Critical Thinking Measurement in ICT

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Abstract

This study examined the status of critical thinking (CT) and reasoning skills in information communication and technology (ICT) for 190 college students in a higher education system. It analyzed how the students performed in CT, reasoning, and internet copyright and ethical issues. A CT assessment was designed to analyze the CT and reasoning skills. The findings showed that the students were not capable of (a) interpreting the chart and question accordingly; (b) processing problem-solving and proposing the proper solutions for the scenario; (c) composing a proper legal action toward the copyright issues; and (d) recognizing internet ethics to treat data legally. Due to limited resources of CT measurements in ICT fields, this paper might be used as the significant evidence promoting students' CT and reasoning skills in educational systems.

Keywords: Critical Thinking, Copyright, Internet Ethics, Information Ethics, ICT, CAT

1. INTRODUCTION

Many studies show college students' information communication technology (ICT) levels are not as competent as the public perceives ("How the new generation," 2007; Kelly & Haber, 2006; Shannon, 2008; Sullivan, 2008). Many educators assume technology skills are purely technical; therefore, since these students seem adept with technology they do not need any formal instruction (Allen, 2007).

The Information Literacy Competency Standards for Higher Education states that "Information literacy is a key component of, and contributor to, lifelong learning (Association of College and Research Libraries [ACRL], 2009)". ACRL (2009) emphasizes that colleges and universities should provide the foundation for continued growth throughout the students' careers to ensure that individuals have the intellectual abilities of reasoning and critical thinking to construct a framework for learning how to learn.

When measuring the levels of ICT, the application skill measurement seems to be the most direct and simple category to be assessed. However, when measuring the students' critical thinking and reasoning skills in ICT, we have not found valid instruments or studies which applied to measuring the students' higher level of cognitive learning in ICT.

National Educational Technology Standards for Students (NETS) entitled six categories to assess the students' ICT proficiency for PK – 12 systems. The standards are listed as follows:

1. Creativity and Innovation
2. Communication and Collaboration
3. Research and Information Fluency
4. Critical Thinking, Problem Solving, and Decision Making
5. Digital Citizenship
6. Technology Operations and Concepts (ISTE, 2009)

The profiles of NETS for students were detailed for each grade level group in each standard mentioned above. However, the implementation and assessment process seems to lack a connection for each standard.

With more than 30 years of teaching in ICT fields from the authors, we found that a majority of college students are not proficient in all of the above standards, even though a majority of them took one or more computer courses before they enrolled into college (Shannon, Bennett, & Schneider, 2009). From the introductory computer courses, we found that the students' ICT skill levels can be improved in many ways. However, we encountered an enormous hurdle of motivating the students to apply their critical thinking and reasoning skills in this digital life environment.

Sullivan stated that the millennial and post-millennial generations of young adults "don't understand ethical uses of technology or the concept of intellectual property rights. Their critical thinking skills are notoriously weak and their reflective capabilities sorely lacking (2008)."

With a burning desire to study how we can help our students practice their CT skills, we implemented the theory from the critical thinking assessment test (CAT) funded by the National Science Foundation to conduct this study.

ICT Literacy Skill Assessment

The National Assessment data have highlighted the problem that has emerged from an overemphasis on skill instruction and multiple-answer testing. Ogle (1992) stated that students can select the correct answer, but lack the ability to explain why they chose their answers or to substantiate their thinking about the choices they make. By using case study scenarios, the students have the opportunity to map their thinking process and provide a higher level of cognitive learning outcome (Bean, 2001; Ogle, 1993; Vanderpool & Robinson, 2003).

While facing a limited resource of critical thinking assessment in ICT fields, the Educational Testing Service (ETS) claimed that the iSkill assessment "is the only ICT literacy test that assesses critical thinking in the digital environment (iSkill, 2009)". Irvin (2007) stated that the iSkill assessment focuses on the cognitive problem-solving and critical-thinking skills associated with using technology to handle information without a multiple-answer format. We are unable to review the reliability and validity of research supporting iSkill assessments in CT and reasoning skills. Several institutions such as the California State University, the University of Wisconsin, and others that applied the iSkill assessment; but the supporting documents are still not in place.

When compared to other instruments that measure critical thinking and intellectual performance evaluated by a broad spectrum of faculty across the U.S. in Science Technology Engineering & Mathematics (STEM) and non-STEM disciplines, the CAT instrument proved to have a high face validity (Stein, Haynes, Redding, Ennis, & Cecil, 2007). Many studies emphasized how writing is linked to learning and critical thinking (Bean, 2001; Vanderpool & Robinson, 2003). The pencil and paper form with a short answer essay method of CAT provided the tool for our students using writing to perform their thinking process.

Critical Thinking

In a college learning environment, the students are expected to think at higher levels and demonstrate their knowledge beyond that given in the classrooms. Jalongo, Twiest, and Gerlach (1999) stated critical thinking evolves with the following stages:

- Apply: use knowledge and understanding to complete a practical task.
- Analyze: break things down into their component parts.
- Synthesize: combine and integrate various sources of information.
- Evaluate: assess the value, merit, or worth of something.

Paul (1995) defined critical thinking as a self-directed, self-disciplined, self-monitored, and self-corrective thinking skill which guides the thinker who possesses a set of effective dispositions. When the students internalize their CT competency, they will develop their ability to:

- raise vital questions and problems
- gather and assess relevant information
- come to well-reasoned conclusions and solutions
- think open-mindedly within alternative systems of thought, and
- communicate effectively with others in figuring out solutions to complex problems (Paul, 1995).

By definition, critical thinking applies skills that contribute to information literacy. Critical thinking and information literacy both require making a distinction between assumption and fact, suspending personal opinion and bias in favor of objectivity, and considering issues from multiple perspectives and in adequate depth (Taylor, Arth, Solomon, & Williamson, 2007). It includes possible processes of reflecting upon a tangible or intangible item in order to form a solid judgment that reconciles scientific evidence with common sense.

Without critical thinking skills, an individual is at a disadvantage and may make a wrong decision because of their inability to discern accurate, precise, relevant and logical information.

Copyright and internet ethical issues

It is imperative that the college students are able to use the critical information resources in the higher educational system. With the new generation of computer literate students and the vast amount of networked information available it is necessary to develop the ability to use information resources properly (Kwon, 2008).

Kwon (2008) stated that critical thinking dispositions work in carrying out information search tasks which enables the student to retrieve their existing knowledge and perform cognitive tasks more effectively.

When facing the copyright and ethical issues of the internet, it is vital for students to exercise their CT and reasoning skills to enable them to make correct decisions concerning the legal intricacies of copyright laws as well as ethical considerations.

The U.S. Copyright Office defined copyright "is a form of protection provided by the laws of the United States (title 17, *U. S. Code*) to the authors of "original works of authorship," including
literary, dramatic, musical, artistic, and certain other intellectual works" (US Copyright Office, 2009). Since the material is original and not borrowed or quoted from another writer, then these writings are considered the property of the writer. Since the writings are from the intellect of the individual(s) involved, the term "intellectual property" was coined (WIPO, 2008). "Intellectual property refers to anything created by the mind, such as literary works (books, poems, essays), artwork (drawings, paintings), inventions, ideas, logos or symbols, names, designs, and images or photographs (Taylor, Arth, Solomon, & Williamson, 2007, p.179)".

To infringe the copyright or right of the author, infringement of copyright is defined as "Anyone who violates any of the exclusive rights of the copyright owner … or who imports copies or phonographic records into the United States … (US Copyright Office, 2009)". Due to the convenience of using the internet to download resources, many instances of unethical behaviors were related to the ease of copying internet resources, especially in the academic settings (Karim, Zamzuri, & Hidayah Ahmad Nor, 2009). The personality variables and unethical Internet

behaviors were identified as conceptualized through Internet-triggered academic dishonesty: (1) agreeableness, (2) conscientiousness, and (3) emotional stability (Karim et al., 2009).

To identify the ethical theories, Quinn (2006) listed various theories, such as: Subjective relativism, Cultural relativism, Divine command theory, Categorical imperative, Act Utilitarianism, Rule utilitarianism, Social contract theory…etc. Each theory presented the pro and con of supporting the ethical issues. While the arguments sustain socially, politically, or psychologically, it is vital for the students processing their critical thinking and reasoning skills to maintain their integrity in this networked society.

2. METHODOLOGY

In spring 2009, we implemented the theoretical framework from the Critical thinking Assessment Test (CAT) to conduct our study.

Reliability
The CAT instrument has been applied by a broad range of institutions across the country since 2007. The National Science Foundation (NSF) has provided support for many CAT activities. "The CAT Instrument is a unique tool designed to assess and promote the improvement of critical thinking and real-world problem solving skills (Critical Thinking Assessment Test, 2009)".

The NSF is supporting efforts to disseminate the CAT instrument to a diverse group of institutions (through train-the-trainer workshops) to prepare representatives from 20 institutions to lead scoring workshops for the CAT instrument at their own institution from 2007 to 2010 (Critical thinking Assessment Test, 2009). Two of our authors participated in this train-the-trainer workshop, and received the CAT instrument together with support for conducting two scoring workshops on their own campus for the foundation of science project under the Quality Enhancement Program (QEP) to meet the criteria of the Southern Association of Colleges and Schools (SACS). The other author also participated in the campus scoring activity for the QEP project in spring 2009.

Instrument
The CAT instrument provided by the National Science Foundation's CCLI (Course, Curriculum, and Laboratory Improvement) Program assesses the following critical thinking skills:

Evaluating Information
- Separate factual information from inferences.
- Interpret numerical relationships in graphs.
- Understand the limitations of correlated data.
- Identify inappropriate conclusions.

Evaluating Ideas and Other Points of View
- Identify and evaluate evidence for a theory.
- Identify new information that might support or contradict a hypothesis.
- Explain how new information can change a problem.

Learning and Problem Solving
- Separate relevant from irrelevant information.
- Integrate information to solve problems.
- Learn and apply new information.
- Use mathematical skills to solve real-world problems.

Communication
- Communicate ideas effectively (CAT, 2009).

The CAT instrument utilized the graph and case scenario to assess the students' level in evaluating the given information. Merging with the students' reasoning and problem solving skills, the CAT instrument is well defined to analyze students' critical thinking skill levels.

Following the guidelines of the CAT instrument, we designed a small scale test to analyze the above four domains from CAT. In addition to use graph and software product scenario, we included the second scenario of copyright statement to assess the students with two cases. To summarize the findings, we reported the students' ability to (a) interpret the graph and questions and response precisely, (b) use a case scenario to process problem solution/s, and (c) use an online copyright statement to

determine whether the student will be tempted to infringe the copyright legal issues.

The scenario of this CT survey is based on the statement listed on Appendix.

Research Hypotheses
H1: The students are capable of interpreting the chart and question accordingly.

H2: The students are capable of processing problem-solving and propose the proper solutions for the scenario.

H3: The students are capable of composing a proper legal action toward the copyright issues.

H4: The students are capable of recognizing internet ethics and to retrieve data legally.

Grading Procedures
To analyze the critical thinking skills, a mixed method was designed for this study. The grading process was to have multiple graders to review the written answers and quantify the answers to the score of 0 to 5 respectively. A third scorer was required to review the items when the assigned scores were not identical from the other two graders. The final score was determined by the mean of the three scores. The Statistical Package for the Social Sciences (SPSS, Version 15.0) was then used to analyze the numerical data. A descriptive method was also implemented to determine the degree of responses from the data.

Question 1: Briefly summarize the pattern of the products in this graph.

This question had a maximum value of two points. One point was issued for providing the statement "increase rate". An additional one point was issued for providing the statement "from Product A to Product E". A zero score was issued for providing any suggestion or other statement not related to the above statements.

Question 2: Briefly explain what product Mary should choose from and provide the reason/s.

Question 2 was designed to see whether the students can provide reasonable solutions based on the knowledge they had on computer security issues. This question had a maximum value of two points. One point was awarded for stating "no product should be recommended". An additional point was issued for stating the reason that "the chart is insufficient for recommending any product". A zero score was issued for providing any other statement and recommendation.

To continue question 2, we provided a table of specification for each product for question 3 that follows:

Question 3: Based on Mary's needs, please recommend 2 products that Mary should consider choosing from and explain the reasons.

This question had a maximum value of three points. One point was issued for choosing "Product B", and an additional point was issued for choosing "Product D". One more point was issued, if the participants stated the reason that "both products provide spyware and adware protection". A zero score was issued for any other answer.

After this problem-solving question, we added one more new condition and asked the participants to choose the final product.

Question 4: Due to the budget limitation, Mary will not be able to afford more than $65.00 to protect her systems. According to Mary's circumstances, please recommend one final product and explain why the product will fit Mary's needs.

This question had a maximum value of five points. One point was issued for choosing "Product D". Four additional points were possible; one point for stating the reason of "under $65.00", one point for stating the reason of "Trojan Horse Protection", one point for stating the reason of "Adware Protection", and one point for stating the reason of "Spyware Protection".

The next two questions were based on a copyright statement from the internet (see Appendix).

Question 5: Will you download the files from this website to post them on your website?

There was only one point issued for this question: one point for "No" and zero points for "Yes".

Question 6: Please provide the reasons, why you chose the specific answer for the question above.

This last question had a maximum value of two points. One point was issued for stating the reason "the foundation does not provide any warranty regarding the copyright status". An additional one point was issued for stating the reason "the user should be responsible for obtaining the copyright status". A zero score was issued for any other statement.

Participants

The survey was conducted during the spring 2009 semester having an enrollment of 298 students from 11 sections of introductory computer courses. There were 190 students (63.8%) that voluntarily completed this survey at the beginning of the semester. The participants' majors were from the College of Arts and Sciences, College of Criminal Justice, and College of Education.

3. FINDINGS

A descriptive analysis and correlation test was applied in this study. The findings will be shown in the sub-headers of Graph and Pattern, Problem-Solving, Copyright and Ethical Issues, Overall CT Scores, and Correlations.

Graph and Pattern

Question 1: Briefly summarize the pattern of the products in this graph.

38.9% of the participants did not provide any correlations shown in the chart. 18.9% of the participant provided a partial statement from the chart. These results explained that approximately 58% of the participants failed to provide a proper statement to explain the pattern of products showed in the chart. A majority of the responses predicted or suggested the product/s for this scenario which the students were not asked to provide their opinions for this question (see Figure 1).

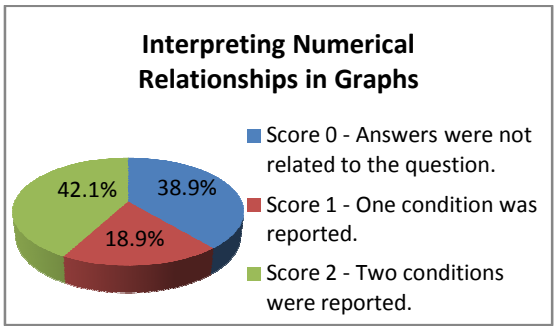

Figure 1. Interpreting Numerical Relationships in Graphs Distribution

Problem-Solving

Question 2: Briefly explain what product Mary should choose from and provide the reason/s.

This is the question where we asked the participants to provide their suggestion of what product they would recommend. The results showed that there were only two out of 190 students who stated that the data we provided were not sufficient to propose any product from the chart. The rest of students (99%) suggested product E as having the highest "virus protection rate". The students were not aware that to depend solely on the virus protection rate was not sufficient to make a suggestion. We would applaud the only two students who pointed out the differences of malware among computer virus, Trojan horse, and spyware.

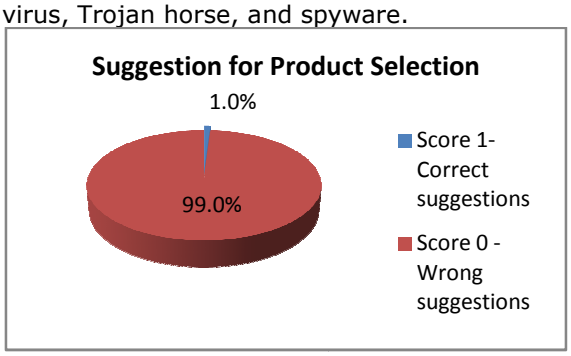

Figure 2. Suggestion Product Selection Distribution

Question 3: Based on Mary's needs, please recommend 2 products that Mary should consider choosing from and explain the reasons.

With a proper specification listed in the table for references, 12.1% of participants that correctly chose products B and D based on the scenario. 26.3% of the participants chose one of the correct products. Overall, 87.9% of students failed to suggest the proper solutions based on the needs proposed in this case study scenario (see Figure 3).

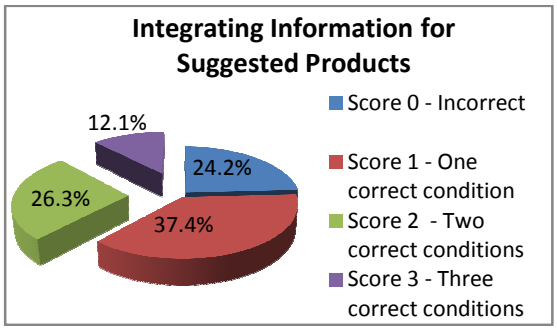

Figure 3. Integrating Information for Suggested Products Distribution

Question 4: According to Mary's circumstances, please recommend one final product and explain why the product will fit Mary's needs.

With the specific instructions added in the question, 45.9% of participants failed to choose the correct product and provide reasonable statements. Only 21% of participants were able to cite reasons for choosing the correct product (see Figure 4).

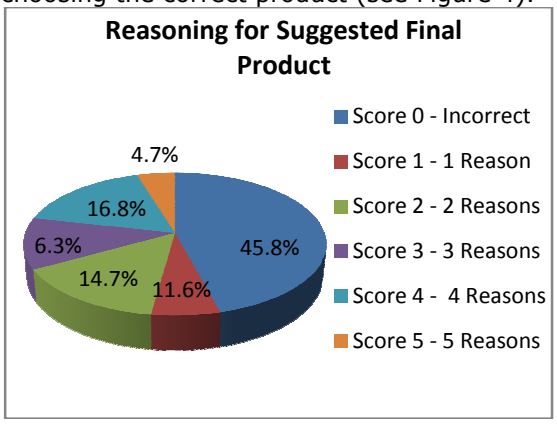

Figure 4. Reasoning for Suggested Final Products Distribution

Copyright and Ethical Issues

Question 5: Will you download the files from this website to post them on your website?

63.2 percent of participants answered "No" meaning not to download the files from this specific website (see Figure 5).

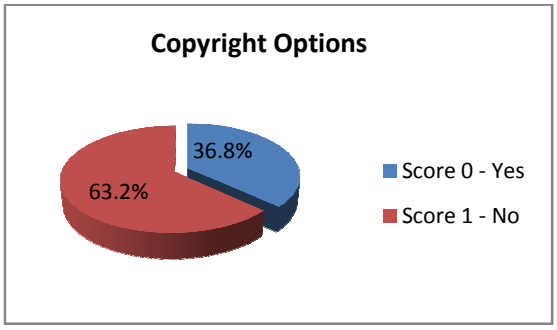

Figure 5. Copyright Options Distribution

Question 6: Please provide the reasons why you chose the specific answer for the question above.

The results showed that 58.9% of participants discovered neither copyright nor ethical issues for this case. However, 36.8% of students did state that copyright infringement was the reason they did not want to download and use the files (see Figure 6).

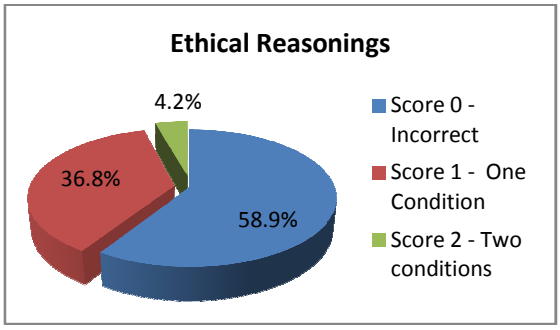

Figure 6. Ethical Reasoning Distribution

Overall Scores

A total of possible 15 points was available from this CT study. The mean of the responses was 5.01 (*N*=190, see Figure 7). The descriptive statistics and histogram exhibited the overview of CT levels in this study.

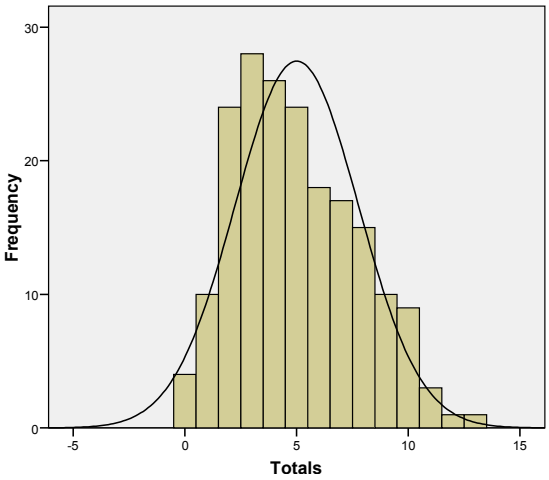

Figure 7. Total Critical Thinking Score Distribution

A positive value of skewness (.449) indicates a pile-up of scores on the left of the distribution (Field, 2000). The distribution on the histogram showed that 61.1% of the participants had their CT scores below the mean of 5.01.

Correlations

We tested the correlation with all of the variables and found that the participants' ability to define a graph pattern is significantly correlated with the ability of problem-solving skills to recommend the proper products and copyright options (see Table 1). In other words, the lower level the participants can read and respond accordingly, the lower their problem-solving skills are.

	Correlation	Significant
Graph Interpretation	.030	.685
Suggested Products	-.260	.001*
Final Product with reasons	-.514	.001*
Copyright	-.180	.013
Ethical Reasoning	-.035	.636

Note: *df*= 187, * *P*<.01

Table 1. Correlation of Graph Pattern versus Other Items

When testing the variable of "Graph Interpretation" with the rest of the items, we found that it is significantly correlated with the item of "Final product with reasons". The score of "Graph Interpretation" was not normally distributed due to the lack of knowledge in computer security issues. 98.9% of students received a zero score for this item; therefore, the correlation analysis for "Graph Interpretation" could not represent the findings properly (see Table 2). For the rest of finding discussion, we would remove the item of "Graph Interpretation" to report valid findings.

	Correlation	Significant
Graph Pattern	.030	.685
Suggested Products	-.020	.785
Final Product with reasons	-.200	.006
Copyright	.035	.629
Ethical Reasoning	.025	.732

Note: *df*= 187, * *P*<.01

Table 2. Correlation of Graph Interpretation versus Other Items

We found that the item of "Suggest Products" is significantly correlated with the rest of variables (see Table 3). After reading the provided information to suggest proper products, the participants who did well on this item also presented skills on interpreting the graph pattern, reasoning their decisions, and recognizing the copyright and internet ethical issues.

	Correlation	Significant
Graph Pattern	-.260	.001
Graph Interpretation	-.020	.785
Final Product with reasons	-.206	.004
Copyright	-.308	.001*
Ethical Reasoning	-.272	.001*

Note: *df*= 187, * *P*<.01

Table 3 Correlation of Suggest Product versus Other Items

The item of "Final Product with Reasons" was to retest the participants' reading and responding skills from the previous item "Suggested Products". The findings confirmed the same significant results as Table 3 (see Table 4).

	Correlation	Significant

Graph Pattern	-.514	.001*
Graph Interpretation	-.200	.006
Suggested Products	-.206	.004
Copyright	-.287	.001*
Ethical Reasoning	-.462	.001*

Note: *df*= 187, * *P*<.01

Table 4. Correlation of Final Product with Reasons versus Other Items

The copyright options showed that it is significantly correlated with the participants' ability to interpret graph pattern, suggest proper products, provide reasons, and recognize the internet ethical issues (see Table 5). In other words, the participants' ability to choose a proper copyright option is related to the ability of their problem-solving and reasoning skills.

	Correlation	Significant
Graph Pattern	-.180	.013
Graph Interpretation	.035	.629
Suggested Products	-.308	.001*
Final Product with reasons	-.287	.001*
Ethical Reasoning	-.302	.001*

Note: *df*= 187, * *P*<.001

Table 5. Correlation of Copyright versus Other Items

When the participants were asked to provide the reasons why they chose the certain copyright options to either download and post the file/s or not to infringe the copyright issues, we found that the result was significantly correlated with the other items again (see Table 6).

The participants' reasoning skills in ethical issues showed the same trend of reasoning in reading, responding, and problem-solving skills.

	Correlation	Significant
Graph Pattern	-.035	.636
Graph Interpretation	.025	.732
Suggested Products	-.272	.001*
Final Product with reasons	-.462	.001*
Copyright	-.302	.001*

Note: *df*= 187, * *P*<.01

Table 6. Correlation of Ethical Reasoning versus Other Items

4. RESULTS

This study results in denying all of the four hypotheses which stated that the students are not capable of performing the following tasks:

1. interpreting the chart and question accordingly,
2. processing problem-solving and propose the proper solutions for the scenario,
3. composing a proper legal action toward the copyright issues, and
4. recognizing internet ethics to treat data legally.

The findings showed there is a significant correlation among the participants' critical thinking, reasoning, and internet copyright issues in information communication technology fields.

5. CONCLUSION

In terms of the CAT instrument, this study showed that the students' critical thinking skills in ICT was significantly incompetent in the skills of *Evaluating Information, Evaluating Ideas and Other Points of View, Learning and Problem Solving,* and Communication.

The students failed to separate factual information from inferences. By reviewing the numerical relationships in graphs, the students failed to understand the limitations of correlated data and to identify appropriate conclusions.

The students were not able to identify new information and evaluate evidence for a theory. Moreover, they failed to explain how new information can change a problem and how to integrate information to solve problems for the scenario. Overall, the statements the students provided showed that they are not capable of communicating their ideas effectively.

Bean (2001) observed a main concern among teachers of critical thinking is that students tend to reach closure too quickly. The students "do not suspend judgment, question assumptions, imagine alternative answers, play with data, enter into the spirit of opposing views, and just plain linger over questions (p. 7)". From this study, we cited evidence how the findings confirmed Bean's concerns in students' critical thinking and reasoning skills. However, on the positive side, many researchers emphasized such deficiencies in our students' learning process. Yang and Chou (2008) suggested the same ideas we have that instructors should be encouraged to cultivate CT in the courses, guiding students to become better thinkers in every aspect of life as professionals and citizens.

We suggest further research to include case study, case scenario, and/or cooperative groups in all disciplines. To effectively promote our students to become critical thinkers, there is no shortcut to deliver a higher cognitive learning process. Without thinking, learners cannot learn. Our recommendation is similar to Rudd (2007) when he stated that students must learn thinking and reasoning skills to reach their fullest potential in today's society.

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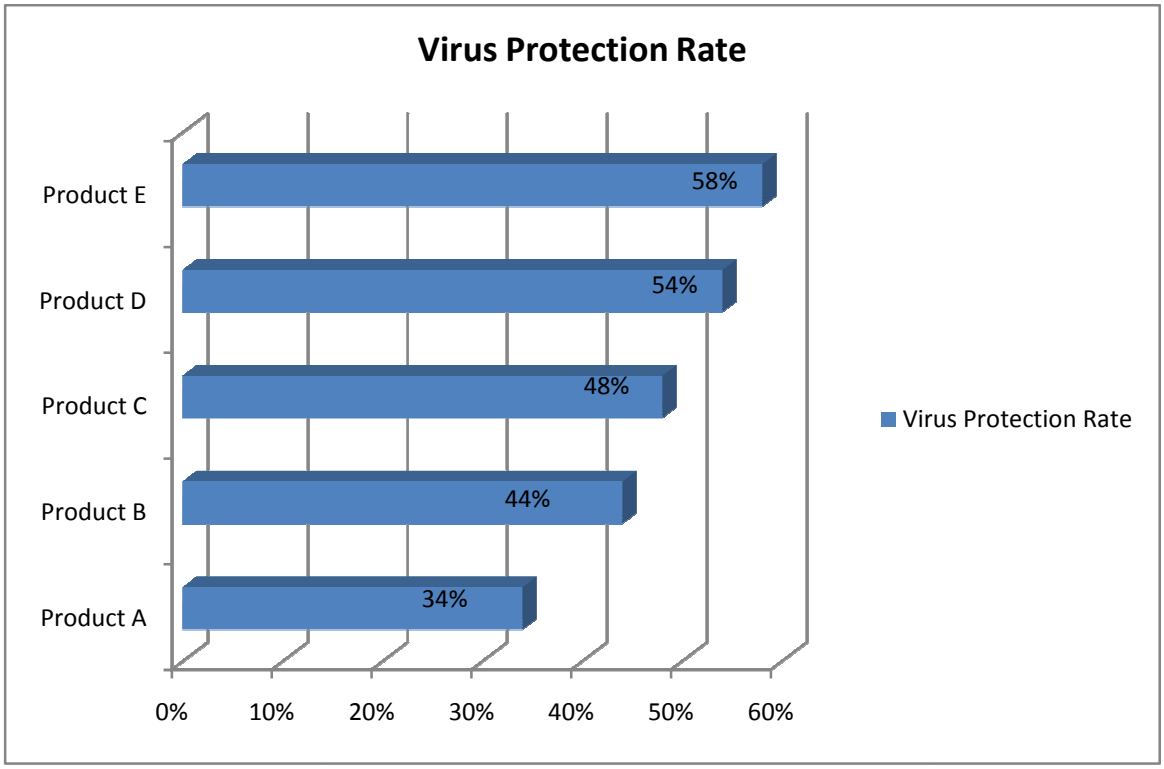
7. APPENDIX

Critical Thinking Skills and Ethics in Computer Information

Mary's home computer has been responding slowly when she opens her network browser. She has 2 more computers on her home network. Since she uses the internet quite a lot, she understands that the Trojan Horse (Identity Theft), Adware, and Spyware might already have affected her computers' performances. Her friend, John, highly recommends that the new antivirus program "Product E" will improve the performance of her home computers.



1. Briefly summarize the pattern of the products in this graph.

_____

_____

_____

2. Briefly explain what product Mary should choose from and provide the reason/s.

_____

_____

_____

Do not go back to page 1!

Review:

Mary has 2 more computers on her home network. Since she uses the internet quite a lot, she understands that the Trojan Horse (Identity Theft), Adware, and Spyware might already have affected her computers' performances.

Mary did some research and summarized her findings per the table listed below.

Software Brand	Price (per year for up to 3 users)	Virus Protection Rate	Adware and Spyware Protection	Identity Theft (Trojan Horse) Protection
Product A	$ 30	34%	Spyware removal; Blocks access to spyware websites	Extensive online/offline fraud monitoring
Product B	$ 70	44%	Identifies and removes spyware and adware	Encrypts passwords & other sensitive data
Product C	$ 80	48%	Detects and removes spyware	$5,000 coverage if identity is stolen
Product D	$60	54%	Blocks and removes spyware and adware	Alerts users to online scams and known fraud websites
Product E	$50	58%	Blocks spyware from tracking your movements online	Phishing alerts prevent criminals from stealing personal information

3. Based on Mary's needs, please recommend 2 products that Mary should consider choosing from and explain the reasons.

_____

_____

_____

4. Due to the budget limitation, Mary will not be able to afford more than $65.00 to protect her systems. According to Mary's circumstances, please recommend one final product and explain why the product will fit Mary's needs.

_____

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This section is only for the graders.

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