

# A Descriptive Analysis of the Critical Thinking and Argumentation Skills of Science, Technology, Engineering, and Mathematics Students

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This study primarily aims to analyse the critical thinking and argumentation skills of science, technology, engineering, and mathematics students. The study also intends to determine the possible relationship of the two skills by using a descriptive correlational method. A total of 105 senior high school students of the Don Honorio Ventura Technological State University were selected using a stratified proportional random sampling technique to participate as the respondents of this study. The skill of critical thinking was measured using a multiple-choice critical thinking test, while the argumentation skill was measured through argumentative writing. The data obtained from the sample indicates that the respondents are considered ‘practising thinkers’ in terms of critical thinking, but ‘competent thinkers’ in regards to argumentation. Based on the findings, the study concludes that their skills in critical thinking and argumentation have a weak positive correlation. However, the relationship is still considered significant, which implies that students’ performance in a multiple-choice critical thinking test could be associated with their performance in argumentative writing. This concludes that students who have higher level of critical thinking are most likely effective in argumentation. Likewise, students who write effective argumentative essays manifest better results in a multiple choice critical thinking test.

**Keywords:** *Critical thinking, Critical skills, Multiple choice test, Argumentative writing, Argumentation.*



## Introduction

Critical thinking is one of the most important outcomes of education. It is the mode of thinking about any subject, in which one improves the quality of his or her thinking by skillfully analysing, assessing, and reconstructing it.

According to Paul and Elder (2002), critical thinking is about becoming a better thinker in every aspect of life. People are what they think. Whatever they do, feel, and want, are all determined by the quality of their thinking. When people are not aware of the way they think, they have no chance of ‘correcting’ it. When thinking is subconscious, problems in it are not seen, and thus, there is no motivation to change it.

Critical thinking also encompasses important factors, such as analysis, evaluation, inference, interpretation, explanation, and self-regulation (Facione, 2006). Moreover, Paul (2004) adds that critical thinking is self-directed, self-disciplined, self-monitored, and self-corrective thinking. It presupposes assent to rigorous standards of excellence and the mindful command of their use. It entails effective communication and problem-solving abilities, as well as a commitment to overcome native egocentrism, and sociocentrism. In short, critical thinking functions to remove prejudice and bias to allow well-reasoned views to take root, in order to motivate a proper action. Given that thinking is the foundation for all true education, education, then, should be assessed based on how well it develops the critical faculty in students.

In academic contexts, students are expected to improve their critical thinking, which according to Bailin, Case, Coombs, and Daniels (1999), is conceptualised in terms of skills, processes, procedures, and practice. Wright (2002), as cited in Fahim and Hashtroodi (2012), also claims that critical thinking is a skill.

The partnership for twenty-first century skills (2009) emphasises that critical thinking skills are among the most important classes of student outcomes in this century. These skills are necessary to other cognitive skills, such as decision-making, and problem-solving.

Likewise, the Educational Policies Commission, as mentioned by Cottrell (2005), claims that critical thinking skills are longstanding desired outcomes of education, and in modern day, they are seen as essential for accessing and analysing the information needed to address the complex, non-routine challenges facing workers in the twenty-first century.

Mason (2008) claims that the goals of critical thinking and life-long learning appear frequently in the rhetoric of current educational reform in many societies across the globe. Similarly, Beaumont (2010) asserts that critical thinking remains at the forefront of educational discussions. Accordingly, these higher-order thinking processes — which include but are not limited to reflection, inference, and synthesizing information — enable individuals to make reasoned judgments, not only in the classroom, but in everyday life. This is in line with the



argument of Cottrell (2005), who claims that nobody is an absolute beginner when it comes to critical thinking. Everyday activities require people to make use of some of the basic skills involved in critical thinking, such as working out whether they believe what they see or hear; taking steps to find out whether something is likely to be true; and arguing their own case, if someone does not believe them.

However, just because one can think critically, does not mean he or she always does, or does it well. This is to be expected, as people do not need to employ the same level of critical thinking for everything they do. They must decide upon how much information is really required. Consequently, school systems demand that critical thinking be incorporated into curricula, and standardised testing increasingly assesses it (Beaumont, 2010).

Recent research studies claim that critical thinking plays an important role in effective language learning and is proven to have many advantages and possibilities (Rafi, 2010; Rashid & Hashim, 2008; Thadphoothon, 2005).

Critical thinking is indeed a major learner outcome for the twenty-first century (Bart, 2010). Williams (2005) notes that “critical thinking is important in all academic disciplines within democratic education, but it is indispensable in the field of teacher education”. It is thus necessary to develop the students’ critical thinking skills through practice. However, there remains the question of how English language teachers include the development and practice of these important skills in their lessons.

Learners must be able to carefully and deliberately determine to accept, reject or suspend judgment about a claim. In the meantime, critical language learners must be able to cite and identify good reasons for their answers and opinions. They should also correct themselves and others’ methods, and cope with regularities, uniformities, irregular circumstances, special limitations, constraints, and over-generalizations (Kabilan, 2000).

Fahim and Pezeshki (2012) also emphasise that teachers should not only focus on testing the students’ knowledge. They should also help them understand that the focus of the test they are taking is to boost their critical thinking. Accordingly, different language tests can be manipulated to engage the learners in critical thinking activities.

Another important skill that is under the concept of critical thinking is argumentation. According to Eemeren, Grootendorst, and Snoeck (1996), argumentation is a verbal and social activity of reason aimed at increasing or decreasing the acceptability of a controversial standpoint for the listener or reader. Argumentation has existed since long before the nineteenth century, which implies that argumentation is already an important factor in society.

At present, students are expected to make an argument, since it is at the heart of critical thinking and academic discourse. According to Epstein (2006), a good argument is one that presents a



conclusion and then gives good reasons for accepting it. Primarily, the goal of argumentation is to justify one's standpoint or to refute someone else's. When one argues, he or she attempts to persuade. However, the goal of logic and argumentation is not simply to persuade; it is to persuade for good reasons.

In argumentative writing, students are required to embrace a particular point of view and convince the reader to adopt the same perspective or to perform a certain action. Writers must also anticipate the audience's position, justify their own position, consider the alternative positions, and if appropriate, rebut the opposing positions (Ferretti, MacArthur & Dowdy, 2000).

Academically, written argumentation helps students acquire knowledge and promotes scientific thinking skills. Furthermore, written argumentation can lead to an increase in intrinsic motivation and problem-solving performance in the academic setting. However, according to Felton and Herko (2004), given the many cognitive demands on the writer, it is not surprising that argumentative writing is difficult for many students to master.

The present study aims to assess the critical thinking and argumentation skills of the respondents using a multiple-choice critical thinking test, and argumentative writing. The multiple-choice critical thinking test could serve several useful purposes if they are valid. In the present study, its components include deduction, credibility, assumptions, induction, and meaning. On the other hand, argumentative essays can be used as a diagnostic device to identify specific areas of reasoning or argumentation, with which learners may need help, and as a device for evaluating effectiveness of instruction in critical thinking or reasoning. The aspects of argumentative writing covered in this study include focus, supporting reasons, reasoning, organisation, and convention.

At present, critical thinking holds an important place in language education. With the increasing national focus on critical thinking skills, argumentation has become even more important to the discipline, as a vehicle to teach critical thinking (Jamaludin, Ho & Chee, 2007).

Dabaghi, Zabihi and Rezazadeh (2013) also emphasise that critical thinking should be the cornerstone of second or foreign language teaching, particularly when it comes to tasks which demand more critical awareness. Teachers should exert more effort in engaging students in meaningful critical tasks. The principles of critical pedagogy are thus indispensable in teaching the students. Wink (2000) describes critical pedagogy as a way of knowing, during which students not only read the word, but also the world.

The more students' skills improve in critical thinking, the better they will be at reasoning, making choices, and weighing evidence. This is critical for academic and economic success (Dodson, 2013). In addition, according to Bracken, Brown, and Feng (2009), the importance of critical thinking is nowadays obvious. It is essential as a tool of inquiry. As such, critical

thinking is a liberating force in education, and a powerful resource in one's personal and civic life.

Critical thinking has often been urged as a goal of education. This prompted the researchers to conduct the present study, specifically, to analyse and describe the critical thinking and argumentation skills of students and explore their possible relationships. This is the practical contribution of this study which may lead to revisiting the present educational setting.

### ***Conceptual Framework***

**Figure 1.** Research Paradigm

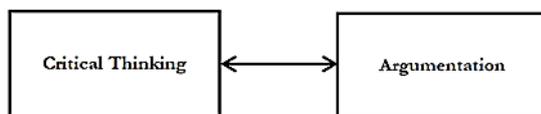


Figure 1 presents the primary interests of the study, which are critical thinking, and argumentation skills. These variables are investigated if they have a significant relationship. The researchers assume, based on the foregoing literature and studies, that the students' critical thinking skills affect their argumentation skills.

### ***Objectives***

The present study aims to analyse the students' critical thinking, and argumentation skills and determine their possible relationship. It describes the students' critical thinking through a multiple choice critical thinking test, and argumentation skills through argumentative writing.

### **Methods**

#### ***Research Design***

This study used the descriptive method of research, specifically, the correlational method. According to Gay and Airasian (2003), descriptive correlational research seeks to determine if a statistically significant relationship exists between two or more variables, and to what degree the relationship exists. A correlational research design is thus appropriate and effective for this study, particularly in describing the respondents' critical thinking, and argumentation skills, and in determining their possible relationship.

#### ***Population and Sample***

The participants of the study were 105 Grade 11 Science, Technology, Engineering and Mathematics (STEM) students of the Senior High School Department of the Don Honorio Ventura Technological State University, in the academic year 2017–2018. The STEM strand



intends to develop and prepare students in the fields of science, technology, engineering, and mathematics. In addition to subject-specific learning, it aims to foster inquiring minds and logical reasoning. The STEM students are thus the chosen respondents because of these relevant characteristics.

The stratified proportional sampling technique was used in selecting the respondents of the study. The sample size was calculated by using a power analysis with the accepted minimum level of significance ( $\alpha$ ) of 0.05, and the expected power  $\beta$  of 0.80, which is the accepted minimum level of power for the test.

### ***Research Instruments***

The researchers used the following tests to gather the data pertinent to the study:

The *CEU-Lopez Critical Thinking Test* was used to measure the critical thinking of the respondents. It is a multi-aspect general knowledge critical thinking test in the form of multiple-choice questions. The aspects of critical thinking that it covers include deduction, credibility, assumptions, induction, and meaning (Lopez, 2012).

The *Illinois Critical Thinking Essay Test* by Marguerite Finken and Robert H. Ennis was used to test the students' argumentation skills. The features of the test include focus, supporting reasons, reasoning, organisation, and convention. Each feature is rated on a six-point scale. The numbers indicate the level of the paper's development, and each feature is rated independently (Finken & Ennis, 1993).

### ***Ethical Consideration***

Full consent was obtained from the respondents prior to the conduction of the study. They were ensured that the results will be treated with utmost confidentiality. In regards to the permission to use the research instruments, the developers were informed through e-mail that their instruments will be used in this study, and they gave their consent, as long as the researchers provide credit in reporting the results.

### ***Procedure***

The researchers personally administered the two tests over a period of one week for the purposes of ensuring a high retrieval rate from the respondents. They were informed regarding the purpose of the study and were guided accordingly for the effective accomplishment of the tests. To complete the CEU-Lopez Critical Thinking Test, the respondents were given a maximum of 60 minutes. For the Illinois Critical Thinking Essay Test, they were also given 60 minutes. An allocation of 10 minutes was used in reading and thinking about the posed question, and the remaining 50 minutes was allocated to completing the essay. The

argumentative essays of the respondents were checked by three language teachers and graded using the scoring rubric provided by the authors of the Illinois Critical Thinking Essay Test.

### *Data Analysis*

After getting the scores of the students in the two tests, the data gathered was collated and organised manually and was processed by using the Statistical Package for Social Sciences (SPSS). The data was treated as follows:

1. To describe the students' skills in the two tests, descriptive statistics, specifically mean, standard deviation, and percentage were employed. The mean scores of the respondents, in the two tests, used the following scales:

CEU-Lopez Critical Thinking Test	
Range of Scores	Verbal Description
0-17	unreflective thinker
18-24	challenged thinker
25-30	beginning thinker
31-37	practising thinker
38-44	advanced thinker
45-87	master thinker

Illinois Critical Thinking Essay Test	
Weighted Mean	Verbal Description
1.00 – 1.82	very limited
1.83 – 2.65	basic
2.66 – 3.48	modest
3.49 – 5.31	competent
5.32 – 6.00	excellent

2. To determine the significant relationship of the variables, correlation analysis was used.

## **Results and Discussion**

### *Respondents' Levels of Critical Thinking and Argumentation Skills*

**Table 1:** Descriptive Analysis of Respondents' Critical Thinking Skills

Aspects	Mean	SD	Description
Deduction	7.27	2.58	Practising Thinker
Credibility	6.60	2.22	Practising Thinker
Assumptions	7.86	2.56	Practising Thinker
Induction	4.71	1.73	Beginning Thinker
Meaning	6.55	2.01	Practising Thinker
<b>Overall</b>	<b>32.99</b>	<b>5.49</b>	<b>Practising Thinker</b>

Table 1 shows that the respondents are considered to be ‘practising thinkers’ in four aspects of critical thinking; specifically, deduction ( $\bar{x} = 7.27$ ), credibility ( $\bar{x} = 6.60$ ), assumptions ( $\bar{x} = 7.86$ ), and meaning ( $\bar{x} = 6.55$ ). In respect to induction, the respondents are ‘beginning thinkers’, as indicated by the mean score of 4.71, and standard deviation of 1.73. In general, they are described as a ‘practising thinker’, as indicated by the computed grand mean score of 32.99, and standard deviation of 5.49. This implies that the respondents need to be exposed to different critical thinking tasks. They are also aware that improvement in critical thinking requires constant practise. However, the application of several sophisticated and complex principles in evaluating arguments is achieved with a certain degree of difficulty (Ennis, 1987; 1996).

**Table 2:** Descriptive Analysis of Respondents’ Argumentation Skills

Features	Mean	SD	Description
Focus	4.26	0.72	Competent
Supporting Reasons	3.80	0.64	Competent
Reasoning	3.80	0.65	Competent
Organisation	4.00	0.70	Competent
Convention	4.02	0.53	Competent
<b>Overall</b>	<b>19.96</b>	<b>3.07</b>	<b>Competent</b>

Table 2 indicates that the respondents are competent in all the aspects of argumentative writing, such as focus ( $\bar{x} = 4.26$ ), supporting reasons ( $\bar{x} = 3.80$ ), reasoning ( $\bar{x} = 3.80$ ), organisation ( $\bar{x} = 4.00$ ), and convention ( $\bar{x} = 4.02$ ). Overall, the computed mean score of 19.96 with a standard deviation of 3.07 indicates that the respondents are competent in writing argumentative essays. The respondents are thus able to present their points of view and positions effectively. The subjects and generalisations made are explicitly announced and maintained throughout the paper. Further, the respondents could justify their claims with supporting details to make the arguments persuasive. These results are parallel with the findings in the study of Flores (2007), where he analysed essays to describe the critical thinking and writing skills demonstrated in the argumentation papers of the students. He concludes that the respondents demonstrate relatively good level skills, and their papers are relatively good attempts at developing arguments with the author, having no difficulty stating viewpoints.

***Significant Relationship between the Respondents' Skills in Critical Thinking and Argumentation***

**Table 3:** Test of Significant Relationship of the Aspects of Argumentation on Students' Critical Thinking

Argumentation	Critical Thinking	
Aspects	R	p-value
Focus	0.232*	0.033
Supporting Reasons	0.215*	0.049
Reasoning	0.196	0.402
Organisation	0.259*	0.017
Convention	0.304**	0.005

*\*Significant at p<0.05      \*\*Highly Significant at p<0.01*

Table 3 features the test of a significant relationship of the aspects of argumentation on critical thinking. The table indicates that all the argumentation aspects, except for reasoning, have a significant relationship on the respondents' critical thinking, with p-values less than the 0.05 level. The aspects are all positively correlated to their critical thinking, which implies a direct relationship. This means that the higher their levels in argumentation, the higher their levels in critical thinking. *Bowell and Kemp (2002)* state that "to attempt to persuade by giving good reasons is to give an argument". They further mention that critical thinkers primarily should be interested in arguments, and whether they succeed in providing good reasons for acting or believing. In addition, *Liu (2009)* concludes that the ability to make arguments is one part of being able to think critically. Furthermore, the relationship of convention to critical thinking is said to be highly significant since the computed p-value is less than the 0.01 level. Hence, it is also interesting to note that students who have clearly stated their arguments with no major errors most likely have a higher level of critical thinking.

**Table 4:** Test of Significant Relationship of the Aspects of Critical Thinking on Students' Argumentation

Critical Thinking	Argumentative Writing	
Aspects	R	p-value
Deduction	0.209*	0.045
Credibility	0.007	0.947
Assumptions	0.129*	0.040
Induction	0.040	0.719
Meaning	0.243*	0.025

*\*Significant at p<0.05      \*\*Highly Significant at p<0.01*

Table 4 exhibits the test of a significant relationship of the aspects of critical thinking on argumentation. Only three aspects of critical thinking, specifically deduction, assumptions, and meaning, are significantly correlated with argumentative writing, with computed p-values less than the 0.05 level of significance. Credibility, and induction have no significant relationship with argumentative writing. This finding lends enough support to the claim that critical thinking is not an indivisible construct but comprises several independent elements (Watson & Glaser, 2006), as only some aspects are associated to the respondents' argumentation skills. Nevertheless, a majority of the critical thinking aspects are significantly related to their skills in argumentation.

### ***Overall Relationship between the Respondents' Skills in Critical Thinking and Argumentation***

**Table 5:** Test of Significant Relationship between the Respondents' Skills in Critical Thinking and Argumentation

Item	Critical Thinking Skills	
Argumentation Skills	Pearson r	0.257*
	p-value	0.017
	Significance	Significant

Table 5 illustrates the test of a significant relationship between the respondents' skills in critical thinking, and argumentation. The data reveals that critical thinking is positively linked to argumentation, with a computed correlation coefficient of 0.257. The degree of relationship between the variables is said to be weak but still significant since the computed p-value of 0.017 is less than the 0.05 level of significance. This only means that the students' performance in the multiple-choice critical thinking test can be associated to their performance in argumentative writing. This finding is supported by literature, and researchers in the field claiming that the two variables are associated (Schafersman, 1998, as cited in Rafi, 2010; Paton, 2008; Fahim & Mirzaii, 2013).

### **Conclusions and Recommendations**

The study concludes that the respondents are practicing thinker in terms of critical thinking. This implies that they need constant practice because application of complex critical thinking principles is done with certain degree of difficulty. Conversely, they are competent in argumentation. This indicates that they could present and justify their arguments and positions to persuade the readers. The study also concludes that the students' skills in critical thinking and argumentation have a positive correlation. The relationship is weak but still considered significant since the computed p-value of 0.017 is less than 0.05 level. This concludes that students who have higher level of critical thinking are most likely effective in argumentation



and students who write effective argumentative essays manifest better results in a multiple-choice critical thinking test.

Based on these findings, it is recommended that teachers should provide more opportunities for students to practice critical thinking skills. Activities like reasoning, analysis, and evaluating arguments may be provided. Teachers are also encouraged to replace the old cycle of transmission pedagogy. Thus, seminars and trainings on critical pedagogy should be provided. Textbook writers and curriculum developers should also infuse critical thinking in the classroom and include critical tasks as core component of instruction.

Everyone should assist students in developing their critical thinking to prepare them in dealing with the changes and challenges in the present educational setting.



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