Development and validation of a critical thinking framework

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Abstract

Critical thinking (CT) is essential in many higher-order thinking skills and should be enhanced by higher education programs. An effective conceptualization of CT should: 1) completely and objectively describe CT, 2) distinguish CT from other skills, and 3) be used by all disciplines. After a literature review revealed the absence of such a definition, the Model of Integrated Thinking Skills (MITS) was developed by the authors and validated against the three criteria through a qualitative survey. Most participants perceived that MITS meets the three criteria, suggesting that MITS can assist student development of CT.

Keywords: critical thinking, intentional thought, cognitive framework

Introduction

Critical thinking (CT) is foundational to many higher order thinking processes including problem solving, a skill consistently ranked among the top skills employers seek in new hires (Adams, 2014; Doyle, 2017; Gray & Koncz, 2017; Gunn, Grigg, & Pomahac, 2007; Tenreiro-Vieira & Vieira, 2000). Since effective problem solvers need well-developed CT skills, developing students' CT abilities in post-secondary institutions is crucial. In addition to having excellent problem solving skills, new graduates seeking employment must also be able to explain their thinking process to potential employers (Adams, 2014; Farenga & Quinlan, 2016). Post-secondary institutions can produce more successful and employable alumni if they train students how to communicate their thinking to others.

CT is one of the most highly discussed and sought skills by universities in Australia and Ontario, Canada (Herbert, 2015; Oliver & Jorre de St Jorre, 2018). However, Canadian policy makers in education also state that "these [skills] are not transparently or consistently measured, assessed, or validated across the system" (p. 38), suggesting that further research concerning CT is required (Herbert, 2015). Multiple theories of CT exist and often present competing definitions, making it challenging for educators to explicitly teach critical thinking skills in their courses ("Critical Thinking," 2018). As a result, students may not be aware of their transferrable thinking skills or how to communicate their abilities to employers. This issue may be alleviated if those in higher education had a common understanding of CT that outlines its purpose, components, and contextual dependencies.

We began this study by consulting the literature to find such a definition of CT. Specifically, we sought a definition that met the following three criteria:

- (1) objectively explains CT in its entirety
- (2) enables the reader to distinguish CT from other cognitive skills
- (3) can be used by all disciplines

Criterion 1 was selected because an accurate conceptualization of CT should include all components of CT. Criterion 2 was selected because explicit distinction between CT and other cognitive skills partially defines CT. Criterion 3 is necessary to situate CT as a transferrable skill whose underlying concepts are consistent between disciplines.

Although we examined four models of CT and one model of problem solving, we failed to find a definition that meets these three criteria. Following this, we developed the Model of Integrated Thinking Skills (MITS) using concepts from the reviewed models and used a qualitative survey to validate MITS against the three outlined criteria.

Existing Views of Critical Thinking

Zechmeister and Johnson (ZJ) View

The ZJ view focuses on how learners enhance their CT skills. Citing Glaser (1985), they state that critical thinkers possess three characteristics: 1) an attitude conducive to perceptive thought, 2) knowledge of logical inquiry and reasoning, and 3) skill in using logical inquiry and reasoning. They emphasize the importance of attitude in CT by citing Dewey (1933) who argued that attitude and knowledge are united in good thinkers (Zechmeister & Johnson, 1992).

The Liberal Academic (LA) View

The LA view of CT is structured as a model of education rather than a model of CT because it focuses on developing the student overall. In principle, an LA-influenced education has four objectives: 1) to pursue truth using critical investigation, 2) to expand the student's outlook, 3) to develop the student's ability to interact in a social and civic manner, and 4) to develop the general intellectual abilities of the student (Johnston, Mitchell, Myles, & Ford, 2011).

The Critical Being (CB) View

The CB view suggests that 'criticality' exists beyond the mind and that it is possible to be both an advanced thinker in one's own discipline and novice thinker in a foreign discipline (Barnett, 1997; Johnston et al., 2011). The authors do not indicate if this tension arises because the thinker's cognitive skills are discipline-specific or if the thinker is limited by their lack of disciplinary knowledge in the foreign discipline. CBs possess critical skills in their thinking, self-reflection, and interaction with the world (Barnett, 1997; Johnston et al., 2011). Individuals achieving the "full potential of critical being" will have superior critical skills and creativity, but creativity is seldom mentioned in the theory (Barnett, 1997; Johnston et al., 2011).

Paul's Model of Critical Thinking

Paul's description of CT is centered on the idea that CT and creative thinking are fundamentally inseparable. He considers the creation of a thought as creative and argues that since all products—including thoughts—are made with a goal in mind, CT is integrated directly into our creative ability (Paul, 1993). The mind automatically uses criteria to filter potential thoughts in response to a stimulus. The relevance and quality of a thought indicates the mind's ability to appropriately select and use criteria. Disciplines use specialized concepts that guide our thinking with order and logic (Paul, 1993).

Creative Problem Solving (CPS) Model

CPS is a process that transforms responses to open-ended questions into targeted strategies that may become solutions. CPS characterizes higher order cognitive processes as a dynamic combination of divergent thinking, "the broad search for many diverse and novel alternatives," and convergent thinking, "a focused and affirmative evaluation of alternatives" (Puccio et al., 2011, p. 66). The goal of convergent thinking is to refine ideas generated by divergent thought through the application of affirmative judgment, or affirmative critical thought (Puccio et al., 2011).

Criteria Fulfilment

None of the CT models met all three of our criteria (Table 1). Even though Criterion 1 was deemed unrealistic, each CT model omitted at least one concept related to CT we

considered crucial. Below we discuss why these models did or did not meet our criteria.

Criterion 1: Complete and Objective

None of the models met Criterion 1. We later realized that Criterion 1 was unrealistic because abstract concepts related to cognition are difficult to explain "in their entirety," as researchers are still trying to uncover the essential elements of CT and related concepts. However, the reviewed models ignored important elements of CT like its components and context. For example, the ZB, CPS, and CB models focus exclusively on the outcomes of CT and the qualities of a critical thinker. Paul's work depicts creativity as a piece of CT and does not acknowledge that creative thinking can be favoured over CT. The LA view discusses CT only in the context of formal knowledge and considers objectivity and absolute truth as obtainable (Johnston et al., 2011).

A valid model of CT should reflect CT that happens in real life, where absolute truth is sometimes unattainable, and that CT is applicable in contexts beyond academia. A more appropriate criterion may be "Considers the multiple and varied aspects of CT."

Criterion 2: Distinguishes CT from other skills

Three of the models did not meet Criterion 2 because they did not address CT directly, instead blending CT with other concepts. For example, CT is not clearly articulated in the LA model and is present in all four LA objectives. The CB model suggests that CT differs between disciplines but does not distinguish contextual thinking from transferrable thinking. The CB model states that mature critical thinkers are creative, but does not detail the relationship between CT and creative thinking. The ZJ model describes how critical thinkers may enhance their CT skills, but does not comment on other cognitive skills.

Criterion 3: Discipline-neutral

All models met Criterion 3 because these theories can be interpreted in multiple disciplines.

The Development of the Model of Integrated Thinking Skills

Although none of the models met all three criteria independently, each criterion was met at least partially (Table 1). The models contradicted each other on certain concepts (e.g., the relationship between CT and creative thinking, and the nature of knowledge), but many of their points reinforced each other. After we became familiar with the literature around CT, creative thinking, and human thought, we realized that isolating CT from creative thinking is a disservice to our comprehension of CT itself. The human thought process is complex and is much better understood when considered holistically.

The Model of Integrated Thinking Skills (MITS) is a framework we developed to combine and add to concepts

proposed by the five discussed models (**Figure 1**). MITS describes intentional thinking as a combination of critical thinking and creative thinking and details the relationship between the two at different levels of thought. MITS was originally designed to provide a useful conceptualization of CT by examining it as a versatile and essential component of thought. After careful consideration, we realized that MITS's true function is to serve as a model of intentional thought, including both CT and creative thinking. We hypothesize that MITS meets our three criteria because it was designed to unite and expand on existing theories and models of CT and creative thinking. An online validation survey was designed to test this hypothesis.

Undergraduate students, graduate students, staff, faculty, and administration from the University of Guelph were invited to share their perceptions of the MITS framework with respect to the three criteria. We discuss how MITS meets the criteria based on participants' responses. Overall, most respondents indicated that MITS adequately meets the three criteria, suggesting that it may be an appropriate conceptualization of CT to guide students' thinking development in higher education.

Methods

Development of the Online Survey

We created a nine-question survey to assess university staff, faculty, and student perceptions of the MITS with respect to the three criteria that guided its development. Research Ethics Board approval was granted in August 2016.

The first five questions of the survey asked participants to indicate their age group, role within the university, highest level of education achieved, home department within the university, and whether or not they had learned about MITS through a presentation.

Participants were then given the MITS text description and diagram at the beginning of the survey (see **Figure 1**). Three open-ended questions asked the participants if they thought that MITS met each of the three criteria: 1) objectively explains CT in its entirety, 2) enables the reader to distinguish CT from other skills, 3) can be used by all disciplines. The final question was a space for participants to note any other comments about the study. Participants were not given instruction about which skills CT could be compared to, nor how different disciplines use CT.

Advertisement and Administration of the Survey

The survey was hosted by Qualtrics Insight Platform (Qualtrics, Provo, UT), an online survey system, and was live for 23 days in September 2016. Thirty posters advertising the study were posted in high-traffic areas throughout the campus. Additionally, the Dean's Assistants of all seven major units on campus were sent an invitation e-mail with a link to the survey requesting that the e-mail be forwarded to undergraduate students, graduate students, faculty, course/teaching staff, and administrative staff. Six of the seven units passed on the

invitation to some or all of the targeted demographics. We did not determine a minimum sample size, rather, we aimed to collect as many responses as possible.

Potential participants accessed the survey online. Participants were asked to respond to the 9 questions. After completing the survey, participants were given the option to enter a draw to win 1 of 10 on-campus dining gift cards (valued at \$10 each).

Data Analysis

A total of 158 responses were recorded. After closing the survey, the responses were imported from the Qualtrics server to Nvivo 11 (QSR International, Melbourne, AUS), a qualitative analysis software program. The primary author analyzed the data using inductive content analysis, a strategy used to draw conclusions from qualitative information through the identification of themes integrated throughout the data (Patton, 2002).

All responses were coded into one of 5 mutually exclusive categories: Complete Agreement, General Agreement, Disagreement, Unsure, and Tangential Answer. Although there is always potential for unconscious bias to affect qualitative analyses, the authors felt that most responses were written clearly and yielded straightforward interpretations. Responses that were unclear were coded into the Unsure and Tangential Answer categories.

Responses that suggest the participant was in full agreement with MITS were coded in the Complete Agreement category. Responses that suggest the participant was in agreement with MITS overall, but had minor suggestions for improvement were coded in the General Agreement category. Responses that suggest the participant rejected or disagreed with a fundamental component of MITS were coded in the Disagreement category. Some responses suggest that the participant did not know their position and were coded in the Unsure category. Responses that did not appear to address the question were coded in the Tangential Answer category. All surveys included in the analysis provided answers to each of the questions targeting the three criteria.

Responses coded under Disagreement and Unsure were analyzed again to identify common themes in participants' reasons for disagreement and uncertainty.

Results and Discussion

Survey participation

In total, 158 responses were recorded. 19 responses were completely blank, leaving 139 responses that provided answers for each question targeting the three criteria. Twenty-five of the thirty-four departments on campus were represented, covering all seven major units of the institution. Excluding four outliers whose survey browsers were active for greater than three hours, participants submitted their responses an average of 18 minutes after beginning the survey. Most participants identified themselves as undergraduate students (**Figure 2**). The undergraduate voice is imperative in this

study because MITS is designed to help them understand the skills they are developing—if undergraduate students relate MITS’s concepts to their own studies, we demonstrate that MITS targets at least one of the appropriate audiences. Graduate students and faculty also provided significant input, along with some participation from course/teaching staff and administrative staff.

Agreement

Overall, most participants appeared to agree that MITS satisfies the three criteria (**Figure 3**). Responses from 75.5% of respondents suggest that MITS is as complete and objective as possible, 70.9% of responses suggest that MITS distinguishes CT from other skills, and 88.5% of responses indicate that MITS is discipline-neutral. Reasons for agreement were grouped into themes. Recurring themes among responses indicating acceptance of MITS are discussed below.

Complete and Objective

Responses from 75.5% of the participants were interpreted as statements that completely agree or generally agree that MITS is complete and objective, while 18.0% of comments were interpreted as being in disagreement. These responses suggested that MITS’ ideas align with those of the participants. An example of one such response is given below:

I do feel this definition of critical thinking describes it objectively and completely as I feel it touches on all bases, such as thinking creatively and keeping an open mind, thinking depending on the situation, and evaluating, etc.

An additional 5% of responses were interpreted as uncertain. Participants appeared to be unsure if MITS is complete and objective. Lack of expertise in metacognition was a common theme among almost all of these responses:

I’m not sure if I would say completely as I can’t speak to the depth of what critical thinking embodies but I do believe this is an objective definition.

One of these participants commented further, noting that CT is a theoretical construct and its definition can be adjusted depending on the needs of the user:

I don’t know enough about it to answer, though it’s a man made concept, so it’s whatever we want to define it.

Finally, one participant noted that critical thought may change as society advances:

No definition of critical thinking can be complete, as the basis of critical thinking will change with the

passage of time. Critical thinking in 2016 is different to that of 1916, 1816, 1716, etc

This passage was not considered to affirm MITS’ completeness because it suggests that CT may be era-dependent. This view is in accordance with postmodern theory, a view which questions our ability to “[guarantee] all knowledge claims irrespective of time and place” (Woods, 2009, p. 10). This insight reinforces the notion that Criterion 1 may be unrealistic. Although most participants agreed that MITS is “complete and objective,” Criterion 1 may be rephrased to more appropriately state that MITS “considers the multiple and varied aspects of CT.”

CT is a major component of the thought underpinning academic activities across all disciplines (Brookhart, 2004; Paul, 1993). Overall, 75.5% of participants agreed that MITS objectively considers the multi-faceted and almost amorphous nature of critical thought. This quality is important in the learning context to ensure that CT is recognized in its various forms. For example, a model describing CT only in the context of designing experiments may cause the user to infer that CT is used *exclusively* to design experiments. Here, a student’s CT development may be biased towards learning how to design experiments, neglecting other forms of CT like appraising artwork or implementing ethical policies. CT is considered a transferrable skill, meaning it is used in many varied situations. By acknowledging and exploring the different ways critical thought manifests, we reaffirm and respect its diverse functionality.

Distinguishes CT

Responses from 70.9% of the participants were interpreted as statements suggesting MITS enabled them to completely or mostly distinguish CT from other skills—in particular, creative thinking. Meanwhile, 22.6% of comments were interpreted as being in disagreement. The excerpts suggest that MITS’s deliberate explanation of CT at multiple levels and use of examples to highlight CT allows readers to identify CT in complex thought processes. Participants indicated that the inclusion of creative thinking as a complementary thinking style enabled them to compare CT and creative thinking, enhancing their understanding of CT. The following excerpt provides an example of a response stating that MITS helped them distinguish CT from other skills:

Yes. Providing a definition of CT, skills and superskills enables the reader to compare the 3 definitions. The examples provided further allow for a clear understanding.

Some participants elaborated, stating that MITS can be used to recognize and characterize various skills and thought processes according to their emphasis of critical or creative thinking:

Yes, it describes critical thinking, compares it to creative thinking, and provides examples to aid in recognizing this form of thinking. It also explains how critical thinking and creative thinking are combined to form skills.

Some participants explained that MITS helped them understand and dissect their own thought patterns, suggesting that MITS may encourage metacognitive reflection:

I feel that now I can [identify] which exact part of my process is critical thinking therefore distinguishing it.

Learners who identify components of their own thought and skill experience deeper learning (Bransford, Brown, & Cocking, 2000). Students engaging in metacognitive reflection become better self-regulators and are more capable of achieving their goals (Cacciamani, Cesareni, Martini, Ferrini, & Fujita, 2012). In addition to self-awareness, receiving targeted feedback is important in the conscious development of any skill because it helps individuals identify their own strengths and weaknesses. A conceptualization of CT that distinguishes CT from other skills is necessary for both educators guiding student growth and students examining their own thought.

Discipline-neutral

Responses from 88.5% of participants indicated that they fully or mostly agree that MITS is discipline-neutral, while 7.9% of comments were interpreted as being in disagreement. Please note that we did not provide participants with an explanation of how CT manifests in various disciplines, so participants' answers may be limited based on their perceptions of disciplines unfamiliar to them.

The majority of respondents agreed that MITS's language is non-restrictive and describes thought processes that transcend disciplines. These qualities contribute to MITS' robustness. For example, one participant wrote:

Yes. It shows that critical skills are not restricted to strict logical or mathematical operations, thus expanding the definition to fit multiple disciplines. Each discipline uses a combination of creative and critical thinking in their own ways.

Some participants commented on MITS's discipline-neutrality, explaining that they easily understood the framework without formal training in metacognition:

I have very little background in science, psychology or related fields to the processes behind thinking and feel that I understood each point & learned a lot about CT.

Other participants mentioned how they applied MITS immediately to their own context, suggesting that MITS offers a user-friendly conceptualization of critical thought:

Yes. I was using examples while reading about how I critically think about my area of study on a daily basis.

At our institution, CT is a university-wide learning outcome; therefore, each program offered must develop CT in its students (Desmarais, 2012). A common understanding that makes sense and is useful in all disciplines is key to ensuring that the integrity of campus-wide CT development remains intact. The robust nature of MITS enables it to be used in many disciplinary contexts.

Fundamental Disparities

Many themes emerged from the arguments of participants who did not agree that MITS satisfies the three criteria. Participants used all three open-ended questions and the space for additional comments to articulate their disagreement. Some of these themes are considered fundamental disparities with MITS, meaning the participants' responses indicated a disagreement with MITS' core elements. The three most common themes are discussed below.

Inappropriate exclusion of doubt and skepticism

Responses from 3.6% of the participants appear to express concern that doubt and criticism were not mentioned in the framework. The idea that skepticism is a fundamental component of critical thinking was observed:

The "critical" in CT is related to critique, which is a style of commentary which questions the arguments and assumptions of its subject matter. This definition does [not] address that.

To me, critical thinking is about doubt. Descartes, a famous mathematician and philosopher, said "doubt everything." This, to me, is the basis of critical thinking. The essence of doubt is not discussed in this proposed definition.

There is a longstanding misconception that CT necessitates doubt. However, when referring to "critical thinking," the word "critical" should be associated more with the word "criteria" than with "criticism" (Gini-Newman & Case, 2015). Good critical thinkers do produce criticism and harsh judgments, but only when such conclusions are appropriate. Thinkers who respond to all new knowledge with cynicism undermine the purpose of CT, which is, in part, to make rational judgments based on reason and evidence (Brookhart, 2004; Gini-Newman & Case, 2015). By allowing doubt to dominate their thoughts, thinkers inadvertently bias their thought against the object at hand. Advanced critical

thinkers fully engage with their environment, and as a result, familiarize themselves with and appreciate diversity (Brookfield, 1987; Vieira, Tenreiro-Vieira, & Martins, 2011).

Let us explore this idea with an example. Critical thinking has an important role in problem solving processes (Gunn et al., 2007). When faced with a dilemma, effective problem solvers have the ability to withhold criticism during the brainstorming phase, encouraging fresh, new ideas to develop (Puccio et al., 2011). They also use CT to discover the merits of outlandish ideas that may actually pose the best solution to the problem at hand (Puccio et al., 2011). If CT necessitated doubt and skepticism, our problem solving techniques would lack innovation.

Inappropriate inclusion of context

Responses from 7.9% of the participants suggest that MITS should deemphasize the influence of context on critical thinking, if it is to be included at all:

The field of an individual has little to do with critically assessing a topic. Knowledge and reason are universal, and should get you where you are trying to go, regardless of background.

Many models of thinking suggest that thinking cannot occur in an intellectual vacuum—in other words, if an individual is going to think, they need something to think *about* (e.g. Brookfield, 1987; Facione, 1990; McPeck, 1994; Moore and Parker, 1986). Disciplines differ from each other in that they discuss different content and, by extension, abide by different guiding criteria. If critical thought is considered analogous with *critical* thought, defining the governing criteria and the content to which the thought applies is necessary to characterize and assess the quality of an individual's critical thinking habits.

Other responses suggested that MITS might not have clearly justified the relationship between disciplinary context and personal context:

[I'm] not sure why critical thinking's defined as being in a personal context.

Disciplinary contexts and personal mental contexts are linked through the act of learning; when a student learns, they construct information in their own mind (Biggs, 1996; Paul, 1993). In other words, information is being created in a unique context that is available solely to the learner. As human beings, our mental contexts are influenced by personal history, emotions, conditions, and other human traits. A relevant model of thinking should acknowledge that the environment where thinking occurs will never be the same between two people, even if their thinking objectives and outcomes are identical.

Inappropriate inclusion of creative thinking

Responses from 5.0% of the participants appear to voice concern surrounding the inclusion of creative thinking in the discussion of critical thinking. The necessity of addressing critical thinking alongside creative thinking may not have been evident:

I [am uncertain] of how much creativity is really a required component of critical thought.

The idea that critical and creative thinking are deeply intertwined is foundational in numerous theories about human thought (ex Bailin, 1993; Gini-Newman and Case, 2015; Paul, 1993; Puccio et al., 2011; Walters, 1994). Post-secondary institutions have long been inundated with “logicistic” perspectives of thinking—that is, “the unwarranted assumption that good thinking is reducible to logical thinking” free from imaginative or intuitive influence (Walters, 1994, p. 1). Good thinkers analyze information using reason and they also encourage creative thoughts to permeate their thinking space (Puccio et al., 2011; Walters, 1994). A theory that discusses creative thinking independently of critical thinking implies that one's thought process must be examined through a creative lens and a critical lens separately (Gini-Newman & Case, 2015). Given that in real life individuals think with a combination of critical and creative thinking, an effective model of thought should explore these two thinking modes simultaneously.

Next Steps and Conclusion

Although MITS was originally developed to describe CT, we now realize that MITS is actually a model that describes intentional thought as a combination of both CT and creative thinking. Since we drew this conclusion after the development and validation of MITS, the framework lacks a detailed explanation of creative thinking. The immediate next step is to revisit the literature to compose a thorough discussion of creative thinking as an equally important but inherently different component of thought. MITS should be revalidated after this major revision.

MITS is a framework of intentional thought that was designed specifically for academic use and validated through qualitative research. It appears to be as complete and objective as possible, distinguishes CT from other skills, and is discipline-neutral. MITS embraces the interconnectivity between CT and creative thinking, providing readers with a holistic conceptualization of intentional thought that is an authentic representation of how individuals think.

MITS may be adapted further to create discipline-rooted tools that aid in the development of students' whole thought processes. One participant noted that implementing such a framework might be beneficial in an educational setting:

Yes, if these disciplines are able to define their context at the student, course, program, and departmental levels. Teaching students to be critical thinkers is a subjective experience unique to each student. Difficult but so valuable.

Another participant suggested that MITS is a useful tool for establishing a basic understanding of human thought processes, but that individuals immersed in a discipline may benefit from more context-sensitive explanations:

I think this definition does its job in describing some of the basic processes, although, speaking to anthropology and philosophy specifically, it does not go far enough for these disciplines in terms of what is required at the upper levels.

Due to MITS' discipline-agnostic nature, it can be used by and adapted to many disciplines. However, further work may be required to make MITS' impact explicit in specific educational contexts.

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Tables and Figures

Table 1. Analysis of how the five models of CT meet our criteria.

Model	Criterion 1: Complete and Objective	Criterion 2: Distinguishes CT	Criterion 3: Discipline-neutral
Zechmeister and Johnson (ZJ)	No – describes qualities of a CTer, not CT itself	No – describes skills related to CT but does not compare with other skills	Yes
Liberal Academic (LA)	No – assumes truth is obtainable	No – elements of CT are blended into four LA objectives	Yes
Critical Being (CB)	No – does not explore components of CT or explains relationship with creativity	No – states that critical thinkers are creative but does not distinguish CT from creativity	Yes
Paul	No – considers creativity as a skill inferior to CT	Yes	Yes
Creative Problem Solving (CPS)	No – does not explore components of CT	Yes	Yes

The Model of Integrated Thinking Skills (MITS)

Overview

Critical thinking may be defined as a thinking style that allows individuals in any discipline to reason and rationalize within their own specific contexts.

Detailed Explanation

Every thought-producing mind thinks critically. Therefore, critical thought transcends disciplines, yet it occurs in a mental context unique to each person. Critical thinkers are able to recognize and characterize their own context. Our contexts are defined by:

- 1) the discipline in which we specialize,
- 2) our personal mental environment (which is affected by human elements such as personal history, beliefs, attitudes, and values), and
- 3) situational circumstances.

There are different levels at which we think: a primary level (A), a secondary level (B), and a tertiary level (C). Critical thinking and creative thinking are both present in every level.

- A. The primary level of thought, or the **Thought Mechanics** level, is the most basic level. This is where we simply produce coherent thoughts. Generating sensible thoughts requires an equal balance of creative and critical thinking, so at the *Thought Mechanics* level, critical thinking and creative thinking are inseparable—one cannot happen without the other.

Explained further: When you make thoughts, your brain uses creative thinking to produce ideas in response to some stimuli (a question, a situation, etc.). Simultaneously, your brain filters possible thoughts based on a set of criteria to ensure that the thought you produce makes sense. For example, if you were asked to name your favourite food, your mind will select an answer that fits certain criteria: your favourite food must be edible and you must enjoy it. Grilled cheese is an acceptable answer and may come to mind. A bicycle is an unacceptable answer and does not come to mind.

- B. The secondary level of thought, or the **Skills** level, is more sophisticated than the *Thought Mechanics* level. *Skills* are typically dominated by creative or critical thought, and as a result become divergent or convergent in nature.

Explained further: For example, brainstorming requires more creative thought than critical thought and may be considered divergent. Alternatively, proofreading requires more critical thought than creative thought and may be considered convergent.

In convergent thinking skills, critical thought dominates creative thought. These skills are used to evaluate some object (physical or abstract) by a set of standards. Convergent skills can be used to find positive and negative points, depending on the attitude of the thinker.

Explained further: Most convergent skills provide objective information so that a well-informed decision can be made. Decision-making is a type of convergent thinking skill because typically one idea is selected for further pursuit. Decision-making is different than other convergent skills because it simultaneously concludes the thinking that has occurred while beginning the next thinking activity by forcing the thinker to ask the question “How do we react to this decision?”

- C. The tertiary level of thought, or the **Superskills** level, is even more sophisticated than the *Skills* level. *Superskills* are useful collections of skills that, when considered all together, approach an equal balance between critical and creative thinking.

Explained further: For example, consider problem solving. After using divergent thinking skills to generate several potential solutions, convergent thinking skills are used to evaluate the benefits and pitfalls of each potential solution. Then a decision is made; one solution is selected as the best solution to the problem.

The following figure provides a visual depiction of how critical thinking and creative thinking interact at each level.

Figure 2. Distribution of participant roles (n=139).

Figure 3. Participants indicate that MITS does or does not meet its three underlying criteria (n=139).