Assessing student CT skills in the disciplines: Partnering students in designing online quizzes for applied learning

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Critical thinking (CT) in Higher Education (HE)

- CT is recognised as a desired learning outcome in HE and a valued competency at the workplace.
- Many professional accreditation standards call for evidence of CT in young job applicants.
- In response, scholars stress the importance of improved CT instruction in HE (Bays & Ralston, 2015) to prepare students for the workplace.
- There has been much discussion on CT in the disciplines, such as in nursing, accountancy, engineering and health sciences education (Bailey et al., 2015; Latif et al, 2019; Sola et al, 2017; Weidman & Salisbury, 2020).
- The value of making CT explicit and visible in the curriculum (Alsaleh, 2020; Bensley & Murtagh 2012; Hattie, 2009; 2017; Willingham, 2019)

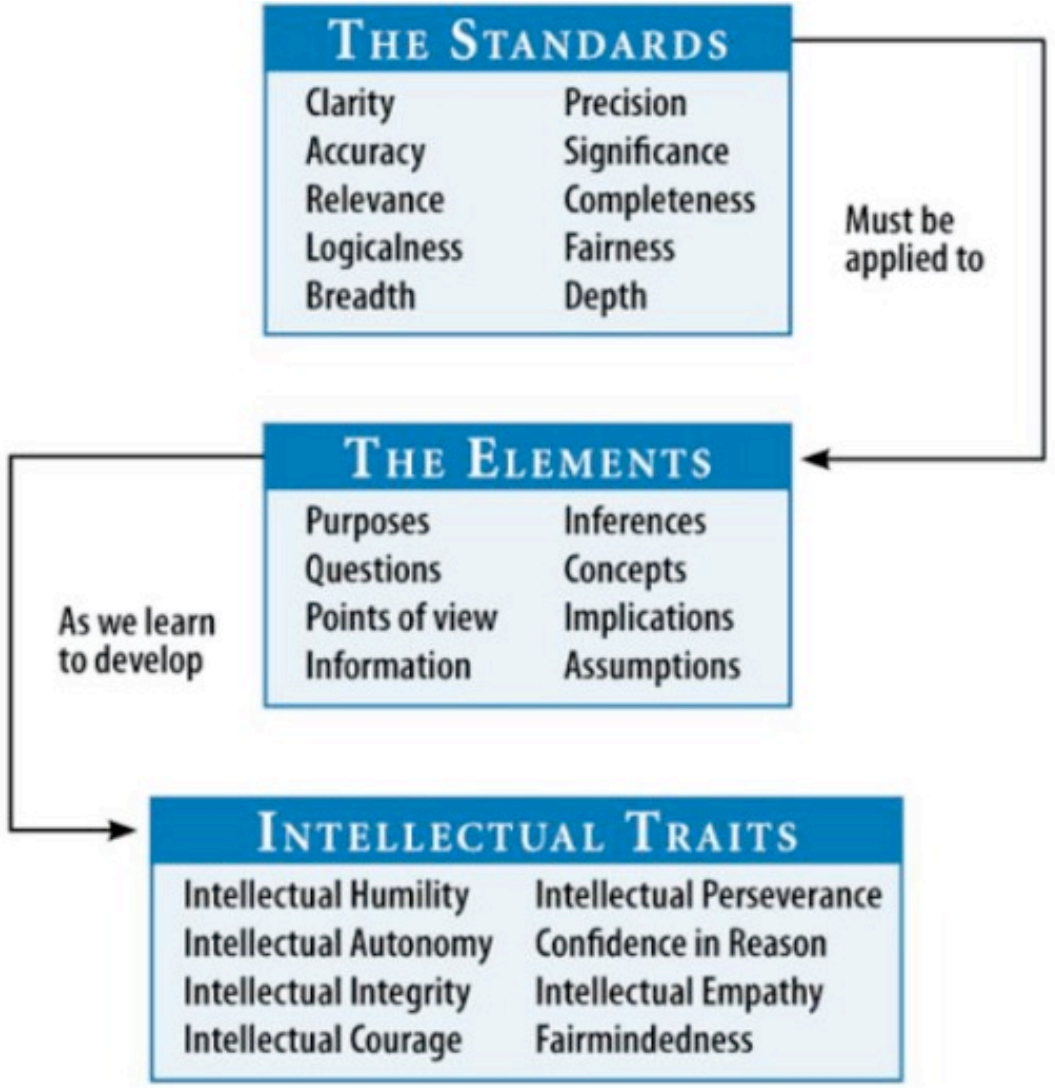
Challenges

- Measurement of students' CT skills remain challenging; many grappling with issues on designing their own CT assessments.
- The issue on whether teachers, during the process of a CT assessment, can reliably assess the level of a student's CT (Quitadamo & Kurtz 2007).
- Quizzes tend to assess understanding/application of content rather than specific thinking skills.
- Very few assessments addressed students' low test-taking motivation in taking low-stakes assessments; student motivation could have a significant impact on test performance (Liu et al., 2016)

CT Frameworks and Models

- Varied concepts and definitions of CT: generic set of skills (Ennis, 1992), discipline-specific processes (McPeck, 1981), the educational cognate of rationality (Siegel, 1988), the formation of good judgement (Lipman, 1991) and thinking that meets relevant standards or criteria of acceptability (Bailin & Siegel, 2003).
- CT models and strategies – e.g., Bloom's(1956) taxonomy of educational objectives; Toulmin's (1958; 2003) model of argument; Facione's (1990) The Delphi Report; Beyer's (1995) evaluative thinking model; and Paul & Elder's (2008;2020) CT framework
- King and Kitchener (1994) proposed stages of critical and reflective thinking. The goal is to help students achieve the higher stages of development of critical thinking as a result of their experiences.
- Kronholm (1996) provides an instructional model that helps students advance their critical thinking skills through seven phases of instruction and related activity.

The Paul-Elder Framework (2019)



Paul, R. & Elder, L. (2019). The Miniature Guide to Critical Thinking Concepts and Tools (8th ed.). Rowman & Littlefield Publishers.

Rationale and Purpose of Study

- On-going investigation into using tutor-student jointly designed online quizzes as a self-assessment component and how they enhance CT learning outcomes of a module. This enquiry contributes to the gap in literature on assessing CT skills in the disciplines and partnership with students in instructional design.
- RQ: How can we partner students in assessing their development of critical thinking skills in the disciplines?
- Purpose: To describe how we created a learning environment to support the development of students' critical thinking (CT) skills. Specifically, we will illustrate how we utilized students' peer review on written drafts to create CT quiz items.

Methods

Critical Thinking and Communicating (CTC) module

- University-wide compulsory module in discipline-specific programmes
- Common CT framework: Paul-Elder
- One module profile, i.e., same learning outcomes; but with instructional materials and assessments customised to each programme
- Pharmaceutical Engineering (PHE) and Speech & Language Therapy (SLT)
- Peer feedback from Assignment 3
  - PHE – technical report
  - SLT – critical review essay

Partnering students: Using peer feedback to develop CT quiz items

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Peer Feedback on Assignment 3
Using Paul-Elder's Criteria for Evaluating Reasoning

Refer to the following set of guiding questions. These questions apply intellectual standards onto the elements of reasoning.

Your feedback on your peer's draft paper can be in the form of questions or statements as you comment on their paper. This exercise will show how Paul-Elder's criteria for evaluating reasoning can be applied to improve writing of the critical review paper.

1. **Purpose:**
What is the purpose of the reasoning? What is their purpose of doing what they are doing? What do they intend to achieve? What is their goal in solving this problem? Is the purpose/goal clearly stated or clearly implied? Is the purpose relevant to the issue?

My questions/comments:

2. **Question at issue or Problem:**
Are the question and purpose directly relevant to each other?

My questions/comments:

CT quiz items

PHE

2	Which **critical question** would be appropriate for the following clarifying statements when evaluating a PHE research proposal on **Tackling the issue of carbon footprint with continuous pharmaceutical manufacturing in Singapore**? (i) The Pharma industry is growing and this clashes with the nation's goal to reach net zero carbon emissions by 2050. Most pharmaceutical companies are still adopting the batch manufacturing process. (ii) Increases in greenhouse emissions would worsen climate change. (iii) Singapore will be increasing the industry's carbon emission tax to $50-$80 per tonne emission by 2030, this is $10-$15 more than stated. (A) Do the authors have any vested interest in this issue of carbon footprint? (B) Have the authors considered the solution on continuous pharmaceutical manufacturing from another perspective? (C) Have the authors illustrated the relevance of carbon footprint to PHE industry with precision?

SLT

2	Which **critical question** would be appropriate for the following statements by Monga et al. when evaluating their journal article? (i) However, declining quality of life (QOL) and increased fatigue remain major concerns in cancer patients. (ii) Fatigue prevalence increases over the course of radiotherapy and worsening of fatigue at later stages of the disease is possible. (iii) Exercise also has been shown to decrease fatigue and improve sleep among healthy adults. (A) Do the authors have any vested interest in this issue of fatigue in cancer patients? (B) Have the authors considered the solution on fatigue in cancer patients from another perspective? (C) Have the authors illustrated the relevance of exercise to fatigue in prostate cancer patients undergoing radiotherapy?
2	Which of the following **critical questions** is helpful for you to understand the intellectual

CT quiz items

PHE

6 In a PHE research proposal on **Overcoming Singapore's chemical industrial heavy metal pollution with greener chemical processes**, the authors included the paragraph below after introducing their research paper and elaborated on their main claim – Singapore's pharmaceutical industry must adopt greener chemical processes which eliminates the need for metal catalysts in order to overcome the increasing prevalence of heavy metal pollution.

The amount of heavy metal exposed to the environment is severe, especially in developing ASEAN countries. According to the US Environmental Protection Agency[1], the provisional guideline value of chromium is 0.1 ppm/L. However, chromium levels in underground water of Indian regions were found to exceed 500 ppm/L, ranking as 174 of 180 according to Yale's Environmental Performance Index[2]. Additionally, in the Red River of Vietnam, the average arsenic concentration is 159 µg/L, exceeding the World Health Organization's (WHO's) provisional guideline value of 10 µg/L[3]. Aggravating the severity of heavy metal pollution, a study[4] has shown that the high amounts of arsenic in Vietnam's Red River has caused a downstream effect of habitat degradation in the Gulf of Thailand as seen in Figure 1. This highlights the urgency of matter and if sustainable solutions are not being implemented soon, the problem of heavy metal pollution would devastate environments even beyond transnational borders.

Which of the following intellectual standards have the authors considered when developing the above paragraph?
(i) Breadth
(ii) Clarity
(iii) Precision
(iv) Significance

(A) (i) and (ii)
(B) (ii) and (iii)
(C) (ii), (iii) and (iv)

SLT

6 In a critical review on **Monga et el.'s paper**, the authors included the paragraph below after introducing their research paper and elaborated on their main claim - Looking through the lens of Swales' (1990) Create A Research Space (CARS) Model to analyse Monga et al. 's (2007) article introduction, the authors generally adhered to sound rhetorical moves for persuasive content in establishing a niche and research gap in the field.

The authors establish territory, through indirect and rhetorical means to claim centrality, in Step 1 of the first move. The paragraph opens with information relevant to the study – cancer and fatigue, concluding with "declining QOL and increased fatigue remaining major concerns in cancer patients" (p. 1416). This appeals to readers about well-established research done on cancer patients, giving rise to interest and having a directive effect on readers (Swales, 1990). However, links to the territory are not explicitly established in specificity to prostate cancer patients, which would impede readers' understanding of the direction of study. In Step 2, topic generalisations are vaguely established as mentioned in "In contrast, studies … among healthy adults." (p. 1416). Authors also fail to bridge findings and claims purposefully to the scope of study, leaving readers to subjective interpretation of their claims.

Which of the following intellectual standards have the authors considered when developing the above paragraph?
(i) Breadth
(ii) Clarity
(iii) Precision
(iv) Significance

(A) (i) and (ii)
(B) (ii) and (iii)
(C) (ii), (iii) and (iv)

Post-quiz survey (based on WSU's Guide to Rating Critical Thinking)

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Have you been able to identify the problem/question at issue of what you read, or consider it when you write, such that the nuances of the issue are also recognised?

- Definitely not
- Probably not
- Probably yes
- Definitely yes

Have you been able to identify and assess key assumptions of what you read or consider them when you write?

- Definitely not
- Probably not
- Probably yes
- Definitely yes

Have you been able to identify and and present other salient perspectives and positions that are important to the analysis of what you read or consider them when you write?

- Definitely not

Have you been able to identify and assess the quality of supporting data/evidence of what you read or consider it when you write?

- Definitely not

Post-quiz survey

Have you been able to objectively reflect upon your own assertions when you write?

- Definitely not
- Probably not
- Probably yes
- Definitely yes

Can you share a brief reflection on your experience to develop critical thinking skills more intentionally in your discipline with the use of explicit critical thinking tools/framework?

Results and Discussion

Combined Results of Quiz (PHE + SLT)

A	B	C
16/30 (53.3%)	5/30 (16.7%)	9/30 (30%)

Results of Quiz (PHE)

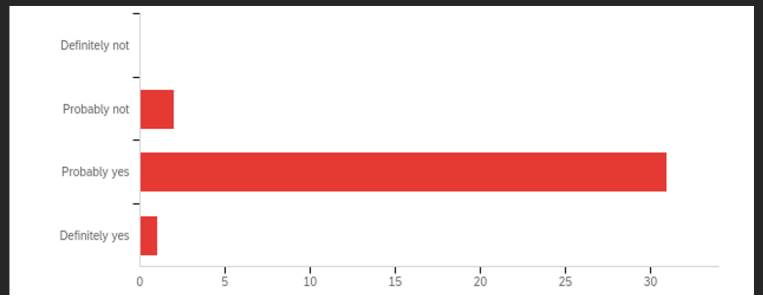
A	B	C
11/14 (78.6%)	2/14 (14.3%)	1/14 (0.07%)

Results of Quiz (SLT)

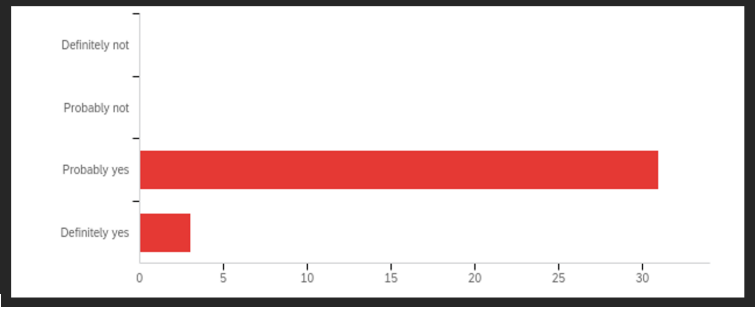
A	B	C
5/16 (31.3%)	3/16 (18.8%)	8/16 (50%)

Results of Feedback Survey

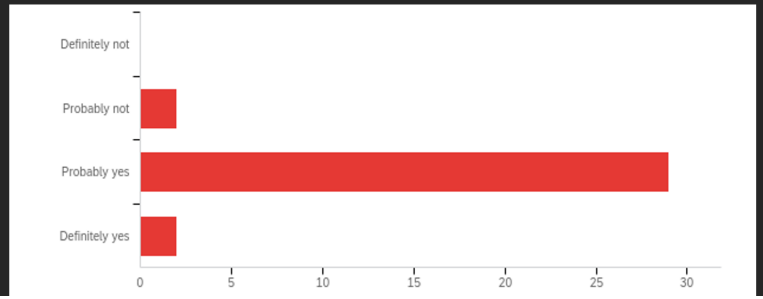
QID1 - Have you been able to identify the problem/question at issue of what you read, or consider it when you write, such that the nuances of the issue are also recognised?



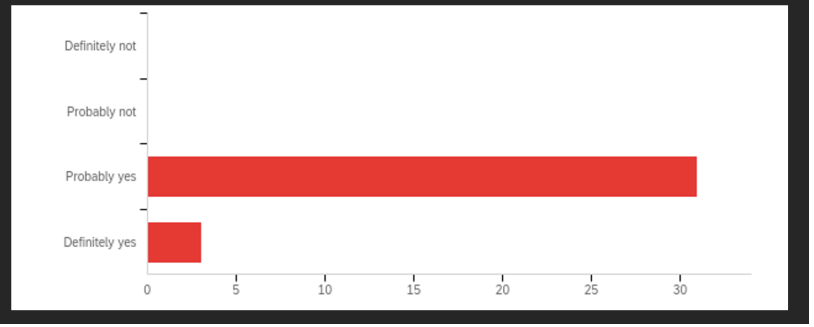
Q4 - Have you been able to identify and assess the quality of supporting data/evidence of what you read or consider it when you write?



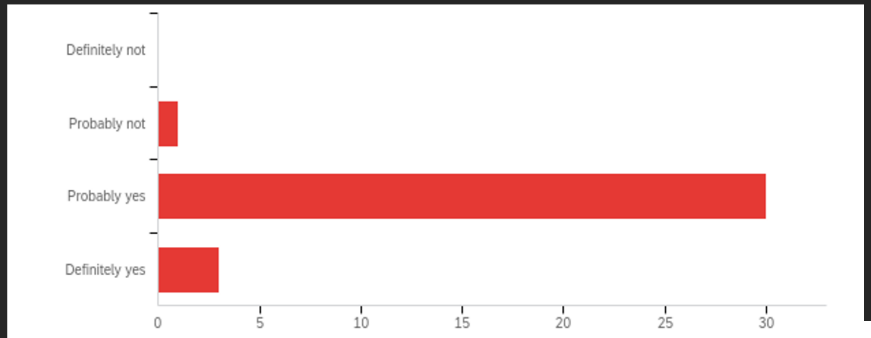
Q2 - Have you been able to identify and present other salient perspectives and positions that are important to the analysis of what you read or consider them when you write?



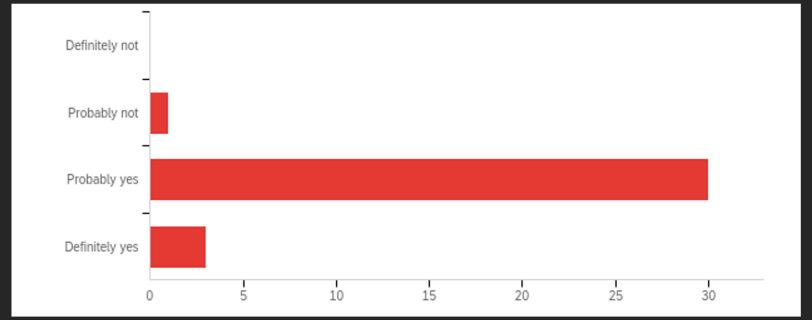
Q5 - Have you been able to analyse the issue of what you read, or consider it when you write, with a clear sense of scope and context?



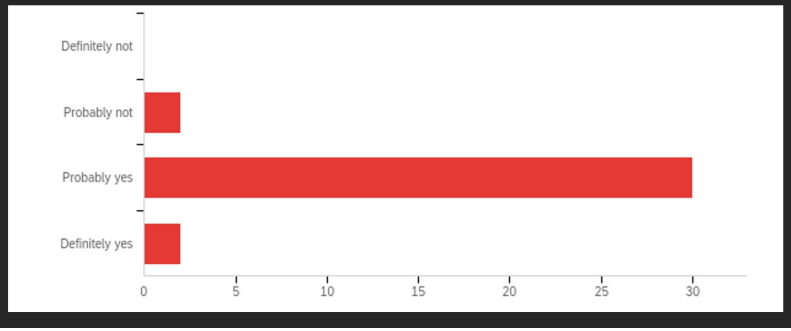
Q3 - Have you been able to identify and assess key assumptions of what you read or consider them when you write?



Q6 - Have you been able to identify and assess conclusions, implications, and consequences of what you read or consider them when you write?



Q7 - Have you been able to objectively reflect upon your own assertions when you write?



Feedback from students

I have been able to use the critical thinking skills that i learned to help me in ny ethics discussions to consider all viewpoints, it has also helped me for design and innovation. I believe these skills are helpful even in my day to day life and the future.

I have learnt to analyse the articles I read using critical thinking and it enables me to apply the relevant knowledge to determine the depth, breadth, complexity and various perspectives that need to be covered.

It enables me to better analyse the articles that I read and ensure that I am not being biased and have explored the various complexities of the issue involved and their solutions.

Critical thinking allow us to apply the element of thoughts to the current pharmaceutical industries problems and make better interpretation of information given

I personally feel that having develop critical thinking skills, I've been able to think more clearly on what i read. It has helped me a lot when i reflect and understand different point of views. Rather than just reading things on the surface level, I now dig deeper and find the importance of the issue while ensuring the source are 1)relevant 2)fair 3)accurate

Feedback from students

As prospective Engineers, the majority of our role involves problem-solving. Instilling consciousness of the Paul-Elder framework has proved to provide guidance on the path towards an ideal solution.

A specific instance that I could share was a research experience project that I am currently involved in. The problem in question is that a certain substance is not dissociating well in a pool of fluid due to its restricted sinking speed/buoyancy. I have quite literally applied the intellectual standard of 'depth' to broaden the solution into a 3-dimensional spatial system instead of limiting it to the horizontal axis. One plausible solution would be to vary the buoyancy of the substance such that it would dissociate in all directions better.

Our Reflections

How can we partner students in assessing their development of critical thinking skills in the disciplines?

Differences in the administration of surveys: asynchronous at home vs in-class and time-based

The challenge of selecting and "converting" students' peer review (comments/questions) into question stems and creating distractor items.

The question of motivating students to attempt ungraded quizzes. Perhaps integrating multimedia and gamification could increase their motivation levels.

Bridging the gap for students to continue practicing CT skills in their disciplines beyond "formal" CTC modules

Conclusion

Recommendations

- Adopt a ‘Community of Inquiry’ (COI) approach - encourages students to explore issues and experiences dialogically and critically (Sharp, 2004).
- Through reading stimulus material and vocalising their thoughts together in a collaborative setting, students develop their own specific thinking competencies and dispositions (Teoh, 2008).
- Explicit integration of a (curated) conceptual framework of CT “tools” in instruction and learning activities to make developing CT skills explicit and visible (Patel, 2021)
- Redesigned Peer Review Form to show original and revised write-up. Include a checklist of critical thinking tools, eg. EoTs or ISs considered in the feedback.
- Use of digital tools - exercise conducted collaboratively online on shared documents.

Implications and Conclusion

- Usefulness of study: continual development of CT skills in students' disciplines
- All faculty to emphasize CT – explicit and visible – i.e., not just within one subject/module
- Future research: partnership with students to be more intentional
- Investigate the efficacy of the tutor-student partnership in designing online quizzes to develop students' critical thinking skills in the disciplines.
- Repository of quiz items, assessing students' application of CT skills in the disciplines
- Moving from a one-off intervention to a more pervasive and intentional integration of CT skills that transcends subjects, courses and disciplines

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Thank You

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