveness). As Table 4.2 illustrates, in this case a correlation coefficient (Spearman’s $\rho$) equals 0.362, and correlation is significant at the 0.05 level ($p$-value = 0.028). Besides, as you can see in Table 4.2 these two variables are fairly correlated with item 86; motivation and interest. This
suggests that curiosity and inquisitiveness possibly arouse individuals’ enthusiasm to actively engage in CT procedures.

Table 4.2 Correlations

<table>
<thead>
<tr>
<th>Spearman's rho</th>
<th>67. Curiosity and inquisitiveness</th>
<th>86. Motivation and interest</th>
<th>8. Critical thinking skills can be generalized across different contexts and domains can thus be taught in a generic way.</th>
</tr>
</thead>
<tbody>
<tr>
<td>67. Curiosity and inquisitiveness</td>
<td>Correlation Coefficient</td>
<td>1.000</td>
<td>.426*</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.</td>
<td>.009</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>86. Motivation and interest</td>
<td>Correlation Coefficient</td>
<td>.426*</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.009</td>
<td>.</td>
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<tr>
<td></td>
<td>N</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>8. Critical thinking skills can be generalized across different contexts and domains and can thus be taught in a generic way.</td>
<td>Correlation Coefficient</td>
<td>.362*</td>
<td>.403*</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.028</td>
<td>.013</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>37</td>
<td>37</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Mr. Xaki (interviewee #3), Ms. Yasi (interviewee #2), Mr. Abi (interviewee #5), Ms. Zard (interviewee #6), and Mr. Sourati (interviewee #7), all describe a student with good thinking habits, as an individual who positively acts as a “brake” on their instruction by asking questions because a student has an eye for detail and asks for further information. The interviewees characterize these learners as students who were not easily convinced (Ms. Zard, personal communication, April 17, 2013; Mr. Xaki, personal communication, April 19, 2013), and who pose critical questions for the class to consider. From teachers’ view, Figure D.1 (Appendix D.1) illustrates the importance of posing such questions. Mr. Abi (interviewee #5) includes all CT abilities in this disposition:

Well, basically critical thinking is a questioning disposition; you know, in all domains, in architecture; why all houses have the same cubic shape? Can we make
them in other shape? … if this *questioning* habit exists, we have all we need! (Mr. Abi, personal communication, March 26, 2013)

Although I do not agree that having an inquiring mind is sufficient, in Mr. Abi’s view, a habitually inquisitive mind is the prerequisite and the essence of capabilities to think critically and to challenge even simple principles and everyday life experiences. From a similar perspective, Mr. Xaki proposed “challenge-thinking” and challenging thought as name critical thought. Inquisitive mind is absolutely necessary but not sufficient.

**4.2.2 Water: Flow of Connections**

As a general competence and skill, six out of seven of interviewees, accentuate individuals’ interest to compare, contrast, and uncover latent interconnections and interconnected ideas/phenomena. This addresses making interdisciplinary connections, by following the consequences of the fluid flow of interconnected ideas, associated with the quality of intuition. Mr. Kerem (interviewee #1), Mr. Abi (interviewee #5), and Ms. Zard (interviewee #6) put emphasis on the quality of intuitive awareness of the relationship among different ideas and contexts, in the learners who have good thinking dispositions.

Qualitative analysis of Interviewees’ perspectives results in a hierarchy of categories for investigation to discover and make connections, by comparing and contrasting ideas:

1. Connections within the subject matter
2. Interdisciplinary connections among different domains
3. Connections with real-life world and everyday experiences

These three levels of connectivity are central to the science teachers’ viewpoints on this second across-all-domain capability to think effectively and critically.
First, connections within the subject matter is the inner layer in the multi-layered nature of connections. To clarify this first layer, Mr. Sourati (interviewee #7) asserts Renzulli’s (Renzulli, J. S., Gentry, M., & Reis, S. M., 2004; Renzulli, J. S., & Reis, S. M., 2012) notion that one of the best and appropriate teaching strategies for gifted middle school learners is the inductive approach to teaching and learning. Ms. Sabz (interviewee #4) mentions that science teachers expect that students can see the connections between different parts of activities and different parts of classroom instruction and logically put different pieces of “the puzzle” together. He argues that induction leads to appropriate generalization and brings out “the big picture” within the subject matter – mainly for specific examples and activities to generalization and rules.

Figure 4.6 Item #40 of the Questionnaire
Ms. Sabz (interviewee #4) and Mr. Sourati (interviewee #7) posit that this approach provide students with the “AHA-moment” opportunities and sudden realization and insight. For instance, Mr. Sourati illustrates:

An example I can remember is the respiratory system. Well, I was explaining the mechanism of the gas exchange in the lungs, and suddenly a student said that this part of mechanism looks just like something happens in our kidney. You know! And they have learned that last year, and I didn’t ever mention that… I mean sometimes these really get me very excited!

He asserts that the flow of connections suddenly reveals “the big picture”, and provides students with the opportunity to delightfully taste the pleasure of revelation and discovery.

Second, interdisciplinary connections among areas as an influential mean deepens students’ understanding of the essence of a concept. Based on the interviewee teachers’ statements, inquiring structural similarities as well as inconspicuous contrasts provide students with critical thinking as well as creative thinking opportunities bringing different contexts/ideas together. However they understand that providing opportunities to think is different than teaching how to think. Ms. Sabz (interviewee #4) and Mr. Sourati (interviewee #7) declare that seeking connections that involves two or more fields of study is closely related to creative thinking and opens the door to creating novel ideas. Therefore, asking students to make interdisciplinary connections is considered as one of the instructional strategies to help “develop” thinking skills in classrooms (item #40 in questionnaire; See Figure 4.6). Bivariate analysis shows a moderate level of relationship between teachers’ responses on item 40 and item 18 of the questionnaire (see Table 4.3). The correlation coefficient (Spearman’s ρ) equals 0.403, and correlation is significant at the 0.05 level (p-
value = 0.013). This correlation moderately indicates that teachers who agree that “CT is higher-order thinking and that cognitive skills and abilities that are more appropriate for high-ability individuals”, usually apply this practical strategy in their classes.

As an example of this second layer of connectivity, Ms. Yasi (interviewee #2) complains that specialization and ‘one-dimensionality’ in talented programs negatively effects students’ sense of cohesion and continuity of scientific concepts in different contexts. She suggests that:

They cannot realize connections, even for the same concept in different domains; well, for example, the concept of atom; you know! They have this concept in both physics and chemistry. However, they sometimes see them as independent concepts and things: physics’ atom and chemistry’s atom! (Mr. Yasi, personal communication, March 16, 2013)

<table>
<thead>
<tr>
<th>Spearman's rho</th>
<th>40. Asking students to make interdisciplinary connections, and to connect subject matter with real-life experiences.</th>
<th>18. CT is higher-order thinking and cognitive skills and abilities that are more appropriate for high-ability individuals.</th>
</tr>
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<tr>
<td></td>
<td>Correlation Coefficient</td>
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<td></td>
<td>Sig. (2-tailed)</td>
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<td>40. Asking</td>
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<td>students to</td>
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<td>interdisciplinary</td>
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<td>connections,</td>
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<td>and to connect</td>
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<td>subject matter</td>
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<td>with real-life</td>
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<tr>
<td>18. CT is</td>
<td>.403</td>
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<tr>
<td>higher-order</td>
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<td>thinking and</td>
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<td>cognitive skills</td>
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<td>high-ability</td>
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<td>individuals.</td>
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</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).
Finally, as Ms. Sabz and Mr. Xaki highlighted, *Connections with real-life experiences* possibly establish a strong extrinsic motive force for gifted learners to engage critically in the learning process (see Dai, 2010; Renzulli, Gentry & Reis, 2004; Renzulli & Reis, 2012). The practicality of acquired knowledge facilitates contextual learning, brings reality and real-world problems into the class, and nurtures a thinking classroom. Five out of seven interviewees place particular emphasis on this aspect of connections.

4.2.2.1 **Real critical challenges & Renzulli’s high-end learning**

Real problems are obscured and surrounded by context, environmental and socio-economic issues, and even history. Use of such questions may encourage students to judge and evaluate the situation, and meaningfully frame “real” critical challenges. As Ms. Sabz asserts, using such questions may open doors to personalized problems and to simulate new interests for gifted learners. Thus, it can help pupils to set and achieve accessible personal goals. Mr. Xaki, for instance, mentions that boys are usually interested in soccer and how he used this interest to motivate them to learn physics: How to bend and curve a soccer ball and what is the scientific mechanism and explanation behind these phenomena. Based on the first phase of this study, classroom observation, Figure D.2 (Appendix D.1), illustrates science teachers’ acceptable awareness and capability to apply and adopt this instructional approach to science education.

Furthermore, this notion is aligned with Renault’s Triad Model and high-end learning. Renzulli and Reis (2012) define high-end learning as “[applying] relevant knowledge, research skills, creative and critical thinking skills, and interpersonal skills to the solution of a real problem” (p. 27). The original Triad Model, as they propose it, involves three types of enrichment: Type I is designed to stimulate new interests in gifted learners.
Type II involves materials and methods that facilitate development of critical and creative thinking. Type III is designed to promote higher level creative and research skills in which students pursue their self-selected area (Renzulli & Reis, 2012; Sternberg, Jarvin & Grigorenko, 2011). In this enrichment model, first-hand inquiry approaches, the challenging levels of investigative activities, real-world oriented problems, authentic contextual situations, and problem-solving skills are highlighted (Renzulli & Reis, 2012, pp. 21-31).

Thinking skills, in general, and creative and critical thinking in particular are inseparable in Renzulli’s conception of gifted programs. Hence, in my understanding of Renzulli’s model every individual who thinks effectively and well is considered as gifted. Three interviewees contend same notion that being a ‘good’ thinker equals ‘giftedness’.

4.2.3 Air: Probability of Other Possibilities
According to the Longman Dictionary of Contemporary English (2009) and Merriam-Webster’s Collegiate Dictionary (2003) “being up in the air” refers to being in an uncertain, doubtful, and undecided situation. So, this classic element of air is metaphorically used and refers to the situation that involves uncertainty and probability of plausible options. Talking about uncertainty, unpacking the nature of ‘air’ as comprised of many gasses all of different properties potentially works here as well. In addition, it implies air’s mobility and ability to penetrate into any ‘situation’, even settled and decided ones. Five of the interviewees propose this disposition as a general habit of thinking critically although just two of them used the word ‘open-mindedness’. From my understanding this element of air aptly addresses the disposition of open-mindedness: to entertain different ideas, to take contrary positions, and see alternative points of view. As air’s fundamental importance is to our lives, considering
other possibilities, making plausible inferences, predictions, or interpretations, and seeing probability of alternative conclusions have fundamental importance to the disposition of CT.

As evidenced in the questionnaire, all of these issues are correlated, “providing opportunities for students to generalize from concrete data to the abstract”; “Encouraging students to judge or evaluate situations, problems, or issues”; “Creating learning environments that involve ambiguity and equivocation”; “Encouraging multiple interpretations of events and situation”; and “Consciously providing an uncertain paradoxical situation in the classroom” (see Table D.1 in Appendix D.2). These correlations imply that these instructional strategies are moderately related for these teachers. Therefore, creating paradoxical and mysterious situations and encouraging students to predict, judge, or evaluate these situations, problems, or issues, provides learners with CT opportunities and facilitate developing their ability to consider other possibilities, recognize differences in points of view, and alternative ideas. Similarly, open-mindedness is one of the “global” habits of mind, central to many conceptualizations of CT (TC^2’s and Paul’s for example; see Case, R. & Daniels, L., 2005; Lipman, 2003; Paul, R., & Elder, L., 2006; Paul, R., Elder, L., & Bartell, T., 1997).

### 4.2.3.1 Possibilities in problem-solving

Furthermore, with regard to science teachers’ concern about problem-solving, in combination with open-mindedness, two of the interviewees Ms. Sabz and Mr. Xaki propose two other general competences:
First is studying, examining, and evaluating different approaches to tackling a question/challenge and solving a problem and then comparing and contrasting these different approaches. (Judge the better or best)

Second is changing a problem’s conditions/parameters, or dependent factors, and investigating the problem under different conditions, even special and critical, such as upper and lower bound limit analysis. (Rework the piece)

Mr. Xaki points out that more degrees of freedom of a problem, system, or situation may pose more “what if” questions, and then catalyze thinking critically and CT’s open-mindedness towards the challenge: “A situation with more degrees of freedom has more possibilities, more problem-solving approaches, and even, you know, may have different answers!” (Mr. Xaki, personal communication, April 19, 2013) He puts emphasis on the motivation and pleasure this framing of problems has for students and suggests two “effective” teaching methods of improving students’ motivation with regard to this issue:

(a) Changing problem’s parameters may arouse pupils’ interests. For instance,

In Newton’s gravity law \[ F = G \frac{Mm}{r^2} \], for example, changing the formula can attract students. You know; what happens if the force is inversely proportional to the power of three of distance \( \left[ \frac{4}{r^3} \right] \), instead of the square of the distance \( \left[ \frac{4}{r^2} \right] \) between the centre of two masses?! It opens door for sometimes imaginative answers. (Mr. Xaki, personal communication, April 19, 2013)
(b) Encouraging students to find other approaches to solve a problem can motivate students, even when we already have a solution, especially finding short problem-solving strategies and short-cuts. This second method address creative thinking, that almost all respondents see closely interconnection between critical and creative thinking. Ms. Yasi, Mr. Xaki, and Ms. Zard stress the fundamental importance of having wide range of experiences for both teachers, to choose appropriate content, and learners, to choose different approaches and to be more open-minded to the possibility that your knowledge or way of thinking might be incorrect.

Ms. Sabz and Mr. Xaki both specified this example in their interviews: In solving a physics (mechanics) problem, students can be asked to solve the problem with different strategies: (i) using kinematics (working with velocity, time, acceleration, etc.), (ii) applying dynamics and Newton’s three laws of motion (working with forces, acceleration, mass, free-body diagrams, etc.), (iii) using the law of conservation of energy (working with different types of energies, such as kinetic and potential), and to compare and contrast these different/alternative points of view. Evaluating these different perspectives on solving a problem is the inseparable part they insist.

Ms. Sabz mentions that she applies the same methods in her creative writing classes for example asking students to write about a special topic from different perspectives. Similarly, she sees “different points of view in literature” (e.g. narrative or third-person point of view) as using “different problem-solving approaches in physics” (e.g. the-law-of-conservation-of-energy method). In addition to these two teaching methods, she emphasizes real-world challenges by posing ‘real’ multi-faceted problems potentially provides more room for thinking about alternative ideas, and considering various aspects of a situation.
rather than using textbooks’ routine exercises such as “an object of mass 4 kg moving along the x axis with an initial velocity of …blah, blah, blah. Object! So, why it’s not a bicycle, instead of an object?” (Ms. Sabz, personal communication, March 18, 2013)

4.2.3.2 The importance of criteria

Bivariate analysis of science teachers’ responses in phase II of the study illustrates teachers’ awareness of “criteria” in creating uncertain learning environments that involve ambiguous situations. The correlation coefficient (Spearman’s $\rho$) between item 27 and 51 of the questionnaire, as you can see in Table 4.4, is 0.428, and correlation is significant at the 0.01 level ($p$-value = 0.008). The correlation coefficient (Spearman’s $\rho$) between item 27 and 47 equals 0.398 and the correlation is significant at the 0.05 level ($p$-value = 0.015). These correlations moderately imply that the teachers who usually create paradoxical and mysterious situation and invite students to consider probability of plausible options or alternative conclusions agree with Lipman’s (2003) perception that to think critically is to think based on, and in light of appropriate sets of criteria. So, for these teachers, considering other possibilities or alternative interpretations does not occur in a vacuum; without any criteria. Creating uncertain situation and invite students to consider other plausible options or alternative conclusions might motivate students to judge or evaluate situations/problems based on and in light of an appropriate set of criteria. In other words, it does not mean to consider all ridiculous probable cases. These science teachers view “possibilities” through the lens of “criteria”.

However, despite the fact that for the participants being open-minded and considering other plausible perspectives exceeded many other CT’s skills and dispositions in importance, classroom observations indicated that their teaching strategies do not satisfactorily meet the
importance of this habit of CT. When comparing scale’s scores in the observation part and responses in the questionnaire for the same items related to this issue (items 8, 22, 25, and 31 from the CO scale, and corresponding items; 42, 69, 47, and 48 in the questionnaire), unearth considerable differences between what these teachers think and what they really do. Figure D.9 (Appendix D.1) visualizes these corresponding items in the scale (left graphs) and the questionnaire (right graphs).

Table 4.4 Correlations

<table>
<thead>
<tr>
<th></th>
<th>51. Creating paradoxical and mysterious situation.</th>
<th>47. Inviting students to consider probability of plausible options or alternative conclusions.</th>
<th>27. To think critically is to think based on and in light of appropriate set of criteria.</th>
</tr>
</thead>
<tbody>
<tr>
<td>51. Creating paradoxical and mysterious situation.</td>
<td>Correlation Coefficient</td>
<td>.456**</td>
<td>.428*</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.005</td>
<td>.008</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>47. Inviting students to consider probability of plausible options or alternative conclusions.</td>
<td>Correlation Coefficient</td>
<td>1.000</td>
<td>.398</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.005</td>
<td>.015</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>27. To think critically is to think based on and in light of appropriate set of criteria.</td>
<td>Correlation Coefficient</td>
<td>.428*</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.015</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>37</td>
<td>37</td>
</tr>
</tbody>
</table>

**, Correlation is significant at the 0.01 level (2-tailed).
*, Correlation is significant at the 0.05 level (2-tailed).

Non-parametric statistical tests were applied to examine these differences: Friedman test and Kendull’s W test analysis of variables was used to compare these items from two phases of the study (classroom observation and survey questionnaire). The non-parametric Kendull’s W test is designed for analyzing significant differences among two groups of independent data that makes no assumption about probability distribution.
At the $\alpha = 0.05$ level of significance, there exists enough evidence to conclude that there is a significant difference between these four similar items in the two phase of the study; between how teachers think they instruct and what they really do (see Tables D.2-D.4 in Appendix D.2). For instance, as you can see in Table 4.5, a Friedman test was conducted to evaluate differences in medians (for the item “Invited students to consider probability of plausible options or alternative conclusions.”) between the scale ($\text{Median}= 4.00$) and questionnaire ($\text{M}=5.00$). The test was significant $\chi^2 (1, N = 27) = 6.368, p (= 0.012) < 0.05$ and the Kendall's Coefficient of Concordance of 0.236 indicated fairly strong differences (see stem-and-leaf graph in the Table 4.5). Tables D.2, D.3, and D.4 in Appendix D.2 present the same statistical analysis (descriptive statistics, Friedman and Kendall’s W tests), stem-and-leaf graphs, and significance differences among the other three items.

Table 4.5 Report for Friedman and Kendall’s W tests

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>CO Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>42. Providing opportunities for students to generalize from concrete data or information to the abstract.</td>
<td>8. Provided opportunities for students to generalize from concrete data or information to the abstract.</td>
</tr>
<tr>
<td>Mean</td>
<td>5.26</td>
</tr>
<tr>
<td>Median</td>
<td>5.00</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>.944</td>
</tr>
<tr>
<td>Variance</td>
<td>.892</td>
</tr>
</tbody>
</table>

Test Statistics\(^a\)

<table>
<thead>
<tr>
<th>Friedman Test &amp; Kendall’s W Test</th>
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<tbody>
<tr>
<td>N</td>
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<tr>
<td>Kendall’s W(^a)</td>
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<tr>
<td>Chi-Square</td>
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<tr>
<td>df</td>
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<td>Asymp. Sig.</td>
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</table>

\(^a\) Friedman Test
\(^b\) Kendall’s Coefficient of Concordance
As a general habit of a critical thinker, these science teachers put emphasis on considering other “possibilities” through the lens of “criteria” and making plausible inferences, predictions, or interpretations, and seeing probability of alternative conclusions. Specifically, possibilities in problem-solving in terms of examining, and evaluating different approaches to tackling a question/challenge, and changing a problem’s conditions/parameters, or dependent factors, and investigating the problem under different conditions.

4.2.4 Fire: Intellectual Courageous Spark

Except for one of the interviewees, all science teachers participating in phase III identified courage as one of the dispositions central to thinking critically. They all assert that ‘to make a comment’, ‘to pose a question’, ‘to participate in a classroom discussion’, ‘to make a prediction’, ‘to evaluate and judge a situation’, courage is a minimum and essential requirement. For each of these teachers, to think critically acting in a humble and courageous manner is an absolute necessity. Therefore, to promote a habit of courage teachers may encourage students “to express their thought” (item 4 of the scale), “to judge or evaluate situations” (item 6 of the scale), and “provide opportunities for students to develop and elaborate on their ideas” (item 30 of the scale).

This disposition is one of the intellectual and competency standards in Paul’s conception of CT (Paul, R., & Eder, L., 2006, 2008), and Mogensen’s (1997) dialectical perspective. Although TC² does not explicitly identify the importance of this habit; it is my understanding that providing students with critical challenges implicitly addresses this issue—in order to become habituated to behaving in a courageous manner students should be given the opportunities to face difficulties/challenges and to demonstrate and increase their
In comparing two groups through cross-tabulation in SPSS, a statistically significant difference was found in “female” and “male” teachers’ instructional behavior, in terms of ‘providing opportunities for students to develop and elaborate on their ideas’. Using the 0.05 cut-off point for Pearson chi square test, $\chi^2 (5, N=27) = 12.439, p\text{-value} (= 0.29) < 0.05$. Figure 4.7 visualizes this difference. For these items of the classroom observation scale (4, 6, and 30) no significant differences were found. This evaluation was done in terms of teachers’ age range, years of teaching experiences with gifted learners, being alumni of gifted schools, and school type (middle/high school) by applying the same non-parametric statistical tests.

Interviewees express powerful ideas about thinking critically. Mr. Xaki emphasizes that students who think critically have the courage to challenge assumptions, even subject matter or teachers’ pre-suppositions. Mr. Sourati (interviewee #7) stresses the importance of courage for students to express their opinions, to be more open-minded to the possibility that their knowledge or understanding might be incorrect (Air element), and to remove the mental barriers; “they have the courage to break invisible barriers and boundary walls that society and people build around them” (Mr. Sourati, personal communication, April 8, 2013). With regard to this notion, Ms. Zard (interviewee #6) maintains that critical thinkers have the courage to be different than others and to think differently. Thinking differently may results in defying some conventional methods and belief. Thus, teachers and parents may misinterpret their behavior as presumptuous manner. From the same perspective, Ms. Sabz states that “an evidence of thinking critically in pupils, I think, is the student who
courageously breaks our fixed thinking framework and um, yeah, I guess it’s related to creativity” (Ms. Sabz, personal communication, March 18, 2013). Ms. Zard mentioned the same relationship.

Figure 4.7 Differences Between Female and Male in Instructional Behavior

In addition to students, Mr. Abi and Ms. Zard acknowledge that teachers need and have to be courageous to promote CT in learners. “A teacher, who has no appropriate amount of courage cannot tolerate students’ courageous manner.” (Ms. Zard, personal communication, April 17, 2013). Mr. Abi observes that to provide a thinking classroom environment and critical challenges the teacher should have courage to energize a thinking atmosphere and to face its difficulties and consequences by question-storming, encouraging different and divergent ideas, regulating class discussions, and engaging in thoughtful classroom management. “It’s difficult. You know! Whoever would like to allow all students to ask any question they have? Well, and have the courage to say ‘I don’t know.’ It’s not easy to deal with. Not easy for everyone to do so.” (Mr. Abi, personal communication, March 26, 2013)
4.2.5 Quintessential Element: Conversation & Interactions

Socrates describes this element when he observes that “there was yet a fifth combination which God used in the delineation of the universe” (Timaeus 55c; as cited in Heisenberg, 2000). Thus, this unchanging element of “ether” is barrowed from ancient philosophy as a metaphor for delineation—or to describe and sketch out something carefully in detail so that people can understand it. The imagery of the quintessential element ether is used to represent the immutable feature of effective CT—the communicational and dialectical aspect of thinking as one interacts within a community aspect of these science teachers’ understanding of CT.

All interviewees addressed communicational and dialectical conversation as an essential feature of CT. According to the four interviewees, teachers can understand nothing about students’ understanding of subject matter, weaknesses, and their learning process, when learners do not actively participate in the class conversation and discussion. All interviewees see a ‘quiet classroom’ as an inappropriate learning atmosphere: “Without reflection, in a silent classroom, I cannot realize what’s going on. Are they thinking? Do they understand? I need hurly-burly of learning! You know! Acceptable amount of mess and commotion!” (Ms. Zard, personal communication, April 17, 2013) In addition, Mr. Sourati underscored the importance of providing a dialogical atmosphere to facilitate cooperative dialogue among students as an essential teaching strategy:

Like a crazy quilt! A piece came from what that student had heard in TV program; a piece was bring from what this student had read in a science magazine; a piece came from other student’s prediction; in some case, I bring some pieces. Finally, small pieces of different shape and colors have been sewn together. (Mr. Sourati, personal communication, April 8, 2013)
Using this metaphor, he describes the way different pieces of the subject matter were cooperatively proposed by students, to map a whole picture.

Mr. Sourati complains about some traditional teaching models such as lecturing that does not support thinking because of the lack of dialogue. These notions are parallel with the Mogensen’s (1997) dialectical perspective and Lipman’s (2003) emphasis on the individual’s interaction. In contrast to the traditional ‘technical’ manner, and under the influence of Vygotskian theory, Lipman believes that the development of CT occurs in the individuals’ interactions with a community of peers, through verbal exchanges and philosophical dialogues to improve personal and social experiences (Daniel & Auriac, 2009).

According to the notion of conversation, Lipman introduces “the community of inquiry” (CoI) approach, as a social activity, to schooling and instruction (Garrison, Anderson, & Archer, 2010). The approach highlights the effectiveness of groups’ use of inquiry-based strategies in the educational areas, and the conversion of routine classrooms into community of inquiry, in which “students can generate and exchange ideas, clarify concepts, develop hypotheses, weigh possible consequences, and in general deliberate reasonably together” (Lipman, 2003, pp. 105-106). In this regard, Ms. Zard and Mr. Abi acknowledge that one of the significant obstacle and restrictions on implementing CT pedagogy in the science curriculum is the traditional view of teaching as the “transmission” model of instruction.

To sum up, Figure 4.8 illustrates and visualizes a pentagram of five elements for thinking critically, based on analyzing Iranian teachers’ perception of CT in the scientific context.
4.3 Pedagogical Tensions

Exploring dimensions of Iranian science teachers’ conceptions of a careful and conscientious thinker, in addition to elemental analysis, my tension-based inquiry reveals more characteristics of these teachers’ attitudes towards CT pedagogy. This tension analysis will facilitate better understanding of elements analysis.

4.3.1 The Transmission vs. Transformation Tension

Mr. Abi complains about the transmission of knowledge, in large amount, especially in gifted enrichment programs (Mr. Abi, personal communication, March 26, 2013). In considering Miller’s (1990) three major positions in curriculum process it’s notable that, the predominant orientation in most Iranian public schools is the “transmission position.” As Miller explains,
“in the transmission position, the function of education is to transmit facts, skills, and values to students” (p. 5). This orientation stresses textbook learning and traditional teaching methods. Mr. Sabz, Ms. Zard, and Mr. Abi put emphasis on Mogensen’s (1997) transformative perspective as well as Lipman’s (2003) view that promoting critical thinking requires “the conversion of ordinary classrooms into communities of inquiry” (p. 105), which is one of the fronts in TC²’s four-pronged approach (Case, R., & Daniels, L., 2005). Figure D.3 illustrates teachers’ attitudes toward creating an interactive learning atmosphere and encouraging class discussions (the questionnaire’s item 57). Although this response shows the importance of interaction within a community of peers in teachers’ view, their responses to the items 38 and 39 implicitly do not support effective use of appropriate instructional strategies, such as grouping students and changing classroom arrangement to facilitate interaction and discussion (see Figure 4.9). Moreover, employing brainstorming techniques is one of the
highly effective teaching strategies to promote cooperation and communication. The stem-and-leaf graph in Table 4.6 visualizes the responses to item 43 of the questionnaire, in which teachers were asked “how often do the following issue(s) happen in your instruction and/or in your classroom”, and item 43 asks specifically about “employing brainstorming techniques”. Additionally, it represents scores for the same item in the classroom observation scale. This analysis suggests a difference between classroom observation and questionnaire data.

Bivariate statistical analysis indicates that at the $\alpha = 0.05$ level of significance, there exists more than enough evidence to conclude there is a significant difference between those aforementioned similar item, in the two phase of the study; between how teachers think they instruct and what they really do, related to brainstorming (see Table 4.6). A Friedman test was conducted to evaluate differences in medians between the scale (Median= 3.00) and the questionnaire (M=5.00). The test was significant $\chi^2 (1, N = 27) = 15.696, p < 0.05$ and the Kendall’s Coefficient of Concordance of 0.581 indicated strong differences (see stem-and-leaf graph in the Table 4.6).

Furthermore, Ms. Sabz proposed “oral peer-evaluation” as one of her direct teaching strategies which “neatly and frankly” brings CT into the classroom discussion. Ultimately, Mr. Xaki mentioned one of the Iranian old proverbs from Sa'dî’s well-known book, The Gulistan (Or, Rose Garden of Sa'dî), which states “while a man says not a word, his fault and virtue are concealed.”⁴ (Archer & Rehatsek, 1964)

4.3.2 The Critical vs. Creative Thinking Tension

Five interviewees discussed the close interconnection between critical and creative thinking.

In these teachers’ view, the area of intersection between ‘Fire’, ‘Water’ and ‘Air’ elements is

⁴ It is better to be thought a fool than to open your mouth and remove all doubt!
creative thinking. First this relationship surfaces in terms of seeking connections that involve
two or more fields of study. Teachers indicate this as they explore structural similarities
between these two modes of thinking as they provide students with creative thinking
opportunities and as they open the door to creating novel ideas bringing different contexts
together. Second, in terms of seeing other possibilities, Mr. Xaki facilitates both creative and
critical thinking as he suggests ‘encouraging students to find other approaches to solve a
problem’ as an “effective” teaching methods to motivate gifted learners.

Table 4.6 Friedman & Kendall’s W Tests

<table>
<thead>
<tr>
<th>N</th>
<th>Mean</th>
<th>Std. Devi.</th>
<th>Min.</th>
<th>Max.</th>
<th>25th</th>
<th>50th</th>
<th>75th</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>2.93</td>
<td>1.328</td>
<td>1</td>
<td>6</td>
<td>2.00</td>
<td>3.00</td>
<td>4.00</td>
</tr>
<tr>
<td>43</td>
<td>5.00</td>
<td>1.074</td>
<td>3</td>
<td>7</td>
<td>4.00</td>
<td>5.00</td>
<td>6.00</td>
</tr>
</tbody>
</table>

Friedman Test & Kendall's W Test

<table>
<thead>
<tr>
<th>Test Statistics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>27</td>
</tr>
<tr>
<td>Kendall's W</td>
<td>.581</td>
</tr>
<tr>
<td>Chi-Square</td>
<td>15.696</td>
</tr>
<tr>
<td>df</td>
<td>1</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>.000</td>
</tr>
</tbody>
</table>

a. Friedman Test  
b. Kendall's Coefficient of Concordance
In the same way, Ms. Sabz declares that “a student who thinks critically, in addition to evaluation based on some criteria, attempts to find other solutions and approaches…. And practically, in order to think critically, we usually ask [students] to put all solutions aside and think about new and better ones” (Ms. Sabz, personal communication, March 18, 2013). She defines creative thinking as a final stage of thinking critically. In contrast, Sternberg (1996) categorized creative thoughts as a first step in thinking processes. He proposes three discrete thinking skills’ function: creative thinking in generating ideas, critical thinking in evaluating these ideas, practical thinking in implementing the ideas, and wisdom to ensure that the decisions are used for a common good (Sternberg, Jarvin, & Grigorenko, 2010).

![Figure 4.10 Item #14 of the Questionnaire](image)
Mr. Xaki and Mr. Sourati express creative thinking as a supplementary part of thinking critically. However, Ms. Zard claimed that CT is a more fundamental thinking skill, rather than creative thoughts. Same notion can be seen in the respondents’ questionnaire. Figure 4.10 illustrates N=37 science teachers’ response to the item 14: “A certain amount of creativity is necessary for critical thought.” Nonparametric analysis shows no differences among demographic variables.

### 4.3.3 The Skills vs. Habits Tension

The philosophical normative perspective on CT has developed through discourse, rationality and logical argumentation while psychological descriptive approaches to CT have elaborated and developed from an experimental research paradigm (Lewis & Smith, 1993). Psychological perspectives emphasize CT’s cognitive *skills* and problem-solving strategies within the actual mental process (Daniel & Auriac, 2009, Sternberg, 1986). Particularly, the cognitive psychological view has focused on the experts’ manner of ‘thinking’ *skills* in relation to ‘intelligence’. In general, cognitive psychology’s conceptualization is a *skill-based* approach to thinking critically. Based on this cognitive skills-based approach, it is common to introduce a taxonomy of skills to categorize CT strategies based on Bloom’s (1956) *taxonomy of educational objectives*.

In contrast, philosophical and pedagogical views put more emphasis on “dispositions” and “habits of mind” of a thoughtful person (Daniel & Auriac, 2009). Based on Paul’s (1997) delineation, a philosophical view is a normative individual-centered one that focuses on characteristics of a hypothetical ideal person who performs, in Case (2005) words, “high-quality” critical thinking—sometimes characterized as “good” thinking. Philosophical and pedagogical approaches tend to identify similar sets of critical thinkers’ habits and
dispositions. For instance, open-mindedness, fair-mindedness, and inquisitiveness are the most commonly cited indicators of a CT’s critical spirit (e.g., see Bailin, S., Case, Coombs, & Daniels, 1999; Case, 2005; Ennis, 1985; Facione, 1990, 2011; Paul & Elder, 2006; Siegel, 1980). Although some researchers in the psychological stream agree that CT involves habits (see Halpern, 1998), the role of dispositions is a matter of an ongoing debate in terms of its practicality.

Table 4.7 Correlations

<table>
<thead>
<tr>
<th>Spearman's rho</th>
<th>67. Curiosity and inquisitiveness</th>
<th>73. Fair-mindedness</th>
<th>74. Independent-mindedness</th>
<th>85. Flexibility</th>
<th>8. Critical thinking skills can be generalized</th>
</tr>
</thead>
<tbody>
<tr>
<td>67. Curiosity and inquisitiveness</td>
<td>Correlation Coefficient</td>
<td>1.000</td>
<td>.168</td>
<td>.273</td>
<td>.447</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.</td>
<td>.322</td>
<td>.102</td>
<td>.005</td>
</tr>
<tr>
<td>73. Fair-mindedness</td>
<td>Correlation Coefficient</td>
<td>.168</td>
<td>1.000</td>
<td>.646*</td>
<td>.719*</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.322</td>
<td>.</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>74. Independent-mindedness</td>
<td>Correlation Coefficient</td>
<td>.273</td>
<td>.646</td>
<td>1.000</td>
<td>.685</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.102</td>
<td>.000</td>
<td>.</td>
<td>.000</td>
</tr>
<tr>
<td>85. Flexibility</td>
<td>Correlation Coefficient</td>
<td>.447</td>
<td>.719</td>
<td>.685</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.005</td>
<td>.000</td>
<td>.000</td>
<td>.</td>
</tr>
<tr>
<td>8. Critical thinking skills can be generalized</td>
<td>Correlation Coefficient</td>
<td>.362</td>
<td>.442</td>
<td>.432*</td>
<td>.422</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.028</td>
<td>.006</td>
<td>.008</td>
<td>.009</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

In my consideration of the five elements of Iranian science teachers’ conceptions of CT, all general abilities are categorized into the philosophically oriented disposition/habits of mind categories. In my understanding of the interviews, teachers’ conception of CT’s generally aligns with their attitudes towards the dispositions and habits of critical and thoughtful minds.
Evidence from phase II of this study supports this notion. For example, teachers’ responses to items 9, 67, 69, 72, 73, 74, and 85 emphasize the importance of dispositions in critical thinking. The chart-bars in Figure D.4 (Appendix D.1) illustrate responses to the question “to what extent the following skills and habits are important in thinking critically?” in relation to open-mindedness, fair-mindedness, independent-mindedness, and flexibility. In summary, with regard to the “Philosophical versus Psychological Tension”, these teachers’ view can be categorized in the philosophical habits-centered perception of thinking critically.

Additionally, a moderate level of correlation was found between item 8 (critical thinking skills can be generalized across different context and domain) and items 67 (curiosity and inquisitiveness), 73 (fair-mindedness), 74 (independent-mindedness), and 85 (flexibility) of the questionnaire (see Table 4.7). Moreover, item 74 (independent-mindedness) and items 11 and 19, negatively correlated. This evidence suggests that from science teachers’ point of view the generalizability of CT abilities is closely related to their understandings of critical spirit and dispositions.

### Table 4.8 Mann-Whitney U Test Statistics\textsuperscript{a,b}

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>113.500</td>
<td>139.000</td>
<td>75.000</td>
<td>104.500</td>
<td>88.500</td>
</tr>
<tr>
<td>Chi-Square</td>
<td>1.757</td>
<td>.148</td>
<td>7.094</td>
<td>2.351</td>
<td>4.425</td>
</tr>
<tr>
<td>df</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>.185</td>
<td>.701</td>
<td>\textbf{.008}</td>
<td>.125</td>
<td>\textbf{.035}</td>
</tr>
</tbody>
</table>
\textsuperscript{a} Kruskal Wallis Test  
\textsuperscript{b} Grouping Variable: 6. What is your area of education?

Non-parametric analysis, Mann-Whitney U test and Kruskal Wallis one-way analysis of variance were conducted to examine differences among the questionnaire’s participants, in terms of gender, age, years of experience with gifted schools, school type (middle/high
school), teaching area, being alumni of gifted schools, and area of educational background. According to Dancey & Reidy (2011), Kruskal Wallis test were used to compare two or more independent samples, which is an extension of Mann-Whitney U test that does not assume a normal distribution, and can be used to examine groups of unequal size. Applying these tests, at the $\alpha = 0.05$ level of significance, Table 4.8 offers enough evidence to conclude that there is a difference in the teachers’ attitude towards the importance of habits/dispositions in thinking critically, in terms of their area of educational background: Teachers with “science & math” background have more positive attitudes towards habits/dispositions, rather than teachers from “engineering” educational background. The stem-and-leaf graph visualizes this difference.

![Figure 4.11 Differences Based on Areas of Education](image)

**6. What is your area of education?**

Figure 4.11 Differences Based on Areas of Education
On the other hand, based on data analysis of the survey questionnaire including items 15, 21, 28, 68, and 76, N = 37 science teachers also have a cognitive skill-based view of CT (Figure D.5 in Appendix D.1, see responses to items 15 and 28). However, a series of correlations reveals positive relationships between teachers’ skill-based approach and their domain-specificity attitudes. For example, teachers who indicate that “cognitive skills and problem-solving strategies are more central to CT rather than reasoning and good judgment, and logic” (item 28 of the questionnaire), also indicate that “critical thinking and thinking abilities in physics are completely different from critical thinking and required abilities in biology” (item 26 of the questionnaire). For this case, \( r (35) = 0.357, p < 0.05 \). See Table 4.9.

Applying nonparametric analysis, Kruskal Wallis one-way analysis of variance, at the \( \alpha = 0.05 \) level of significance, quantitative data analysis proposes statistical evidences implies that there is a difference among biology, chemistry, and physics teachers’ attitudes towards the importance of cognitive skills in thinking critically (Table 4.10). In comparison, the biology and chemistry teachers participating in the phase II of this study have more positive attitudes towards skill-oriented psychological view on CT as opposed to the more normative views held by physics teachers (See stem-and-leaf graph).

Furthermore, a Mann-Whitney U test was conducted to examine differences among the questionnaire’s N = 37 participants, in terms of gender, school type (middle/high school), and being alumni of gifted schools. Findings from nonparametric analysis show that science teachers who are not alumni of the Iranian gifted schools believe that “cognitive skills and problem-solving strategies are more central to CT, rather than reasoning, good judgment, and logic”, more than alumni teachers (item 28). Based on my experience with gifted schools and my conversation with teachers non-alumni teachers tend to have a psychological view of CT.
Table D.5 in Appendix D.2 contains a stem-and-leaf graph that visualizes this difference among teachers.

**Table 4.9 Correlations**

<table>
<thead>
<tr>
<th>Spearman’s rho</th>
<th>16. Critical thinking and required abilities in biology are completely different from critical thinking and required abilities in history.</th>
<th>26. Critical thinking and required abilities in physics are completely different from critical thinking and required abilities in biology.</th>
<th>28. Cognitive skills and problem-solving strategies are more central to CT, rather than reasoning, good judgment, and logic.</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. Critical thinking and required abilities in biology are completely different from critical thinking and required abilities in history.</td>
<td>Correlation Coefficient</td>
<td>1.000</td>
<td>.481</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td>.003</td>
</tr>
<tr>
<td>26. Critical thinking and required abilities in physics are completely different from critical thinking and required abilities in biology.</td>
<td>Correlation Coefficient</td>
<td>.481</td>
<td>1.000</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.003</td>
<td>.</td>
</tr>
<tr>
<td>28. Cognitive skills and problem-solving strategies are more central to CT, rather than reasoning, good judgment, and logic.</td>
<td>Correlation Coefficient</td>
<td>.432</td>
<td>.357</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.008</td>
<td>.030</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).**  
**. Correlation is significant at the 0.05 level (2-tailed).**

A synthesis of the aforementioned findings leads to the conclusion that if teachers, with different characteristics could be ranked in terms of a cognitive skill-based psychological conception of CT this research supports the position that physics teachers, who are the alumni of gifted schools, are at the end of that ranking list—meaning that these physics teachers have a more philosophical habits-centered perception of thinking critically (Table 4.10).
28. Cognitive skills and problem-solving strategies are more central to CT, rather than reasoning, good judgment, and logic.

15. Critical thinking is a set of (mental) procedures, such as steps involved in problem-solving, or the stages of inquiry.

21. Speed of mental processing is an important factor in thinking critically.

68. Speed of mental processing

<table>
<thead>
<tr>
<th></th>
<th>28. Cognitive skills and problem-solving strategies are more central to CT, rather than reasoning, good judgment, and logic.</th>
<th>15. Critical thinking is a set of (mental) procedures, such as steps involved in problem-solving, or the stages of inquiry.</th>
<th>21. Speed of mental processing is an important factor in thinking critically.</th>
<th>68. Speed of mental processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>3.972</td>
<td>3.731</td>
<td>7.439</td>
<td>6.337</td>
</tr>
<tr>
<td>df</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>.137</td>
<td>.155</td>
<td>.024</td>
<td>.042</td>
</tr>
</tbody>
</table>

a. Kruskal Wallis Test
b. Grouping Variable: 4. What is your teaching subject and area?
All in all, based on elements analysis and tension analysis in this research study, understanding of these teachers’ perception of CT follows:

- The intersection of Water, Air, and Fire elements addresses creative aspects of critical thoughts (Figure 4.12).

![Figure 4.12 The Intersection Area for Creative Thinking](image1)

- The intersection of Earth, Water, and Air elements imply open-mindedness – willingness to entertain different ideas, recognize contrary positions and differences in points of view (Figure 4.13).

![Figure 4.13 The Intersection Area for Open-mindedness](image2)
The intersection of Earth, Fire, and Ether elements addresses creating and posing critical challenges (Figure 4.14).

The area of intersection between Air, Fire, and Ether imply fair-mindedness –

Figure 4.14 The Intersection Area for Posing Critical Challenges

Figure 4.15 The Intersection Area for Fair-mindedness
empathizing with others through fair hearing to alternative and other *voices*, to consider real possibilities, and to avoid judging based on personal interests (Figure 4.15).

- The area of intersection between Earth, Water, and Ether addresses full-mindedness – an inclination to recognize a web of effects, different stereotypes, and to acquire a holistic view and adequate understanding of the phenomena before taking a position (Figure 4.16).

As a representation of my *elemental & tensional inquiry* and analysis, the previous five-pronged pentagram and the areas of intersections visualize dimensions of aforementioned Iranian science teachers’ conception of CT.
4.4 Pre-conditions for a “quality thinking” classroom

Before we turn to introducing these pre-conditions, it is note-worthy to mention following points from interviewees’ responses.

- Middle school, especially grade 7 is the most appropriate time for promoting CT in these science teachers’ view.

- Five interviewees express note-taking as one of the significant and real obstacles in the way of fostering CT in the learners. For example, Mr. Sourati mentioned that in the first session of each class, he humorously explains to students that “there is a ‘writing nerve’ that directly goes from your ears to your right [or left] hand without passing through your brain. Yes! So, while taking notes, your brain is off!” *(Mr. Sourati, personal communication, April 8, 2013)*

- Teachers’ after-school availability and after-school programs have a profound pedagogical impact on developing effective CT abilities.

In these science teachers’ views, four kinds of pre-conditions are required to prepare appropriate learning situation and CT atmosphere in classrooms. First, they put considerable emphasis on awareness of students; their concerns, fears and interests, talents, their family backgrounds, friends, strengths and weaknesses, and their successes and failures in previous years of schooling. Specifically, awareness of students’ learning styles (visual, auditory, kinesthetic, etc.) provides teachers with effective teaching approaches to engage different learners in the thinking process. Second, teachers’ relationships with their students, in terms of having the sense of how they feel and think, is necessary to assist them in CT approaches. Awareness of, and developing relationships with students are central elements in a student-centered facilitator approaches to differentiate and to teach effectively *(Fenstermacher & Soltis, 2009)*. According to Fenstermacher and Soltis (2009), Gardner’s theory of multiple
intelligences offers an effective way to understand the two aforementioned factors. Multiple intelligences empower teachers’ capacity to become aware of their students. However, it is really taking the time to understand your students’ strengths and weakness and teaching to them; the MI theory is one way of thinking about this.

Thirdly, considering “Embedded vs. Explicit” tension within the field of CT pedagogy, all interviewees advocate an embedded approach to curriculum. They see critical thinking as a way of teaching, rather than an add-on to the curriculum. Although some recent studies found that an explicit mode of teaching CT is more effective (Marin & Halpern, 2011), the notion that curriculum-embedded approaches to improve CT abilities is endorsed by many authorities in the field (Case, 2005; McPeck, 1981; Paul & Elder, 2006). Finally, in the interview respondents’ view, appropriate content is one of the key factors in infusing critical thinking throughout the curriculum. As Mr. Abi asserts, choosing appropriate content, based on students’ concerns, interests, talents, strengths and weaknesses, better facilitates their engagement, motivates them to participate in classroom discussions, and encourages them in thinking collaboratively. For example, he compared concepts of heat and magnetism for middle school pupils and concluded that heat is a more appropriate subject as a context of thinking critically as it is more related to students’ everyday experiences and it does not need technical knowledge to proceed with thinking. So, it gives all students the courage to speak up.
Chapter 5: Conclusion

In this multi-phased mixed method thesis, through the lens of “4+1 classical elements” conceptual framework and my tension-based inquiry, I have explored dimensions of Iranian science teachers’ conceptions of thinking critically and a careful and conscientious thinker in the context of four Iranian exclusive gifted schools. This empirical inquiry is framed by TC²’s four-pronged framework I examined N=37 Iranian science teachers’ understandings of critical thinking in grades 7, 8, 9, and 10.

5.1 Pedagogical Tensions
Evidence from the inquiry indicates that these teachers’ views can be summarized as the following:

The Generality vs. Domain-specificity Tension. Critical thinking involves basic elements, features and characteristics that can be generalized across different contexts and domains. However, students may exhibit CT and related abilities in one domain or context but fail to do so in another.

The Critical vs. Creative Thinking Tension. Five interviewees discussed the close interconnection between critical and creative thinking. In these teachers’ views the ‘Fire’, ‘Water’ and ‘Air’ elements are at the intersection of CT and creative thinking.

The Skills vs. Habits Tension. From my consideration of the five constituents of Iranian science teachers’ conceptions of CT, all of the general abilities that they addressed can be categorized into the habits of mind category rather than a “skill” one.
The Philosophical vs. Psychological Tension. Viewed from my understanding of the interviews, these teachers’ conception of CT’s generally aligns with their attitudes towards the “philosophically oriented” habits of critical and thoughtful minds rather than a psychological one.

The Explicit vs. Implicit Tension. All interviewees see critical thinking as a way of teaching, rather than as an add-on to the curriculum and advocate an implicit embedded approach to CT curriculum.

Figure 5.1 illustrates interviewee science teachers’ attitudes towards the five aforementioned tensions in the previous chapters.

<table>
<thead>
<tr>
<th>Tensions’ Semantic Differential Spectrum*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
</tr>
<tr>
<td>Philosophical</td>
</tr>
<tr>
<td>Psychological</td>
</tr>
<tr>
<td>Explicit</td>
</tr>
<tr>
<td>Embedded</td>
</tr>
<tr>
<td>Generality</td>
</tr>
<tr>
<td>Specificity</td>
</tr>
<tr>
<td>Skills</td>
</tr>
<tr>
<td>Habits</td>
</tr>
<tr>
<td>Critical</td>
</tr>
<tr>
<td>Creative</td>
</tr>
</tbody>
</table>

* The sign represents teachers’ position and view on the spectrum.

Figure 5.1 Tensions’ Spectrum

5.2 Pentagram of Habits
Qualitative analysis, coding, categorizing, and developing hierarchical categories of emergent themes in the in-depth interviews reveals five crucial elements in these Iranian science teachers’ perception of CT and a critical thinker’s general competences:

- Earth: Inquisitive & questioning mind. Curiosity and a questioning mind is a central sub-structural component of critical thinkers’ mindset in these teachers’
conceptualization of CT. They mention ‘posing critical questions/challenges to the classroom’ as evidence of the importance of this element in students’ behavior.

- **Water:** *Flow of connections.* Comparing and contrasting interconnected ideas/phenomena, seeking and uncovering latent connections, and making interdisciplinary connections are the other habitual characteristics of critical thinkers. Following the “flow of connections” suddenly reveals “the big picture”, and provides learners with the opportunity to delightfully taste the pleasure of revelation and discovery—aha moments.

- **Air:** *Probability of other possibilities.* This classic element metaphorically is used to refer to situations that involve uncertainty and probability of plausible options: The art of uncertainty and being positively skeptical in situations that do not require a black-or-white view. Furthermore, this element addresses open-mindedness: to entertain different ideas, contrary positions, alternative points of view, and alternative conclusions.

- **Fire:** *Intellectual courageous manner.* Most interviewees participating in phase III were asked to describe general CT abilities indicate that a humble and courageous manner are an absolute necessity as one of the habits central to thinking critically. (Note: the TC2 proposal does not include courageous.)

- **Ether:** *Conversation & interactions.* All interviewees address communicational and dialectical conversation as inseparable aspects of CT. The imagery of the quintessential element (ether) is used to represent the immutable aspect of effective CT as one interacts within a community of peers.
Based on these Iranian science teachers’ perspectives, these five building blocks are common components and habits of CT. Figure 5.2 illustrate this *habitual manner* in a pentagram for thinking critically in the scientific context.

![Pentagram of Habitual Manner](image)

### 5.3 Recommendations for Instructional Implementation

Based on my findings, I offer the following teaching techniques and instructional strategies as recommendations to support bridging the theory practice gap and helping improve gifted science education in Iranian schools.
5.3.1 Instructional Strategies

The interviewees highly recommend following four strategies to support embedding CT into teaching science:

*History of Science*: Simulating science history to put students in early scientists’ situation is one of the absolutely fascinating ways of teaching, through which learners can act like real scientists. Such an historical approach to teaching science provides students with opportunities to view human dimensions of scientific works, in terms of seeing failures, trial and error, dead-end paths, contextual biases, and thinking processes. It gives students the courage to act as a member of critical community. Teaching and learning within the history of ideas opens up opportunities to promote different habits of mind, especially inquisitive and questioning mindfulness (Earth element). Taking up a challenge requires open-mindedness (Air element) to view challenges from early scientists’ viewpoints and the intellectual courage (Fire element) to engage in thoughtful deliberation. For example, Mr. Xaki mentions applying historical approaches to teach electricity in physics, and Mr. Sourati explains steps in using the same method in teaching spontaneous generation and its disproof by Pasteur’s experiments.

*Problematising Public Beliefs*: Popular scientific misconceptions are educational opportunities to invoke students’ motivation in thinking deliberately. Mr. Xaki expressed many scientific misconceptions in different animation series (such as The Simpsons, Tom and Jerry, The Road Runner Show, and more culturally Shekarestan (شکرستان; which means Sugarland in Persian) and other animated series that can be employed as instructional tactics to create a CT environment in physics classes. The idea of “problematising” curriculum topics is the general emancipationist strategy in the classroom and is central to the TC² approach (Fenstermacher & Soltis, 2009, p. 67).
Parallel to this notion, Mr. Sourati particularized his steps in teaching Darwin’s theory of evolution using public beliefs as a critical challenge: Explaining specific belief; providing students with details, examples, observations, and evidence from experiments; problematizing the belief and students’ background knowledge; encouraging students to judge, evaluate, and to draw a conclusion.

*Real-life Challenges versus Theoretical Situations:* “Students do not typically have the feeling that they are facing real problems. We do not provide students with ‘real’ critical challenges.” Ms. Sabz stated this as a formidable obstacle to embedding CT into the science curriculum, and to engage gifted learners in thinking critically. Challenging levels of investigative activities, first-hand inquiry approaches, and a real-world problem-oriented manner are highlighted in Renzulli’s enrichment model (Renzulli & Reis, 2012, pp. 21-31), and TC²’s (2006) approach to nurturing habits of mind. Mr. Sourati asserts that we can use pupils’ everyday experiences as an appropriate context for science education. For instance, he describes using students’ experience in blow up the balloons, that after the fourth or fifth balloon they feel dizzy.

Again, the idea of real-life challenges is in the same direction with the “Emancipatory” version of the Liberationist approach to teaching. As Fenstermacher and Soltis (2009) state

Emancipatory teaching… is aligned with notion of *praxis*, a concept that forges strong links between ideas and action. The emancipationist argues that the purpose of education is not simply to initiate the young into a civilized, enlightened life, but to encourage and enable them to critique its shortcoming and to act to realize its promises. (p. 51)
Such real-life challenges open up opportunities to nurture different habitual and emergent elements of this study, especially open-mindedness (Air element) to view challenges from real-life contextual and practical standpoints, making interdisciplinary connections (Water element) and to uncover latent interconnections and interconnected ideas/phenomena, and intellectual courage (Fire element) to engage in real problem-solving activities.

**Inductive versus Deductive Learning**: As a serious obstacle to nurturing a thinking environment in science classrooms, three interviewees complained about the deductive approach to teaching science. They state that in an inappropriate way, “we apply highly structured manifestations of content: Science teachers usually present general ideas by first defining a principle/concept, and then providing students with examples and then having students perform experiments to test and verify the principle.” Most text-books are also deductive in nature. In these teachers’ views this approach happens in the wrong order. This approach is considered as a method that creates an optimal learning atmosphere to transmit knowledge from instructor to learner. However, in my understanding, inductive learning addresses inquiry teaching in which students are encouraged to observe, pose questions, to test their predictions, and then to generalize from concrete data to the abstract—providing opportunities for CT.

**5.3.2 Teaching Approaches**

The four aforementioned strategies (based on the findings of the first and the third part of this study) have a high degree of congruence and commonality with the following two teaching approaches that I recommend from the literature:

*Cooperative Learning*. In order to provoke communicational and dialectical aspects of thinking critically and giving a voice to students, cooperative learning strategies provides
rich opportunities to transfer from teacher-centered strategies to student-centered strategies. Cooperative learning, as Slavin (2010) states, refers to “a set of instructional strategies in which students work together in small groups to help each other learn academic content” (p. 160) that tend to transform teacher-telling types of instruction. Through the active exchange of ideas within small groups, “discussion, clarification of ideas, and evaluation of others' ideas,” cooperative learning promotes critical thinking and problem-solving skills among learners (Gokhale, 1995). Arguably, this approach and related strategies directly effects and develops the fourth and the fifth abilities and elements of science teachers’ conception of CT: an intellectual courageous manner (Fire), and conversation & interactions ( Ether).

Renzulli’s High-end Learning. Renzulli and Reis (2012) characterize there approach as meeting three conditions. First, the students personalize the issue or problem. Second, the students act like professionals, using methods of investigation. Third, the student’s work usually involves a product or service that “performs” to particular audience. Moreover, they postulate the following principles to help define the “high-end learning” concept:

- Each learner is unique, in terms of abilities, interests, and learning styles.
- Enjoyment, as a goal, should be considered in constructing learning experience.
- Content and process should involve real-world and present problems.
- The major goal of this approach is student construction, replacing passive learning with engaged active learning.

However, enjoyment and engagement alone do not include all of the conditions for the development of a thinking classroom atmosphere. This requires defining the high-end learning environment as “applying relevant knowledge, research skills, creative and critical thinking skills, and interpersonal skills to the solution of a real problem” (p. 27).
5.4 Implications for Future Research

While this study provides insights into the ways that Iranian science teachers conceptualize thinking critically, one of the areas that requires further research is whether CT pedagogical models such as the TC²'s framework can practically and successfully be tailored and embedded into the two recommended approaches – cooperative learning and Renzulli’s high-end learning model. Specifically, how can educators particularize standards of instructional techniques for these two approaches in the context of science and physics education for gifted individuals? Despite the consensus on the key role of critical thinking as being central to education in general and gifted education in particular, there is a lack of unanimous understanding about teaching CT in terms of pedagogical approach (Bailin, et al., 1999; Case, 2005; Marin & Halpern, 2011).

Additionally is the question of how findings of this study, in terms of both tension-based analysis and elemental analysis can inform teaching CT. Although there are some pedagogical models offered to support teaching critical thinking in regular classrooms, there is no well-defined program for gifted students in which gifted and talented students’ needs are considered. My research indicates that an identifiable approach to teaching critical thinking (CT) to gifted learners is nearly non-existent. For example, Linn and Shore (2008) assert that “[r]ecent research in critical thinking … has not yet been applied to any great extent in the specific context of gifted education.” (p. 157)

Moreover, to answer the question, “what other factors affect people’s …ability to think critically?”, interviewees highlight that social and contextual environment have a significant impact on CT development in students. They address some significant socio-cultural issues outside the scope of this research, such as cultural approaches to parenting, social norms and values. They also identify how students have changed within the last ten
years and discuss many parameters that affected students’ changes such as technological change, mass media, working families, change in parental roles, and more and more use of the Internet and the Internet lifestyle (for e.g., virtual communication, social networks, Internet dating/shopping/games and specifically online games). Two interviewees highlight a domestic factor which has a growing influence on the Iranian students:

Ten years ago, on average, Iranian parents usually had three children. Today, in comparison to ten years ago, an ordinary family in Iran consists of two parents and only one child. For many reasons such as economical and social circumstances, the incidence one-child families are growing steadily. Considering economic classes in labor and middle class families which have working parents, the child/student spends most of their after-school time alone. This loneliness exposes the immature student to some dangerous and undesired situation where s/he is not protected from inappropriate experiences. On the other hand, in upper-class families, parents provide the student with a wide range of services and help. The student faces parental involvement in all individual affairs and activities. Consequently, these students don’t acquire and develop some basic and practical life skills in proper time and proper place.

All of these socio-cultural and contextual issues deserve further research studies to explore and examine these parameters in relation to teaching gifted students. Finally, from a Vygotskian (1986) perspective, language and thought are closely connected. The TC²’s framework and four-pronged approach are outlines in English language and North American culture. Therefore, through the lens of Vygotskian perspective, how might representing thinking critically differ in the Persian language and culture? For example, do good habits of thinking critically differ from language to language? Or culture to culture? For example what
might the central “five elements” in Canadian, American, or French science teachers’ conception of CT look-like?
References


Appendix A: BREB Approval

The University of British Columbia Okanagan
Research Services
Behavioural Research Ethics Board
3333 University Way
Kelowna, BC V1V 1V7 Phone: 250-807-8832
Fax: 250-807-8438

CERTIFICATE OF APPROVAL - MINIMAL RISK

<table>
<thead>
<tr>
<th>PRINCIPAL INVESTIGATOR:</th>
<th>INSTITUTION / DEPARTMENT:</th>
<th>UBC BREB NUMBER:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philip Balcaen</td>
<td>UBC/UBCO Education, Faculty of UBCO Education, Department of</td>
<td>H13-00072</td>
</tr>
</tbody>
</table>

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:

<table>
<thead>
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<th>Institution</th>
<th>Site</th>
</tr>
</thead>
</table>

CO-INVESTIGATOR(S):
Mehdi Ghahremani

SPONSORING AGENCIES:
N/A

PROJECT TITLE:
CONSIDERING SCIENCE TEACHERS' CONCEPTION OF THE PEDAGOGY OF CRITICAL THINKING IN SEVERAL OF IRAN'S SPECIAL GIFTED SCHOOLS: A MULTI-PHASED STUDY

CERTIFICATE EXPIRY DATE: February 12, 2014

DOCUMENTS INCLUDED IN THIS APPROVAL:  

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Version</th>
<th>Date</th>
</tr>
</thead>
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<tr>
<td>Consent Forms</td>
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<td>External Consent Form</td>
<td>N/A</td>
<td>February 5, 2013</td>
</tr>
<tr>
<td>Assent Forms:</td>
<td></td>
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<td>February 6, 2013</td>
</tr>
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<td>Questionnaire, Questionnaire Cover Letter, Tests:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers' Survey Questionnaire for the Pedagogy of CT</td>
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<td>February 5, 2013</td>
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<tr>
<td>Classroom Observation Scale for the Pedagogy of Critical Thinking</td>
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<td>February 5, 2013</td>
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<td></td>
<td></td>
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<tr>
<td>Dr. VanTassel-Baska's permission</td>
<td>N/A</td>
<td>January 6, 2013</td>
</tr>
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</table>

The application for ethical review and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human subjects.

Approval is issued on behalf of the Behavioural Research Ethics Board Okanagan and signed electronically by:

Dr. Carolyn Szostak, Chair

https://rise.ubc.ca/riseDoc/0C2C0KT97D3247DMi0CSVMGLRDF/#omString.html 1/2

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A.1 TCPS 2 Core Certification

Certificate of Completion

This document certifies that

Mehdi Ghahremani

has completed the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Course on Research Ethics (TCPS 2: CORE)

Date of Issue: 17 April, 2012

Figure A.1 TCPS 2 Core Certification
A.2 Dr. VanTassel-Baska’s Permission (E-mail)

Figure A.2 Dr. VanTassel-Baska’s Permission (E-mail)
A.3 External Consent Letter

External Consent – School Principal/Educational Vice-President

CONSIDERING SCIENCE TEACHERS’ CONCEPTION OF THE PEDAGOGY OF CRITICAL THINKING IN SEVERAL OF IRAN’S SPECIAL GIFTED SCHOOLS: A MULTI-PHASED STUDY

Request for External Consent: Mr. S. Shoohtari Zadeh
Educational Vice-President
Allameh Helli Gifted High School
Tehran, Kargar-e Jonoubi St. Kamali St. Ghaffari St.
Tel. 0098(21)55415556
Fax: 0098(21)55409354
P.O. Box: 1333714383
info@helli.ir

Principal Investigator: Dr. Philip Balcaen, PhD
Associate Professor, Faculty of Education,
University of British Columbia Okanagan

Co-Investigator(s): Mehdi Ghahremani, BS, MSc
Graduate Student, Faculty of Education
University of British Columbia
(250) 300 8980, ghahremani.me@gmail.com

This research is part of a thesis in partial fulfillment of a Master of Arts in Education.
Findings of this research will be published in a thesis, which is a public document. The identity of the school, location, and participants will be confidential as assigned numeric or pseudonyms will be used throughout.
Purpose
In the last two decades, one can see the widespread acceptance and universal consensus on the importance of critical thinking (CT hereafter), as a 21st-century skill and a central goal of contemporary education, for all students from primary to graduate schools. To consider all students, the “Gifted” student population is one of the key groups that require opportunities to acquire and develop CT skills and habits of mind. Despite the consensus on the key role of critical thinking, as central to education, there is a lack of agreement about teaching CT, in terms of pedagogical approach. Furthermore, like most teachers, gifted and talented teacher behaviors are not systematically monitored. Based on my understanding of teachers’ key roles effecting the degree that students learn subject matter, as well as CT skills and habits, the objectives of this study are:

- To examine science teachers’ perception(s) of teaching critical thinking in gifted classrooms,
- To assess science teachers’ instructional behavior, in terms of CT pedagogy, based on The Canadian Critical Thinking Consortium’s four-front conception of CT.
- To discuss relationship(s) between science teachers’ demographic information, (such as gender, number of years of experience in Iranian gifted schools, their educational background), and their quality of CT pedagogy.
- To compare teachers’ instructional behavior among physics, chemistry, and biology classes, in terms of their quality of CT pedagogy.

Study Procedures
The design of this study will be a multi-phased and mixed methods sequential design. My research procedures involve three sequential phases:

Classroom observation. Stratified random sampling will be used to choose 24 science teachers in 4 grades (7-10): 12 middle school teachers; including 4 physics (2 male teaching grade 7 and 8, 2 female teaching grade 7 and 8), 4 chemistry (2 male teaching grade 7 and 8, 2 female teaching grade 7 and 8), and 4 biology (2 male teaching grade 7 and 8, 2 female
teaching grade 7 and 8, and 12 high school teachers; including 4 physics (2 male teaching grade 9 and 10, 2 female teaching grade 9 and 10), 4 chemistry (2 male teaching grade 9 and 10, 2 female teaching grade 9 and 10), and 4 biology (2 male teaching grade 9 and 10, 2 female teaching grade 9 and 10), providing samples from both middle school and high school, and three science areas. To avoid “precautionary” changes in teachers’ behavior as participants, phase 1, classroom observation, will be implemented before phase 2, survey questionnaire. Randomly selected Iranian science teachers’ instructional behavior will be observed, two times in one month (altogether 48 observations), probably in March 2013. The researcher will request participants/teachers to explain to students that an observer (Mehdi Ghahremani) will visit their class on two dates. The length of observation will be two full class sessions (approximately two 80-minute) for each selected subject.

Survey questionnaire. Participants in the second phase are the same as first phase. A paper-and-pencil survey questionnaire is designed to investigate science teachers’ conception of critical thinking, and to assess their instructional strategies to promote CT in their classroom. For phase 2 (survey questionnaire), the subject will need approximately one hour to complete the survey-questionnaire. (The survey-questionnaire is 7 point Likert scale.)

Follow-up interviews. Based on these two first phases, 4 to 6 science teachers will be selected for the next step; an approximately 2 hours semi-structured interviews.

At any point during the study, if teachers want to withdraw from the study, they are free to do so. Any data collected about a withdrawing participant will not be included in the study and will be destroyed.

In the questionnaire part, some personal information about the teachers may be collected for statistical purposes, such as age, gender, number of years teaching in gifted schools, and educational background. This information is available from the school, and this request is, in part, to receive permission to access this information for the study. All information will be kept strictly confidential.
To ensure protecting privacy of the participants, they will be assigned random numeric codes and will not be identified. In the published thesis, the school and teachers will not be identified.

The study will take place between February 10 and April 10, 2013.

**Study Result**
The results of this study will be reported in a graduate thesis and may also be published in journal articles and books.

**Potential Risks and Benefits**
There are no potential risks to the teachers. We do not think there is anything in this study that could harm teachers or be bad for them. Participants will not be rewarded for participation, because participation needs to be completely voluntary. No special treatment or special consideration will result from participation in the study. At the end of the study, the findings will be made available to the participants.

**Confidentiality**
The participants’ identities will be kept strictly confidential, as well as the school’s name and location. Teachers’ confidentiality will be respected. All assessments and other documents related to the study will be kept in a locked filing cabinet at the school, and after the study is complete, they will be kept in a locked filing cabinet in Dr. Balcaen’s office (EME Building # 3173) at UBC-O for a period of five years. When those five years are past, all documents and assessments will be destroyed. If any electronic record is made, it will be destroyed as well. Teachers will not be identified by name.

**Contact for Concerns about the Rights of Research Subjects:**
If you have any concerns about your rights as a research participant and/or your experiences while participating in this study you may contact the Research Subject Information Line in the UBC Office of Research Services at 1-877-822-8598 or the UBC Okanagan Research Services Office at 250-807-8832. It is also possible to contact the Research Subject Information Line by email (RSIL@ors.ubc.ca).
Consent:
Giving consent to allow Mr. Mehdi Ghahremani to conduct this research at the Allameh Helli gifted high school (special Iranian gifted school) is entirely voluntary and you may refuse to allow him to conduct the research or ask him to stop the study at any time. Once you have returned the Request for External Consent, a copy will be made and returned to you for your records.

I consent to participate in this study.

____________________________________________________

Mr. S. Shoohtari Zadeh, Educational Vice-President, Allameh Helli high school

____________________________________________________

Date
A.4 Teacher Consent Letter

Teacher Consent Form

CONSIDERING SCIENCE TEACHERS’ CONCEPTION OF THE PEDAGOGY OF CRITICAL THINKING IN SEVERAL OF IRAN’S SPECIAL GIFTED SCHOOLS: A MULTI-PHASED STUDY

Principal Investigator: Dr. Philip Balcaen, PhD
Associate Professor, Faculty of Education, University of British Columbia Okanagan

Co-Investigator(s): Mehdie Ghahremani, BS, MSc
Graduate Student, Faculty of Education
University of British Columbia
(250) 300 8980, ghahremani.me@gmail.com

This research is part of a thesis in partial fulfillment of a Master of Arts in Education. Findings of this research will be published in a thesis, which is a public document. The identity of the school, location, and participants will be confidential as assigned numeric or pseudonyms will be used throughout.

Purpose
In the last two decades, one can see the widespread acceptance and universal consensus on the importance of critical thinking (CT hereafter) as a 21st-century skill and a central goal of contemporary education, for all students from primary to graduate schools. To consider all students, the “Gifted” student population is one of the key groups that require opportunities to acquire and develop CT skills and habits of mind. In this light, you, as a science teacher in gifted schools, are being invited to take part in this research study.

Despite the consensus on the key role of critical thinking, as central to education, there is a lack of agreement about teaching CT, in terms of pedagogical approach. Based on my
understanding of your key roles, as a science teacher, effecting the degree that students learn subject matter, as well as CT skills and habits, the objectives of this study are:

- To examine your perception(s) of teaching critical thinking in gifted classrooms,

- To examine your instructional behavior, in terms of CT pedagogy, based on The Canadian Critical Thinking Consortium’s four-front conception of CT.

- To discuss relationship(s) between science teachers’ demographic information, (such as gender, number of years of experience in Iranian gifted schools, their educational background), and their quality of CT pedagogy.

- To compare your instructional behavior with other science courses’ teachers (physics, chemistry, and biology classes), in terms of their quality of CT pedagogy

We are inviting science teachers like you to help us examining the quality of instruction, in terms of CT pedagogy, and to learn more about their strategies for and conception(s) of teaching thinking critically for high-ability learners.

Study Procedures
The design of this study will be a multi-phased and sequential design. If you decide to take part in this research study, here are the sequential procedures we will do:

Classroom observation. At the beginning of the study, based on your agreement, we will set a time for two full class sessions (two approximately 80-minute) classroom observations. The researcher, Mehdi Ghahremani, will request you to explain to students that an observer (Mehdi Ghahremani) will visit their class on two dates.

Survey questionnaire. In the second phase, after second classroom observation, you will be asked to fill a paper-and-pencil survey questionnaire. The questionnaire is designed to help us to learn your conception of critical thinking, and to understand your instructional strategies to promote CT in your classes. You will need approximately one hour to complete the survey-questionnaire. (The survey-questionnaire is 7 point Likert scale.)
Follow-up interviews. Based on the findings in the first two phases, in terms of the teachers’ quality of the pedagogy of CT, and their responses to the survey questionnaire, 4 to 6 science teachers will be selected for the next step; interviews. So, you might be selected for an approximately 2-hours interview. The interview will be recorded and transcribed. You will be provided with the transcriptions, prior to use by the researcher.

At any point during the study, if you want to withdraw from the study, you are free to do so. Any data collected about a withdrawing participant will not be included in the study and will be destroyed.

In the questionnaire part, some personal information about you may be collected for statistical purposes, such as age, gender, number of years teaching in gifted schools, and educational background. This information is available from the school, and this request is, in part, to receive your permission to access this information for the study. All information will be kept strictly confidential. You are free to not answer any question that you are not comfortable answering and you are free to withdraw from the study at any time without any negative consequence.

To ensure protecting your privacy, you will be assigned random numeric code and will not be identified. In the published thesis, the school and teachers will not be identified.

The study will take place between February 10 and April 10, 2013.

Study Result
The results of this study will be reported in a graduate thesis and may also be published in journal articles and books. A summary report of the study will be made available to you by email.

Potential Risks and Benefits
There are no potential risks to the teachers. We do not think there is anything in this study that could harm you or be bad for you. Participants will not be rewarded for participation, because participation needs to be completely voluntary. No special treatment or special consideration will result from your participation in the study. At the end of the study, the summary of the findings will be made available to the participants.
The study will examine science teachers' conception of critical thinking and their strategies to promote thinking critically in high-ability learners. This multi-phased research study will provide benefits for science teachers/instructors at middle and high school, as well as science education and gifted education researchers, curriculum planners, gifted programs developer, and others doing scholarly work in critical thinking, gifted education, and science education by recognizing areas of strength and informing them about current practice and possible areas of improvement.

Confidentiality
The participants’ identities will be kept strictly confidential, as well as the school’s name and location. All assessments, questionnaires, transcripts, and other documents related to the study will be kept in a locked filing cabinet at the school, and after the study is complete, they will be kept in a locked filing cabinet in Dr. Balcaen’s office (EME # 3173) at UBC-O for a period of five years. When those five years are past, all documents will be destroyed. All documents will be identified by code numbers. If any electronic record is made, it will be destroyed as well. Teachers will not be identified by name in any report of completed study.

Your participation in this study is entirely voluntary and you may refuse to participate or withdraw from the study at any time without giving a reason and without any negative impact on your situation and with no negative consequences.

Contact for Concerns about the Rights of Research Subjects:
If you have any concerns about your rights as a research participant and/or your experiences while participating in this study you may contact the Research Subject Information Line in the UBC Office of Research Services at 1-877-822-8598 or the UBC Okanagan Research Services Office at 250-807-8832. It is also possible to contact the Research Subject Information Line by email (RSIL@ors.ubc.ca).

Teacher Consent:
Giving consent to allow Mr. Mehdi Ghahremani to conduct this research, specially observing classroom instruction at the Allameh Helli and Farzanegan gifted high schools (special Iranian gifted school) is entirely voluntary and you may refuse to allow him to conduct the research or ask him to stop the study at any time.
Your participation in this study is entirely voluntary and you may refuse to participate. You are free to withdraw from the study at any time without giving a reason and without any negative impact on your situation and any negative consequences. Once you have returned the consent form, a copy will be made and returned to you for your records.

Your signature below indicates that you have received a copy of this consent form for your own records. Your signature indicates your consent to participate in this study. Moreover, your second signature indicates your willingness to participate in the follow-up interview.

Please note that as the co-investigator of this study (Mehdi Ghahremani) has worked in one of the gifted high schools, some individuals may know him, as a friend and/or colleague. So, the co-investigator will not include any participants who had a prior significant relationship – where conflict of interest may be a problem. Your decision to participate (or not) will have no bearing on any such relationships.

Consent

I, __________________________, have read and heard the summary for the research project “CONSIDERING SCIENCE TEACHERS’ CONCEPTION OF THE PEDAGOGY OF CRITICAL THINKING IN SEVERAL OF IRAN’S SPECIAL GIFTED SCHOOLS: A MULTI-PHASED STUDY” conducted by Mr. Mehdi Ghahremani, Faculty of Education at The University of British Columbia, Kelowna, Canada. I understand what the research project entails and I have been provided with an opportunity to ask questions about the research.

I consent to participate in this study.

____________________________________________________
Teacher Signature                       Date

____________________________________________________
Printed Name of the Teacher signing above
I **consent** to participate in the third phase of this study – follow-up interview.

________________________________________________________________________

Teacher Signature          Date

________________________________________________________________________

Printed Name of the Teacher signing above
Appendix B: Three Phases’ Instruments
B.1 Classroom Observation Scale

**Name of Study:** CONSIDERING SCIENCE TEACHERS’ CONCEPTION OF THE PEDAGOGY OF CRITICAL THINKING IN SEVERAL OF IRAN’S SPECIAL GIFTED SCHOOLS: A MULTI-PHASED STUDY

**School Identity Code:** ________________________  **Teacher Identity Code:** _____________

### Classroom Observation Scale for the Pedagogy of Critical Thinking

<table>
<thead>
<tr>
<th>General Teaching Behavior (Formative Assessment)</th>
<th>Exposure</th>
<th>Advanced</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher …</td>
<td>Novice</td>
<td>Aware</td>
<td>Familiar</td>
</tr>
<tr>
<td>1. set high expectation for student performance.</td>
<td>No idea; no strategies; no implementation</td>
<td>Vague idea; no strategies; no implementation</td>
<td>Basic understanding; limited strategies; minor implementation</td>
</tr>
<tr>
<td>2. incorporated activities for students to apply new knowledge.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3. engaged students in planning, monitoring, or assessing their learning.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. encouraged students to express their thoughts.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
5. had students reflect on what they had learned.

<table>
<thead>
<tr>
<th></th>
<th>Exposure</th>
<th>Advanced</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>No idea; no strategies; no implementation</td>
<td>Vague idea; no strategies; no implementation</td>
<td>Basic understanding; limited strategies; minor implementation</td>
</tr>
</tbody>
</table>

Comments:

Nurturing a thinking classroom environment

The teacher …

6. encouraged students to judge or evaluate situations, problems, or issues.

<table>
<thead>
<tr>
<th></th>
<th>Exposure</th>
<th>Advanced</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

7. engaged students in comparing and contrasting ideas (e.g., analyze generated ideas).

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<thead>
<tr>
<th></th>
<th>Exposure</th>
<th>Advanced</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

8. provided opportunities for students to generalize from concrete data or information to the abstract.

<table>
<thead>
<tr>
<th></th>
<th>Exposure</th>
<th>Advanced</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

9. encouraged students synthesis or summary of information within or across disciplines.

<table>
<thead>
<tr>
<th></th>
<th>Exposure</th>
<th>Advanced</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

10. nurtured classroom expectation about thinking.

<table>
<thead>
<tr>
<th></th>
<th>Exposure</th>
<th>Advanced</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

11. established classroom routines to support thinking.

<table>
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<th></th>
<th>Exposure</th>
<th>Advanced</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

12. provided modeling of good thinking.

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<tr>
<th></th>
<th>Exposure</th>
<th>Advanced</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
13. used classroom communication to enhance thinking.  
14. facilitated students’ opportunity to participate in “critical” community.

<table>
<thead>
<tr>
<th>Comments:</th>
</tr>
</thead>
</table>

### Teaching Intellectual Tools Supporting Critical Thinking as per TC²’s Model

<table>
<thead>
<tr>
<th>The teacher …</th>
<th>Exposure</th>
<th>Advanced</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>15. incorporated criteria for judgment.</td>
<td>Novice: No idea; no strategies; no implementation</td>
<td>Aware: Vague idea; no strategies; no implementation</td>
<td>Familiar: Basic understanding; limited strategies; minor implementation</td>
</tr>
<tr>
<td>16. developed background knowledge.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>17. provided information that students need to make a well-informed judgment.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>18. developed criteria to judge various alternatives and helped students thinking based on those criteria.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>19. provided students with thinking strategies (for e.g., role-taking, organization, etc).</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>20. employed brainstorming techniques.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>21. nurtured habits of mind (for e.g., fair-mindedness and independent-mindedness.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
22. encouraged students to demonstrate open-mindedness and tolerance of imaginative, sometimes playful solutions to the problem.

23. taught and applied critical thinking vocabulary (for e.g., inference, generalization, conclusion, and bias).

Comments:

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Advanced</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice</td>
<td>Aware</td>
<td>Familiar</td>
</tr>
<tr>
<td>No idea; no strategies; no implementation</td>
<td>Vague idea; no strategies; no implementation</td>
<td>Basic understanding; limited strategies; minor implementation</td>
</tr>
</tbody>
</table>

Providing Critical Challenges and Opportunities for Critical Thinking (where criteria for judgment are required.)

The teacher …

24. meaningfully framed challenges that are likely to engage students in tackling questions.

25. invited students to consider probability of plausible options or alternative conclusions.

26. provided challenges that address key aspects of the subject matter.

27. supported students in acquiring the essential tools required to meet the critical challenges.

28. created critical thinking opportunities.
29. asked questions to assist students in making inferences from data and drawing conclusions.
30. provided opportunities for students to develop and elaborate on their ideas.
31. encouraged multiple interpretations of events and situation.

Comments:

<table>
<thead>
<tr>
<th>Summative Assessment of Critical Thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher …</td>
</tr>
<tr>
<td>32. evaluated students’ background knowledge in terms of adequate and accurate information.</td>
</tr>
<tr>
<td>33. assessed students’ relevant criteria for their judgment.</td>
</tr>
<tr>
<td>34. appraised students’ understanding of critical thinking vocabulary.</td>
</tr>
<tr>
<td>35. evaluate students’ use of appropriate thinking strategies.</td>
</tr>
<tr>
<td>36. considered habits of mind in the evaluation of students’ thinking.</td>
</tr>
<tr>
<td>37. assessed critical thinking</td>
</tr>
</tbody>
</table>
more valued students’ “good” questions, rather than their “right” answers.

Comments:

Date: __________________
Observer's name and signature: _______________________________
Name of Study: CONSIDERING SCIENCE TEACHERS’ CONCEPTION OF THE PEDAGOGY OF CRITICAL THINKING IN SEVERAL OF IRAN’S SPECIAL GIFTED SCHOOLS: A MULTI-PHASED STUDY

School Identity Code: _______________________
Teacher Identity Code: ________________

Teachers’ Survey Questionnaire for the Pedagogy of Critical Thinking

<table>
<thead>
<tr>
<th>A) Statistical/Demographic information</th>
<th>You are free to not answer any question that you are not comfortable answering and you are free to withdraw from the study at any time without any negative consequence.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gender:</td>
<td>☐ 1 Female. ☐ 2 Male.</td>
</tr>
<tr>
<td>2. Age:</td>
<td>_______ Years.</td>
</tr>
<tr>
<td>3. How long have you been teaching in gifted schools?</td>
<td>_______ Years.</td>
</tr>
<tr>
<td>4. What is your teaching subject and area?</td>
<td>☐ 1 Biology ☐ 2 Chemistry ☐ 3 Physics</td>
</tr>
</tbody>
</table>
5. Are you alumni of gifted schools?  
☐ 1 Yes.  ☐ 2 No.

6. What is your area of education?  
☐ 1 Engineering  ☐ 2 Science & Math  ☐ 3 Arts & others

7. What is your current educational status?  
☐ 1 Bachelor student  ☐ 2 Bachelor  ☐ 3 Master`s student  
☐ 4 Master  ☐ 5 PhD student  ☐ 6 PhD

<table>
<thead>
<tr>
<th>8. Critical thinking abilities can be generalized across different contexts and domains and can thus be taught in a generic way.</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9. The outcomes of critical thinking are judgments, rather than solving problems.</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
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<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10. Intelligence is one of the key factors in thinking critically.</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11. Students may exhibit critical thinking skills and abilities in one context, or domain, but fail to do so in another.</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12. Critical thinking is a general human quality, and it is largely genetically determined.</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>13. Providing critical challenges is central to developing thinking critically.</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
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<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>14. A certain amount of creativity is necessary for critical thought.</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>15. Critical thinking is a set of (mental) procedures, such as steps involved in problem-solving, or the stages of inquiry.</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
16. Critical thinking and required abilities in biology are completely different from critical thinking and required abilities in history.  
17. Familial socio-economic status is one of the important factors, which has considerable effect on the quality of critical thinking in students.  
18. CT is higher-order thinking and cognitive skills and abilities that are more appropriate for high-ability individuals.  
19. Critical thinking skills can only be taught in the context of a specific domain.  
20. As an instrument for teaching and developing CT, logic (reasoning) and problem-solving have some serious limitations.

<table>
<thead>
<tr>
<th>B) Please circle the most appropriate number of each statement that closely represents your response.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disagree</strong></td>
</tr>
<tr>
<td><strong>Strongly Disagree</strong></td>
</tr>
</tbody>
</table>

| 21. Speed of mental processing is an important factor in thinking critically. | 1 2 3 4 5 6 7 |
| 22. Students in the classrooms are not being supported in developing good habits of thinking critically. | 1 2 3 4 5 6 7 |
| 23. Instead of nurturing children’s thinking skills/aptitude, classrooms in gifted schools more concern knowledge accumulation and memorization. | 1 2 3 4 5 6 7 |
| 24. Thinking critically in students is highly malleable and can be shaped through various kinds of interventions. | 1 2 3 4 5 6 7 |
| 25. Critical thinking and creative thinking are closely related. | 1 2 3 4 5 6 7 |
| 26. Critical thinking and required abilities in physics are completely different | 1 2 3 4 5 6 7 |
from critical thinking and required abilities in biology.

27. To think critically is to think based on and in light of appropriate set of criteria.

28. Cognitive skills and problem-solving strategies are more central to CT, rather than reasoning, good judgment, and logic.

29. Social and contextual environment have a significant impact on critical thinking development in students.

30. Intelligence (high IQ) is one of the key factors for sound judgment.

31. Critical thinking, as a general personal ability, can be measured objectively with the critical thinking tests.

32. Cultural context plays an important role in developing critical thinking.

33. Promoting critical thinking abilities in “gifted” learners is more crucial rather than “non-gifted” individuals.

34. Good habits of thinking critically differ from culture to culture.

<table>
<thead>
<tr>
<th>C) How often do the following issues happen in your instruction and/or in your classroom? Please circle the most appropriate number that closely represents your response.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Almost Never</strong></td>
</tr>
<tr>
<td><strong>35. Students make plausible predictions.</strong></td>
</tr>
<tr>
<td><strong>36. Establishing criteria for evaluation.</strong></td>
</tr>
<tr>
<td><strong>37. Asking students to find fallacies and biases in their arguments.</strong></td>
</tr>
<tr>
<td><strong>38. Grouping students in small groups to analyze and solve problems.</strong></td>
</tr>
<tr>
<td><strong>39. Changing classroom arrangement to make appropriate environment for class</strong></td>
</tr>
</tbody>
</table>
discussion and to support thinking.

40. Asking students to make interdisciplinary connections, and to connect subject matter with real-life experiences.

41. Encouraging students to judge or evaluate situations, problems, or issues.

42. Providing opportunities for students to generalize from concrete data or information to the abstract.

43. Employing brainstorming techniques.

44. Consciously providing an uncertain paradoxical situation in the classroom.

45. Applying critical thinking vocabulary (for e.g., inference, generalization, conclusion, and bias).

46. Ending class with a question or challenge.

47. Inviting students to consider probability of plausible options or alternative conclusions.

48. Encouraging multiple interpretations of events and situation.

49. Evaluating students’ background knowledge in terms of adequate and accurate information.

50. Providing opportunities for students to elaborate on their own ideas.

C) How often do the following issues happen in your instruction and/or in your classroom? Please circle the most appropriate number that closely represents your response.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Almost Never</th>
<th>Often</th>
<th>Almost Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>51. Creating paradoxical and mysterious situation.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52. Commotion and noisy classroom; students concurrently talk together.</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>53. Creating learning environment that involves ambiguity and equivocation.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>54. Considerable modification in your syllabus to have more time and give students the opportunity to have more practice for thinking critically.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>55. Students categorize subject matter/information and draw a conclusion.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>56. Applying concept-mapping, conceptual graphs, diagrams, and visual language.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>57. Creating interactive learning atmosphere and encouraging class discussion.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>58. Providing a framework for analyzing subject matter and evaluation.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>59. Answering students’ question completely and thoroughly in each session of class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>60. Posing a surprising question/challenge or phenomenon at the beginning of class.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>61. To cover the definite and planned curriculum, ceasing to continue class discussions or to meet challenges/questions.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>62. Assessing students’ understanding of critical thinking vocabulary/concepts.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>63. About students, thinking is replaced with in-class note-taking.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>64. There is no enough time for students to engage critically with subject matter.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>65. Use of figurative and metaphorical examples to link new and old concepts.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>66. Asking students to summarize key points/issues of the session.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unimportant</th>
<th>Neutral</th>
<th>Important</th>
</tr>
</thead>
</table>

191
D) Based on your experience with gifted education, to what extent the following skills and habits are important in thinking critically. Please circle the most appropriate number that closely represents your response.

<table>
<thead>
<tr>
<th></th>
<th>Important</th>
<th>Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>67. Curiosity and inquisitiveness</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>68. Speed of mental processing</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>69. Open-mindedness and having no prejudice</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>70. Judging and evaluating</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>71. Having the knowledge of the thinking vocabulary such as difference between ‘conclusion’ and ‘premise’, ‘cause’ and ‘correlation,’ or ’cause’ and ‘effect’</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>72. Sensitivity to context and awareness</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>73. Fair- mindedness</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>74. Independent-mindedness</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>75. Ability to ask and pose “good” and “new” questions</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>76. Expeditious use of information</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>77. Ability to consider other possibilities and probability of plausible conclusions</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>78. Clarity in expressing ideas</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>79. Accuracy</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>80. Cautiousness</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>81. Ability to adapt to the surrounding environment</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>82. Divergent thinking</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>83. Learning from ideas and environment</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>84. Analysis of firsthand events and phenomena</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>85. Flexibility</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>86. Motivation and interest</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>
B.3  پرسش نامه برای پژوهش پیبرامون دیدگاه دبیران علم در مورد تفکر انتقایی یا سنجدنشلگیانه انديشيدن (Critical Thinking)

(برناختن خود علوم و تفکر انتمادی)

نام پژوهش:

بپرور دیگر (مقدمه) "تفکر انتمادی" مفهومی در زبان فارسی برای کلمه ی CRITICAL THINKING تفکر انتمادی یا Critical Thinking ترجمه ی عربی و برداشت‌های منظوری از این مفهوم، توسط گروه‌های مختلف وجود داشته‌باشد. در جهت تغییر و تربیت دیدگاه، برداشت و تلقی معلمان و دبیران نقشی تعیین کننده در پرورش مهارت‌های انديشيدن اینه می‌نماید. در این پرسشنامه، ترتیب‌های «تفکر انتمادی»، «سنجدنشلگیانه انديشیدن» و «درست انديشیدن» ترتیب‌های است که معادل برای مفهوم CT به کار رفته است.

پیش‌تر از توجه، حوصله و دقت شما در بازخی‌پذیری این پرسشنامه تهیه می‌شود.

الف) اطلاعات آماری جمعیت شناختی

<table>
<thead>
<tr>
<th>شماره</th>
<th>جنسیت</th>
<th>سن</th>
<th>مدرسه</th>
<th>تدریس میکنید؟</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>2 مدرسه</td>
<td></td>
</tr>
<tr>
<td>2</td>
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<td>6</td>
<td>7</td>
<td>5</td>
<td>6</td>
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</tbody>
</table>

(ب) در مورد اظهارات و جملات زیر، لطفاً عدد مناسب را، که به خوبی بیان کننده ی موافقت/مخالفت و دیدگاه شماست، خط بکشید.

8- مهارت‌های درست اندیشیدن (CT) در میان زمینه‌ها و رشته‌های متغیر، قابل تعمیم دادن است و درنیچه می‌تواند به صورت عمومی تدریس شود.
9- تنبه‌ی تفکر انتقادی (CT)، پیشرفت داوری و ارزیابی است تا حل مسأله.
10- هموی یکی از عوامل کلیدی در سنجشگران اندیشیدن (CT) است.
11- ممکن است دانش‌آموزان در یک رشته و زمینه ی خاص مهارت و توانایی‌های تفکر انتقادی را بروز دهد، ولی در زمینه‌ی یک رشته ای دیگر موفق نباشند.
12- تفکر انتقادی یک کیفیت و ویژگی در ادمی است که عوامل زننیکی در آن بسیار مؤثر است.
13- فراهم کردن حال حساس و اساسی برای دانش‌آموزان، در پروپری سنجش گرانه اندیشیدن نقش حیاتی دارد.
14- برای درست اندیشیدن (CT)، مقداری خلاصیت لازم است.
15- تفکر انتقادی مجموعه‌ای از پروسه‌ها و برداشتهای ذهنی است؛ مانند گام‌های حل مسأله یا مراحل یک پژوهش.
16- توانایی‌های لازم برای سنجشگران اندیشیدن در رشته‌ای درسی است، با توانایی و مهارت‌های لازم برای سنجشگران اندیشیدن در رشته‌ای درسی تاریخ کمال متقابل است.
17- جایگاه اجتماعی-اقتصادی خانواده، یکی از عوامل مهمی است که اثر قابل توجهی در کیفیت
<table>
<thead>
<tr>
<th>تفکر انتقادی در دانش‌آموزان دارد.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT سنجشگری‌اندیشی (Cognitive Skills)</td>
</tr>
<tr>
<td>7 6 5 4 3 2 1</td>
</tr>
<tr>
<td>28 - مهارت‌های شناختی (Cognitive Skills) و استراتژی‌های حل مساله، نقد مرکزی و محوری در درست‌اندیشیدن (CT) ایفا می‌کنند.</td>
</tr>
<tr>
<td>29 - محدودت و تاثیر سیستم‌های اجتماعی، در پرورش تفکر انتقادی در دانش‌آموزان، نقش و تأثیر</td>
</tr>
<tr>
<td>27 - تفکر انتقادی اندیشیدن بر مبنا مجموعه ی مناسبی از ملاحظات می‌باشد.</td>
</tr>
<tr>
<td>26 - توانایی‌های لازم برای سنجش‌گران اندیشی در رشته‌ای‌درس فیزیک، با توانایی و مهارت‌های لازم برای سنجش‌گران اندیشی در رشته‌ای‌درس‌زیست‌شناسی کامل‌منفعت است.</td>
</tr>
<tr>
<td>25 - تفکر خلاق (CT) و تفکر انتقادی (CT) به هم نزدیک و مربوط اند.</td>
</tr>
<tr>
<td>24 - در دانش‌آموزان، درست‌اندیشیدن (CT) بسیار انعطاف‌پذیر و تربیت‌پذیر است و می‌تواند از طریق شرکت در دانستن‌های گروه‌گام شکل داده شود.</td>
</tr>
<tr>
<td>23 - کلاس‌های درس در مدارس نیز‌هوش به جای پرورش استعدادهای فکری، به صرف ابزارهای اطلاعاتی و مفاهیمی توجه دارند.</td>
</tr>
<tr>
<td>22 - معمولا دانش‌آموزان در کلاس درس، برای پرورش عادات و خوی و منت تفکر انتقادی حمایت نمی‌شوند.</td>
</tr>
<tr>
<td>21 - شرط کافی در فعالیت‌های گروه‌گام شکل داده شود.</td>
</tr>
<tr>
<td>20 - منطق و حل مساله به منزله‌ی ابزار آموزش درست‌اندیشیدن، دارای محدودیت‌های جدی‌اند.</td>
</tr>
<tr>
<td>19 - توانایی تفکر انتقادی تها می‌تواند در متن حیطه‌ای مشخصی از دانش پرورش یابد و تدریس شود.</td>
</tr>
<tr>
<td>18 - سنجشگری‌اندیشی (CT)، تفکر در سطح بالا و شامل مهارت‌ها و توانایی‌های شناختی است، که بیشتر در فرد با توانایی سطح بالا مانع است.</td>
</tr>
<tr>
<td>7 6 5 4 3 2 1</td>
</tr>
<tr>
<td>17 - سرعت پردازش ذهنی، یک عامل مهم در سنجشگری‌اندیشیدن (CT) است.</td>
</tr>
<tr>
<td>16 - ساختار و جملات زیر، لطفا دور عذد هناسه را، که ته خویت تیاى کننذه ی هوافمت/هخالفت و دیذگاه شواست، خط تکشیذ</td>
</tr>
<tr>
<td>15 - در هورد اظهارات و جولات زیر، لطفا دور عذد هناسه را، که ته خویت تیاى کننذه ی هوافمت/هخالفت و دیذگاه شواست، خط تکشیذ</td>
</tr>
<tr>
<td>14 - ادامه‌ی بخش (ب): در مورد اظهارات و جملات زیر، لطفا دور عذد هناسه را، که ته خویت تیاى کننذه ی هوافمت/هخالفت و دیذگاه شواست، خط تکشیذ</td>
</tr>
<tr>
<td>13 - پیش‌بینی کننده موارد مختلف/مخالفت و دیذگاه شواست، خط تکشیذ</td>
</tr>
<tr>
<td>12 - شرط کافی در فعالیت‌های گروه‌گام شکل داده شود.</td>
</tr>
<tr>
<td>11 - کلاس‌های درس در مدارس نیز‌هوش به جای پرورش استعدادهای فکری، به صرف ابزارهای اطلاعاتی و مفاهیمی توجه دارند.</td>
</tr>
<tr>
<td>10 - در دانش‌آموزان، درست‌اندیشیدن (CT) بسیار انعطاف‌پذیر و تربیت‌پذیر است و می‌تواند از طریق شرکت در فعالیت‌های گروه‌گام شکل داده شود.</td>
</tr>
<tr>
<td>9 - تفکر خلاق (CT) و تفکر انتقادی (CT) به هم نزدیک و مربوط اند.</td>
</tr>
<tr>
<td>8 - معمولا دانش‌آموزان در کلاس درس، برای پرورش عادات و خوی و منت تفکر انتقادی حمایت نمی‌شوند.</td>
</tr>
</tbody>
</table>

195
| ج (ج) هر چند وقت یک، موضوعات و موارد زیر در تدریس و یا کلاس درس شما اتفاق می‌افتد؟ لطفاً با خط‌کشیدن دور عدد مناسب در جدول پاسخگویی نمایید. |
|---|---|---|---|---|---|---|
| 30 | هورش (IQ) یا لا (لا) از عوامل کلیه برای داوری و ارزیابی درست و هدف‌گذاری است. |
| 31 | درست آموزشی (CT)، به‌طور کلی کمک‌های عضوی در افراد، با آزمون‌های نفرک انفعالات، مانند یک واقعیت خارجی، قابل سنجش و اندوزه گیری است. |
| 32 | زمانی برای فرهنگی در گسترش و رشد تفکر انفعالات نش می‌گمی ایفا می‌کند. |
| 33 | پورش توانایی سنجشگرانه اندیشین (CT) در دانش آموزان. نیروی، حیاتی تر از پورش ان مهارت‌های در دانش آموزان غیر نیروی است. |
| 34 | خوی و مش و عادات فکری مناسب برای سنجشگر انگیزدان (CT) از فرهنگی به فرهنگ دیگر، منتفاوت است. |

<p>| 35 | دانش آموزان به شریعتی که قابل قبولی انجام می‌گیرد. |
| 36 | وضع کردن ملامه و معارف‌های برای ارزیابی و قضاوت و یا مقایسه. |
| 37 | از دانش آموزان خواسته می‌شود که پشت‌داری‌ها و امتیاز‌های استدلال یکدیگر را بپذیرد. |
| 38 | دانش آموزان برای تجزیه و حل مسئله، در گروه‌های کوچکی گروه‌بندی می‌شوند. |
| 39 | از شایعه کلاس درس، تا فضای کلاس برای پرورش مهارت‌های اندیشیدن مناسب تر شود. (برای مثال تغییر وضعیت نمک‌ها به صورت نیم‌جعبه، برای کنس متفاوت و به‌طور کلی (کلاسی) منطقی) |
| 40 | از دانش آموزان خواسته می‌شود تا ارتباط‌های میان رشته‌ای بین موضوع درس و تجربه‌های زندگی واقعی برقرار کند. |
| 41 | دانش آموزان به داوری و ارزیابی موضوعات، مسائل، و یا موضوع تربیتی و تشویق می‌شوند. |
| 42 | فرض نهایی برای دانش آموزان فراهم می‌شود تا اطلاعات و داده‌های عینی و محسوس را به‌طور منفعت‌آمیز استفاده نمایند. |</p>
<table>
<thead>
<tr>
<th>صورت اطلاعات و داده‌ای ذهنی و اندازایی تعمیم دهنده.</th>
</tr>
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<tbody>
<tr>
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</table>

<table>
<thead>
<tr>
<th>وارد کننده‌ی مخک‌ش (اج): هر چند وقت یک بار، موارد و موضوعات زیر در تدریس و یا کلاس درس شما اتفاق می‌افتد؟ لطفاً با خط‌کشیدن دور عده مناسب در جدول پاسخ دهید.</th>
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<td>58</td>
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<tr>
<td>62</td>
</tr>
<tr>
<td>66</td>
</tr>
</tbody>
</table>
| 71 | دانش‌آموز درمورد اصطلاحات و مفاهیم مرتبط به انقباض‌اندیشی‌ترین مانند تفاوت بین نتیجه‌گیری و مقدمه، فرض و حکم، علته و همبستگی، یا علت و معلول. | 72 | هشیاری و حساسیت نسبت به اوضاع و شرایط پیرامون | 73 | دانش‌آموز ذهن بی‌عرض و منصف
<table>
<thead>
<tr>
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<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
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</thead>
<tbody>
<tr>
<td>74</td>
<td>داشتن ذهنی مستقل</td>
<td>75</td>
<td>توانایی طرح کردن و پرسیدن سؤالات جدید و «خوب»</td>
<td>76</td>
<td>سرعت به‌کارگیری و استفاده از اطلاعات و داده‌ها</td>
<td>77</td>
</tr>
<tr>
<td>79</td>
<td>دقت</td>
<td>80</td>
<td>هشیاری و احتیاط</td>
<td>81</td>
<td>توانایی سازگاری با محیط و شرایط پیرامون</td>
<td>82</td>
</tr>
<tr>
<td>84</td>
<td>تجزیه و تحلیل کردن اطلاعات دست‌اول</td>
<td>85</td>
<td>انعطاف‌پذیری</td>
<td>86</td>
<td>علاقه و اکزیژه</td>
<td></td>
</tr>
</tbody>
</table>
B.4 Interview Guideline

Name of Study: CONSIDERING SCIENCE TEACHERS’ CONCEPTION OF THE PEDAGOGY OF CRITICAL THINKING IN SEVERAL OF IRAN’S SPECIAL GIFTED SCHOOLS: A MULTI-PHASED STUDY

Interview Questions - Guideline

1] Should the teaching of critical thinking be domain specific, domain general, or both?

2] Based on your experience with gifted learners, in your opinion what are the best strategies and approaches to promote thinking critically in a gifted science curriculum?

3] In your opinion, what is the evidence(s) of critical thinking you would be looking for in students’ scientific work?

4] To what extent and in what ways is critical thinking ability related to IQ?

5] What other factors affect the people’s judgment and therefore their ability to think critically?

6] To what extent are you currently using critical thinking strategies in your class with students? Please explain and provide examples.

7] Describe, if any, obstacles and restrictions on using critical thinking pedagogy in science education?

8] What are the similarities and differences between critical thinking and scientific thinking? Please provide examples.
9] Please add any further comment that you believe is important to understanding your work to teach critical thinking.
Appendix C: Qualitative & Quantitative (Sample Figures & Tables)

Figure C.1 Sample Interview Transcripts (Qualitative)
Figure C.2 Different Emergent Themes from Interviews

Figure C.3 Sample Meaning Blocks
Figure C.4 Sample Meaning Blocks
36. considered habits of mind in the evaluation of students’ thinking.

Statistics

36. considered habits of mind in the evaluation of students’ thinking.

<table>
<thead>
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<td>Median</td>
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<td>Mode</td>
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<td>2</td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Minimum</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td>6</td>
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</tbody>
</table>

Mean = 2.37  
Std. Dev. = 1.149  
N = 27
Figure C.6  Item #33 of the Scale (Quantitative)

Statistics

33. assessed students’ relevant criteria for their judgment.

<p>| | |</p>
<table>
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<tr>
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<td>Minimum</td>
<td>2</td>
</tr>
<tr>
<td>Maximum</td>
<td>6</td>
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</tbody>
</table>
Appendix D: Figures & Tables

Figure D.1 Item #75 of the Questionnaire

75. Ability to ask and pose "good" and "new" questions

- Extremely important: 10
- Very important: 19
- Moderately important: 6
- Neutral: 1
- Slightly important: 1
- Low importance: 1
- Not at all important: 0

Count
Figure D.2  Item #9 of the Scale
57. Creating interactive learning atmosphere and encouraging class discussion.

Figure D.3 Item #57 of the Questionnaire
Figure D.4 Habits of Mind
15. Critical thinking is a set of (mental) procedures, such as steps involved in problem-solving, or the stages of inquiry.

28. Cognitive skills and problem-solving strategies are more central to CT, rather than reasoning, good judgment, and logic.

Figure D.5 Items #15&28 of the Questionnaire
Figure D.6 Stem-and-leaf, Comparison Between Scale and Questionnaire

Figure D.7 Stem-and-leaf, Comparison Between Scale and Questionnaire
Figure D.8  Stem-and-leaf, Comparison Between Scale and Questionnaire
Figure D.9: Comparison Between Scale and Questionnaire.

31. encouraged multiple interpretations of events and situation.
32. invited students to consider probability of plausible options or alternative conclusions.
33. encouraged students to demonstrate open-mindedness and tolerance of imaginative, sometimes playful solutions to the problem.
34. provided opportunities for students to generalize from concrete data or information to the abstract.

47. Inviting students to consider probability of plausible options or alternative conclusions.
48. Encouraging multiple interpretations of events and situation.
49. Open-mindedness and having no prejudice.
50. Providing opportunities for students to generalize from concrete data or information to the abstract.
Table D.1  Correlations

<table>
<thead>
<tr>
<th>Spearman’s rho</th>
<th>41. Encouraging students to judge or evaluate situations, problems, or issues.</th>
<th>42. Providing opportunities for students to generalize from concrete data or information to the abstract.</th>
<th>44. Consciously providing an uncertain paradoxical situation in the classroom.</th>
<th>48. Encouraging multiple interpretations of events and situation.</th>
<th>53. Creating learning environment that involves ambiguity and equivocation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>41. Encouraging students to judge or evaluate situations, problems, or issues.</td>
<td>Correlation Coefficient</td>
<td>1.000</td>
<td>.370*</td>
<td>.364*</td>
<td>.320</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.</td>
<td>.024</td>
<td>.027</td>
<td>.054</td>
</tr>
<tr>
<td>42. Providing opportunities for students to generalize from concrete data or information to the abstract.</td>
<td>Correlation Coefficient</td>
<td>.370*</td>
<td>1.000</td>
<td>.342*</td>
<td>.482**</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.024</td>
<td>.</td>
<td>.038</td>
<td>.002</td>
</tr>
<tr>
<td>44. Consciously providing an uncertain paradoxical situation in the classroom.</td>
<td>Correlation Coefficient</td>
<td>.364*</td>
<td>.342*</td>
<td>1.000</td>
<td>.334*</td>
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<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.027</td>
<td>.038</td>
<td>.</td>
<td>.044</td>
</tr>
<tr>
<td>48. Encouraging multiple interpretations of events and situation.</td>
<td>Correlation Coefficient</td>
<td>.320</td>
<td>.482**</td>
<td>.334*</td>
<td>1.000</td>
</tr>
<tr>
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<td>Sig. (2-tailed)</td>
<td>.054</td>
<td>.002</td>
<td>.044</td>
<td>.</td>
</tr>
<tr>
<td>53. Creating learning environment that involves ambiguity and equivocation.</td>
<td>Correlation Coefficient</td>
<td>.388*</td>
<td>.286</td>
<td>.473**</td>
<td>.423***</td>
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<td>Sig. (2-tailed)</td>
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<td>.003</td>
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* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
Table D.2 Report for Friedman and Kendall’s W Tests

<table>
<thead>
<tr>
<th>CO Scale</th>
<th>Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>22. Encouraged students to demonstrate open-mindedness…</td>
<td>69. Open-mindedness and having no prejudice</td>
</tr>
</tbody>
</table>
Mean                                                                 | 3.44                                                                         | 6.19                                                                         |
Median                                                                | 3.00                                                                         | 6.00                                                                         |
Std. Deviation                                                        | 1.311                                                                        | .834                                                                         |
Variance                                                              | 1.718                                                                        | .695                                                                         |

**Test Statistics**

<table>
<thead>
<tr>
<th>Friedman Test &amp; Kendall’s W Test</th>
<th>N</th>
<th>Kendall’s W</th>
<th>Chi-Square</th>
<th>df</th>
<th>Asymp. Sig.</th>
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<tbody>
<tr>
<td>a. Friedman Test</td>
<td>27</td>
<td>.926</td>
<td>25.000</td>
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<td>.000</td>
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<td>b. Kendall’s Coefficient of Concordance</td>
<td></td>
<td></td>
<td></td>
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</table>

Table D.3 Report for Friedman and Kendall’s W Tests

<table>
<thead>
<tr>
<th>CO Scale</th>
<th>Questionnaire</th>
</tr>
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<tbody>
<tr>
<td>25. Invited students to consider probability of plausible options or alternative conclusions.</td>
<td>47. Inviting students to consider probability of plausible options or alternative conclusions.</td>
</tr>
</tbody>
</table>
Mean                                                                 | 3.85                                                                         | 5.19                                                                         |
Median                                                                | 4.00                                                                         | 5.00                                                                         |
Std. Deviation                                                        | 1.586                                                                        | 1.272                                                                        |
Variance                                                              | 2.516                                                                        | 1.618                                                                        |

**Test Statistics**

<table>
<thead>
<tr>
<th>Friedman Test &amp; Kendall’s W Test</th>
<th>N</th>
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Table D.4 Report for Friedman and Kendall’s W Tests

<table>
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<tr>
<td>31.</td>
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<td>48. Encouraging multiple interpretations of events and situation.</td>
</tr>
<tr>
<td>Mean</td>
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<td>Std. Deviation</td>
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<td>Variance</td>
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<td>1.842</td>
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<table>
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<th>Friedman Test &amp; Kendall’s W Test</th>
<th>Test Statistics(^a)</th>
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<tr>
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\(^a\) Friedman Test
\(^b\) Kendall’s Coefficient of Concordance

Table D.5 Report for Friedman and Kendall’s W Tests

<table>
<thead>
<tr>
<th></th>
<th>28. Cognitive skills and problem-solving strategies are more central to CT, rather than reasoning, good judgment, and logic.</th>
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<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>93.500</td>
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<td>Asymp. Sig.</td>
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</tbody>
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\(^a\) Kruskal Wallis Test
\(^b\) Grouping Variable: 5. Are you alumni of gifted schools?