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Work in Progress: Critical Thinking and Information Literacy: Assessing Student Performance

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Abstract

Critical thinking and information literacy share many common goals. Fundamentally, critical thinking involves the systematic and appropriate exploration and evaluation of ideas for the purpose of making a decision or forming an opinion on a topic or problem. Information literacy competencies are tightly intertwined with critical thinking, as information literacy requires students develop an appropriate research question, locate relevant information, evaluate it, apply it to their question, and communicate the results. In this paper, the authors seek to further explore the relationship between information literacy and critical thinking through a correlational analysis of an information literacy skill assessment developed by the authors and a critical thinking assessment developed at Tennessee Technological University. The two instruments, the Critical Engineering Literacy Test (CELT) and the Critical Thinking Assessment Test (CAT), were disseminated to a population of first-year engineering students. Preliminary analysis showed that the total scores for CELT and CAT instruments were positively associated ($r = 0.47$, $p < 0.01$, $N = 44$). By broadening the discussion of information literacy to encompass critical thinking, additional avenues of collaboration between librarians and engineering educators can be opened toward the shared goal of producing not only better lifelong learners, but higher quality problem solvers of the open-ended, complex tasks students will face in their careers after graduation.

Introduction

Information literacy is commonly referenced as an increasingly important 21st century skill needed in today's knowledge-based economy. ABET's criterion 3.i declares that students have "a recognition of the need for, and an ability to engage in life-long learning." Shuman, Besterfield-Sacre, and McGourty[1] propose several attributes of lifelong learning, including "follow a learning plan; identify, retrieve, and organize information; understand and remember new information; demonstrate critical thinking skills; and reflect on one's own understanding." These criteria align well with the core concepts of information literacy. Information literacy is most popularly defined by the American Library Association as set of skills that enables the ability to recognize the need for information, and the ability to search for, access, evaluate, and use information to fulfill a specific purpose[2]. Further explanation of the connection between the ALA standards and ABET criteria can be found in a review of these standards by Riley, Piccinino, Moriarty, and Jones[3]. In our paper, we specifically explore the connection between information literacy and critical thinking.

Fundamentally, critical thinking involves the systematic and appropriate exploration and evaluation of ideas for the purpose of making a decision or forming an opinion on a topic or problem. In order to support effective decision-making, students must collect appropriate information, evaluate its quality and authority, as well as its relevance to the topic at hand. Students must integrate the new information gathered with their prior knowledgebase to resolve any conflicts, and finally, draw reasonable conclusions and realize limitations to the certainty of

their conclusions, as well as determine what additional information would provide evidence for the validity of their conclusions.

There has been some amount of argument around the nature of the relationship between information literacy and critical thinking. For example, Breivik[4] suggests that "a person who is information literate specifically uses critical thinking to negotiate our information-overloaded world." In contrast, Ward[5] suggests that information literacy goes beyond being a critical thinker, arguing that "being information literate requires more than the ability to work analytically with information. It also demands that we know how to manage information in creative and meaningful ways." Others use critical thinking as a vehicle to broaden the capacity of information literacy from the stigma of narrow, skill-focused bibliographic and retrieval instruction sometimes associated with the term[6].

Albtiz[7], for example, argues that information literacy is more concrete and skill-based, whereas critical thinking is less a set of skills as set of higher-order cognitive processes, particularly when critical thinking is used in a meta-cognitive capacity, which goes beyond most definitions of information literacy. The role of cognitive development likely plays in the development of information literacy skills was also discuss by Weiler[8], who suggests that students just entering college who have not yet progressed past a dualistic level of intellectual development have more difficulty thinking critically about information and expect an Authority (e.g., a professor or librarian, or the Internet) to supply the answers they need. While there is clearly disagreement on how information literacy and critical thinking should be defined, there is enough difference between the two constructs to indicate that they are not interchangeable, and enough commonality to indicate that they are fundamentally interconnected.

Information Literacy and Critical Thinking Assessment

Critical Engineering Literacy Test

The information literacy instrument used in this study was first developed by the authors in 2010[9]. The objective of the Critical Engineering Literacy Test (CELT) is to measure students' ability to collect information from text, activate prior knowledge to critically evaluate information, in addition to accurately summarize and interpret information. Overall there are 16 multiple-choice items, two multiple-binary "select all that apply" items and ten open-ended constructed response items. Table 1 provides a blueprint for the 18 selected-response items and sample items for each category[10]. In a separate study, the authors performed an item analysis and reliability analysis of the CELT instrument. Cronbach's alpha was 0.67 for a sample of 188 first-year engineering (N = 72), aviation technology (N = 91), and nursing (N = 25) students[11].

Table 1. *CELT instrument blueprint and sample questions*

Objective (Student can…)	***Item number***	***Sample Items***
1. identify implicit and explicit assumptions	1	Which one of the following is an assumption made in this memo/report?
2. identify and resolve conflicts between presented information and prior knowledge	2	Which one of the following statements is incorrectly presented as factual information?
3. accurately interpret information	3	According to the authors, what does the $2,760 represent?
4. evaluate the reliability of information and use reliable information sources	4, 16*, 17	Which of the following pieces of information provided in the memo is likely the least reliable?
5. accurately document the sources referenced	5, 6, 12*	Which one of the citations is incorrect or incomplete?
6. evaluate overall quality of a written document	7, 8, 13, 18	Which of the below is a strength of this memo/report?
7. determine what information is needed to make a strong argument	9, 10, 11, 14	What information is missing that would strengthen the memo?
8. determine key words to locate information relevant to a specific topic	15	If you wanted to find out more information about…, which of the following searches would likely yield the best results?

*Select all that apply items.

Critical Assessment Test

The Critical Assessment Test (CAT) is a well-known, validated instrument developed at Tennessee Technological University and has been disseminated to over 50 institutions nationwide[12]. The CAT consists of 15 constructed response items. The items are based in real-world scenarios, with multiple items per scenario. The CAT is a secure instrument, however a sample item is provided in Table 2.

Table 2. *CAT sample item*

Scenario	***Sample Items***
A scientist working at a government agency believes an ingredient commonly used in bread causes criminal behavior. To support his theory the scientist notes the following: ▪ 99.9 percent of the people who committed crimes consumed bread prior to committing crimes. ▪ Crime rates are extremely low in areas where bread is not consumed.	1. Do the data present by the scientist strongly support their theory? Yes ____ No ____ 2. Are there other explanations for the data besides the scientist's theory? If so, describe. 3. What kind of additional information or evidence would support the scientist's theory?

Scoring for the CAT assessment is rubric-based and requires training. To maintain scoring reliability, each question is graded by at least two graders; three if there is a disagreement. The CAT has a scoring reliability is 0.82, and the instrument has documented Cronbach's alpha of 0.70 for the current grading system[13].

Method

Sample and Setting

Participants in this study included 44 students enrolled in one section of a first-year engineering course in the fall 2012 semester at Purdue University. The first-year engineering course is required for all engineering students, and is traditionally taken in the first semester of college. Students were given both the CELT and CAT assessments as part of regular course assignments. The CELT instrument, however, was an optional extra credit assignment. A total of 72 students of the 120 enrolled in the course completed the CELT instrument. The CELT was administered online, and students could access the internet while taking the assessment if they chose. The CAT instrument was administered with paper and pencil during a regular class period. A total of 112 students completed the CAT. A subset of 44 students who completed both the CELT and CAT instruments were randomly selected for preliminary analysis.

Data Analysis

We performed a correlational analysis on the 18 selected response questions from the CELT instrument and the 15 constructed response items of the CAT. Te results report the Pearson's correlation for the total score and individual items of both assessments. Item analysis, including item difficulty and item discrimination of the CELT assessment, are discussed in a separate study[11].

Results

For the 44 participants, the mean score of the CELT was 17.36 (SD = 3.10) out of a possible 24 points, and the mean score of the CAT was 19.75 (SD =6.71) out of a possible 28 points. The results of the correlational analysis are presented in Table 3. As expected, the CELT total score had a positive relationship with the CAT total score ($r = 0.47$, $p < 0.01$). Item 5 of the CELT had the strongest association the CAT total score ($r = 0.51$, $p < 0.01$), in addition Item 5 had significant associations with five CAT items at a $p < 0.05$ level, and a trending association with a sixth ($p < 0.08$). In addition, CELT Items 11, 16, and 17 also had positive associations with the CAT total score. Overall, only CEL Items 3, 4, 8, and 18 had no significant association with any part of the CAT instrument. Finally, Item 15 had a significant negative association one CAT item (CAT 9). While, Item 15 showed a negative correlation to the CAT total score, the correlation is not significant.

Table 3. *Correlation matrix of CELT items and CAT items*

	CAT 1	CAT 2	CAT 3	CAT 4	CAT 5	CAT 6	CAT 7	CAT 8
Item 1	0.13	0.15	0.24	0.17	**0.31***	0.22	0.01	- 0.11
Item 2	0.08	0.26	**0.36***	**0.31***	- 0.12	-0.19	0.26	0.17
1tem 3	0.18	0.06	0.12	0.12	- 0.19	- 0.22	0.18	0.14
Item 4	0.00	0.14	0.13	0.15	-0.10	0.10	0.10	0.00
Item 5	0.27	**0.36***	**0.28**	**0.42****	**0.45****	**0.44****	0.25	0.09
Item 6	0.06	0.25	0.05	0.17	**0.37***	0.19	0.09	0.06
Item 7	0.02	0.14	-0.01	0.06	0.04	**0.39***	0.07	0.21
Item 8	0.07	0.03	-0.09	0.10	0.02	- 0.09	0.08	- 0.09
Item 9	**0.32***	-0.05	**0.27**	0.12	0.14	- 0.07	**0.37***	0.13
Item 10	0.20	0.19	0.04	0.19	0.22	0.26	0.16	- 0.08
Item 11	0.14	**0.30***	**0.34***	0.27	0.03	**0.29**	**0.33***	**0.32***
Item 12_a	0.02	0.08	0.12	0.20	- 0.15	- 0.12	0.08	- 0.03
Item 13	0.06	0.08	-0.02	0.21	- 0.03	- 0.01	- 0.01	0.06
Item 14	0.09	0.03	0.18	**0.27**	0.12	0.10	0.10	0.02
Item 15	-0.03	0.11	0.08	0.04	- 0.23	- 0.25	0.03	- 0.14
Item 16_a	-0.02	0.21	**0.33***	**0.36***	0.14	**0.27**	0.01	**0.28**
Item 17	0.25	**0.31***	**0.36***	**0.27**	0.12	0.19	**0.34***	0.21
Item 18	0.03	0.09	**0.27**	0.13	- 0.16	- 0.23	0.12	0.03
CELT *T*	0.29	**0.39****	**0.43****	**0.47****	0.13	0.18	**0.40****	0.18

(continued)

Table 3. *Correlation matrix of CELT items and CAT items (continued)*

	CAT 9	CAT 10	CAT 11	CAT 12	CAT 13	CAT 14	CAT 15	CAT *T*
Item 1	0.12	0.01	0.09	0.03	-0.10	0.15	0.02	0.20
Item 2	0.26	-0.02	0.00	0.13	0.00	-0.16	0.09	0.17
1tem 3	0.21	-0.03	-0.18	0.21	0.04	-0.05	0.17	0.08
Item 4	-0.06	0.07	0.16	0.27	0.13	-0.13	0.22	0.14
Item 5	**0.39****	0.12	-0.11	-0.06	0.26	0.24	0.24	**0.51****
Item 6	0.24	-0.02	-0.02	0.01	0.12	0.03	0.04	0.21
Item 7	0.04	**0.41****	-0.15	0.18	0.05	-0.13	-0.01	0.12
Item 8	-0.03	0.05	0.04	0.06	0.05	0.03	0.08	0.05
Item 9	0.24	-0.09	0.18	-0.04	0.05	0.21	0.14	0.24
Item 10	0.23	-0.11	-0.16	-0.06	0.15	0.12	0.14	0.22
Item 11	0.21	0.06	**-0.29**	-0.06	0.18	0.06	0.14	**0.32***
Item 12_a	**-0.28**	-0.12	-0.15	-0.02	0.18	0.06	**0.36***	0.09
Item 13	-0.17	-0.11	-0.20	0.01	0.06	0.03	**0.34***	0.08
Item 14	0.06	-0.10	-0.22	0.11	0.15	0.20	0.14	0.20
Item 15	**-0.36***	-0.10	0.02	-0.20	0.16	-0.10	0.25	-0.19
Item 16_a	**0.28**	0.08	-0.04	0.19	0.08	0.15	0.24	**0.37***
Item 17	0.16	0.02	0.11	0.11	0.23	0.03	0.06	**0.35***
Item 18	-0.07	-0.11	0.21	0.02	-0.04	-0.06	0.13	0.05
CELT *T*	0.22	0.04	-0.07	0.13	0.23	0.07	**0.36***	**0.47****

Note. $N = 44$. [a]Multiple binary (e.g., select all that apply) items. Bold values represent significant or trending relationships ($p < 0.08$). *$p < .05$. **$p < .01$.

Discussion

Overall, the strong association between the CELT total score and CAT total score supports the supposition that information literacy and critical thinking are interrelated. However, the instruments are not so strongly correlated that they are measuring the same constructs across the entirety of both instruments. Instead, the item to item analysis provides evidence as to which CELT items are mostly likely providing the best measurement of critical thinking constructs. Table 4 provides a summary of the CELT items that showed a positive association the CAT total score. Items significantly correlated with the CAT total score, overall are paired with key objectives such as, *accurately document*, *determine what information is needed,* and *evaluate the reliability*. These results infer a possible subset of skills where information literacy and critical thinking skills fundamentally overlap.

Table 4. *Summary of CELT items and associated objectives positively associate with CAT total*

CELT Item Number	***Objective (Student can…)***	***Item Stem***
Item 5	**accurately document** the sources referenced	Which one of the citations is incorrect or incomplete?
1tem 11	**determine what information is needed** to make a strong argument	Which of the following comparisons of … is most relevant …?
Item 16	**evaluate the reliability** of information and use reliable information sources	What would help the review panel validate the data presented?
Item 17	**evaluate the reliability** of information and use reliable information sources	Where would you likely find authoritative information on …?

CELT Item 15 is also a special case where it had a significant negative association with one item of the CAT assessment. While there were several other items with a negative association, none of the others were significant at the $p < 0.05$ level. In comparison to the item analysis of the CELT instrument, items 3 and 15 both had very low item discrimination values as determined by the point biserial correlation, and thus were determined to be poor items[11]. More detailed discussion of the item analysis can be found in this separate study.

Future Work

In the next phase of our project, we will be looking more closely at the item to item analysis, and in particular categorizing the CAT items to identify sub-categories within the broad critical thinking construct to better identify the strengths and weakness of the CELT instrument in addressing critical thinking within the context of information literacy. We will expand our analysis to include the remainder of the first-year engineering students and a population of first-year aviation technology students.

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