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Application of critical reading skills in academic writing among first-year engineering students: Initial findings and next steps

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ABSTRACT

CONTEXT
While a great deal of importance is attached to communication and critical thinking skills in engineering, lecturers may not be dedicating enough classroom time to their development (International Engineering Alliance, 2021; Kovac & Sirkovic, 2017; Ministry of Education, 2020). Alternatively, such training might be outsourced to a language and learning support team that shares general guidance and/or helps individuals with deficits (Wingate, 2006). On top of this, undergraduate engineering students' reading and writing skills may be underdeveloped when they first enter their programme, making it difficult to meet expectations for writing assignments. Under such conditions, they may make minimal progress in academic and technical writing skills over the course of their studies and struggle with the communication demands of their profession.

PURPOSE OF THE STUDY
To address this issue, a customised lecture was taught to a new cohort of engineering students at the University of Waikato. It introduced them to a formulaic approach to applying critical reading skills in their first writing assignment. The aim of this study is to closely examine the written output and determine trends in the students' application of critical reading skills. This analysis will inform recommendations for teaching and assessment strategies applied in engineering programmes.

METHODS
A formative assessment, utilising a bespoke rubric and feedback comment library, was done on 197 students' submissions. This yielded data on five criteria and the related feedback provided. A quantitative analysis was conducted to determine the numbers of students assessed at each rating in the rubric and who received a particular feedback comment relating to each of the five criteria.

OUTCOMES
The data reveal that just over 50% of students used two or more relevant and appropriate sources in the submission; however, a sizeable number did not meet research expectations because they relied — in part or entirely — on inappropriate sources (e.g., blogs, websites) instead of using scholarly ones. In addition, when using source content in their writing, the majority of students' application of paraphrasing skills was inconsistent or incorrect, or they included too many quotations. Their struggle to follow discipline-specific writing conventions when using source content, paired with an oft-imperfect application of APA format, explains the high rate of cases of minor plagiarism within submissions. On top of that, nearly all submissions contained at least minor organisational issues, usually involving source content appearing in place of a topic sentence and/or concluding sentence.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY
Based on this evidence, a lecture on applying critical reading skills in academic writing — even when customised to the engineering discipline — is positive yet not sufficient to ensure that undergraduate students understand conventions and can meet expectations of university-level writing assignments. Development of teaching and assessment strategies is recommended to address these issues. It would be beneficial to build process writing into engineering programmes so students gain more practice, and more frequent use of formative feedback is recommended to assess critical reading and academic writing skills. Additionally, a blended learning approach could be applied in which students gain much-needed practice via a series of online activities — a strategy that will be trialled as part of the next phase of this research project.

KEYWORDS
engineering; critical reading; academic writing

Introduction

While a great deal of importance is attached to communication and critical thinking skills in engineering, lecturers may not be dedicating enough classroom time to their development (International Engineering Alliance, 2021; Kovac & Sirkovic, 2017; Ministry of Education, 2020). Alternatively, such training might be outsourced to a language and learning support team that shares general guidance and/or helps individuals with deficits (Wingate, 2006). On top of this, undergraduate engineering students' reading and writing skills may be underdeveloped when they first enter their programme, making it difficult to meet expectations for writing assignments. Among these is the ability to apply critical reading skills; new students may struggle to find and use quality source content while following the writing conventions of engineering texts. Under such conditions, they may make minimal progress in academic and technical writing skills over the course of their studies and struggle with the communication demands of their profession.

These conditions, having been observed at the University of Waikato (UoW) in New Zealand, may be addressed by a different approach linked to the academic literacies model. The model's effect on pedagogy will be discussed next, followed by a description of the teaching context in which this study was conducted. Then results of the quantitative analysis will be presented, and recommendations for teaching and assessment provided.

Literature Review

This quantitative study of engineering students' initial critical reading skills is linked to ongoing, broader ethnographic research, and an understanding of the academic literacies model is pertinent. This field of inquiry concerns itself with meaning making and identity in connection to reading and writing practices at the tertiary level (Lea & Street, 1998, 2006; Lillis & Scott, 2007). It examines various influences on student learning, including social exchanges, a discipline's context, and the wider institutional culture (Lea & Street, 1998, 2006). For this study, however, readers should be concerned mainly with how embedding this model affects pedagogy.

Certain pedagogical practices are vital when embedding the academic literacies model in the disciplines. According to Lea and Street (2006), the model requires educators "to be concerned with literacies more generally across academic contexts and not only the assessed texts produced by students" (p. 375). This applies specifically to the design of learning materials because students need to acquire explicit awareness of the ways of writing associated with their discipline (Lea & Street, 1998, 2006). Creating opportunities for collaboration is also integral to an embedded academic literacies approach because such moments can help students realise what relevant knowledge they already possess, what techniques they have practiced, and what gaps exist that must still be addressed so they can meet the expectations of their discipline (Lea & Street, 2006). Educators can apply the pedagogical principles of the academic literacies model in a variety of ways: the use of model texts, scaffolding a comparative analysis, group discussions about writing conventions, formative feedback, and reflective forums about writing in a discipline.

While existing literature examines how this model has been embedded in a variety of disciplines, it does not overlap often with engineering. Studies by Gustafsson (2011) and Strauss and Grant (2018) are rare examples of this pairing, but neither of them focused on critical reading within the writing process. Critical reading, as an essential component of pre-writing, involves the analysis and evaluation of published works to determine their viability as referenced sources in a piece of writing. Therefore, engineering students' ability to apply these skills can influence the quality of discipline-specific texts they produce as part of their studies.

Other recent studies have explored critical reading in connection to engineering (Luarca & Ramachandran, 2023; Saidalvi et al., 2022; Weaver et al., 2023). While these authors were unanimous in their position on the importance of critical reading skills, none of their studies followed the academic literacies model. Therefore, this paper offers a unique examination of undergraduate engineering students' critical reading skills development, sharing initial results from a teaching intervention. Further details will be provided later to contextualise this study as one phase within a greater whole.

Purpose of the Study

The aim of this study is to closely examine the written output of first-year engineering students and determine trends in their application of critical reading skills. The trends analysed herein will inform recommendations for teaching and assessment strategies applied in engineering programmes.

Context of the Study

This paper covers the first phase of a larger, ongoing research project. In this project, the academic literacies model is applied to examine the development of critical reading skills among engineering students. This project was partially inspired by a previous role teaching English for Academic Purposes to Chinese engineering students enrolled in one of UoW's transnational programmes. When teaching and learning was forced online during the Covid-19 pandemic, it was found that practice once completed during classroom activities could be adapted using Moodle's interactive learning tools, thus ensuring students' online engagement and collaboration (Busteed, 2022). During this time, discussions with colleagues in UoW's School of Engineering led to the realisation that some of those online activities could be adapted for the benefit of all new engineering students. It was posited that a highly structured lesson leading into such online activities would best serve the students if customised to engineering and embedded in a course by linking it to an existing assessment.

To begin this study, a customised lecture was taught to a new cohort of engineering students enrolled in Engineering and Society (ENGEN170) at UoW. Delivered at the beginning of Trimester A in March 2023, it introduced them to a formulaic approach to applying critical reading skills. This formula broke pre-writing into four phases: (a) analyse the task instructions; (b) brainstorm keywords, ideas, and questions; (c) collect relevant resources; and (d) draw connections between sources and your own ideas. Each phase had its own key steps and recommended actions to follow. These were supported by examples and model texts tied directly to their first writing assignment (Assignment 2 – Task #1), thus fully embedding the lecture in the course curriculum. It was pointed out that students could apply the formula to any other instances where critical reading was needed as part of producing an engineering text, thus aligning it with the pedagogical principles of the academic literacies model. The end of the lecture directed students to additional resources on ENGEN170's Moodle page that would aid in the completion of Task #1; among these files was a copy of the critical reading rubric (see Appendix A) so they could learn how submissions would undergo formative assessment. The rubric's criteria descriptors had been reviewed by the course convenor to ensure alignment with existing expectations. Students had a few days to write Task #1 and submit through Moodle. Over the next week, the formative assessment was completed. Later phases of the teaching intervention involve online practice of the formula in connection to further assessment; however, this paper will focus exclusively on the customised lecture's impact on students' written output.

Methods

A formative assessment was done on 197 students' submissions for Task #1. This assessment was completed via Turnitin Feedback Studio using the critical reading rubric and the corresponding feedback comment library (see Appendix B). It should be noted that, in many but not all cases, formative feedback comments relating to all five of the rubric's assessment criteria were attached to each submission. In some instances, a student may have received fewer than five feedback comments since they were applied based on relevance.

Next, the assessment data from the rubric and feedback comments were used to conduct a quantitative analysis. It determined the numbers of students assessed at each rating in the rubric and who received a particular feedback comment relating to each of the five criteria. Approval to use this data was granted by UoW's Te Wānanga Toi Tangata Division of Education Research Ethics Committee.

Results

The analysis of data from Task #1's formative assessment offers several key findings. Figure 1 shows the numbers of students assessed at each rating across the rubric's five criteria when applying critical reading skills in the writing assignment. In addition to learning their rubric ratings, each student received multiple corresponding feedback comments. A tally of comments used is shared in Table 1 on the next page. Together, the data reveal trends in engineering students' ability to apply critical reading skills based on learning the formula from the customised lecture.

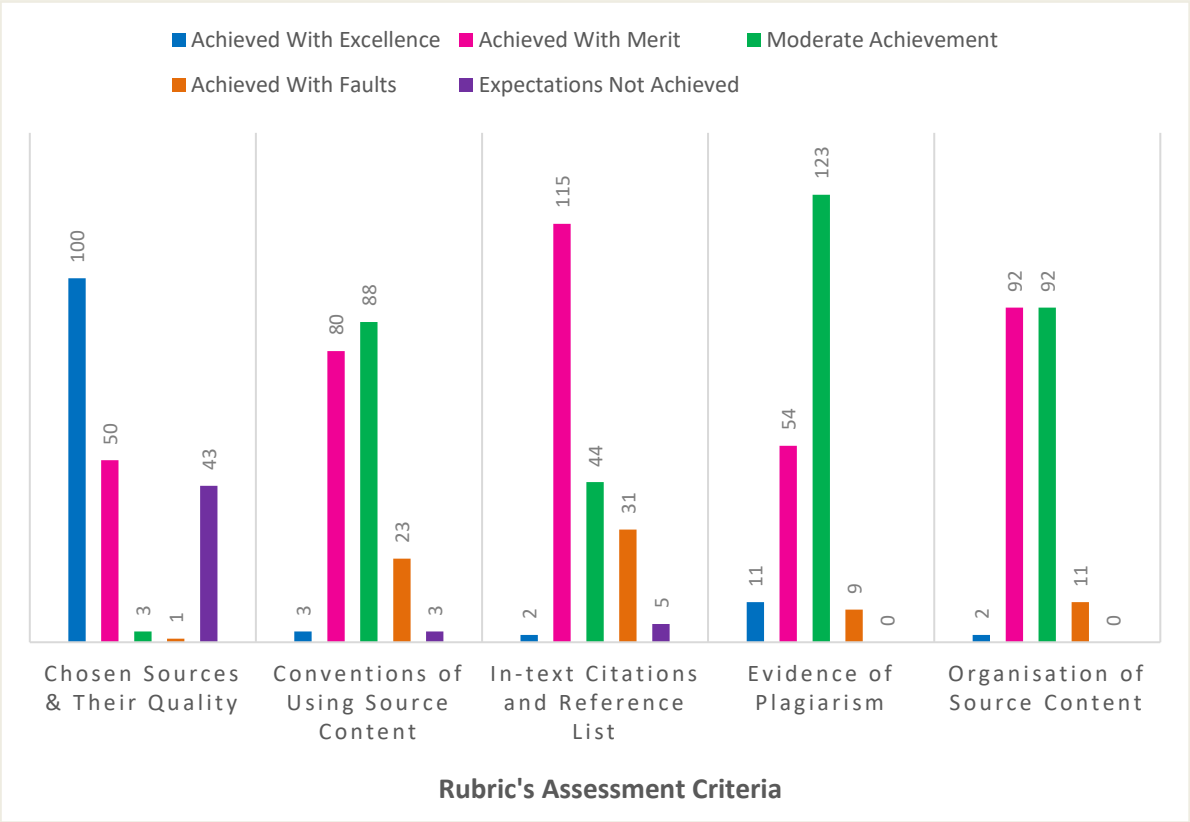

Figure 1: Formative assessment of Task #1 using critical reading rubric

The data reveal that just over 50% of students used two or more relevant and appropriate sources in the submission; however, a sizeable number did not meet research expectations because they relied — in part or entirely — on inappropriate sources (e.g., blogs, websites) instead of using scholarly ones. In addition, when using source content in their writing, the majority of students' application of paraphrasing skills was inconsistent or incorrect, or they included too many quotations. Their struggle to follow discipline-specific writing conventions when using source content, paired with an oft-imperfect application of APA format, explains the high rate of cases of minor plagiarism within submissions. On top of that, nearly all submissions contained at least minor organisational issues, usually involving source content appearing in place of a topic sentence and/or concluding sentence.

These findings are significant because the lecture was customised to Task #1 and fully embedded in ENGEN170. Wingate (2006) had described generic training in study skills as something that was detached from individual disciplines, or 'bolted on', often leaving students unable "to understand the sources, to select the relevant ones, or to know why and when to reference" (p. 463). The academic literacies model is meant to address this by embedding the teaching of these skills and customising learning materials to the students' discipline. Despite following this model when designing and teaching the critical reading lecture, it did not provide

Table 1: Feedback comments used

Assessment Criteria & Feedback Comment Names	Number of Students who Received Feedback Comment
Chosen Sources & Their Quality	
Excellent Sources	97
Lacking Quality Sources	40
Source Appropriateness	35
Faulty Source Choice	9
Not Enough Sources	5
Conventions of Using Source Content	
Deeper Analysis Needed	66
Problematic Integration	30
Quote Less	28
Too Many Quotations	6
Lacking Analysis	5
Skilled Paraphrasing	2
Weak Paraphrasing	2
Integration Not Achieved	2
In-text Citations and Reference List	
Strong Referencing	100
Missing Source & Errors	32
Faulty Referencing	26
Referencing Not Attempted	5
Excellent Referencing	2
Evidence of Plagiarism	
Improve P/Q Technique	101
Minor Plagiarism	83
No Plagiarism	12
Sig. Plagiarism = Warning	7
40%+ Plagiarism	0
Organisation of Source Content	
Improve Org. & Logic	90
Improve Logic	78
Support Ideas + Fix Logic	8
Faulty Organisation	3
Excellent Organisation	2
Organisation Not Achieved	0

sufficient training to ensure most of the engineering students achieved high ratings across the five criteria for Task #1. Their dependence on easy-to-find online sources, underdeveloped paraphrasing skills, and lack of familiarity with how to follow APA's strict rules while operating within a linear organisational text structure all suggest that a lecture alone is not enough to prepare engineering students to meet expectations for writing assignments in their programme.

Discussion

Based on this evidence, a lecture on applying critical reading skills in academic writing — even when customised to the engineering discipline — is positive yet not sufficient to ensure that

undergraduate students understand conventions and can meet expectations of university-level writing assignments. Development of teaching and assessment strategies applied within engineering programmes is recommended to address the issue. This section recommends two pathways that would align better with the pedagogical principles of the academic literacies model.

Firstly, it would be beneficial to build process writing into engineering programmes, so students gain more practice in critical reading and writing. Process writing breaks text creation into stages — pre-writing, writing, and revision — and, when applied in the classroom, offers learners opportunities to ponder, explore, and practice the stages (Flower & Hayes, 1981; Murray, 2003). With process writing embedded in engineering courses, more frequent use of formative feedback (from lecturers, tutors, peers) is recommended to assess the application of critical reading in assignments. This could be achieved through dedicated pre-writing and revision time in workshop sessions leading to a writing portfolio assignment. The portfolio could include a collection of texts written during a course, each introduced by an annotation describing the student's writing goals for the text, how critical reading skills were applied when producing it, and the revisions made after receiving formative feedback. The portfolio would end with a short journal entry wherein students consider the evolution of their process writing skills during the course. They could reflect on goals achieved, challenges faced, their growth as a writer, issues that remain and how to address them, etc. For this assignment, greater value ought to be attached to quality of writing as one of the assessment criteria. This would go beyond writing mechanics to focus on how well pre-writing and revision skills were applied in the texts as well as the depth of reflections shared.

Additionally, a blended learning approach could be applied in which students gain much-needed practice via a series of online activities — a strategy that is being trialled as part of the next phase of this broader project. Blended learning involves "the convergence of text-based asynchronous Internet-based learning with face-to-face approaches" (Garrison & Kanuka, 2004, p. 96). If engineering students are introduced to a critical reading formula during a face-to-face lecture, subsequent online activities could reinforce that learning. Moodle activities, plugins like H5P, and external online learning tools (e.g., Mentimeter, Dotstorming, Parlay Ideas) allow educators to design interactive content and give students a chance to practice a formula's phases. Arranged as a series, online activities can incorporate "collaborative, independent, and problem-based learning to reach the broadest range of learning types" (Lothridge et al., 2013, p. 408). Many of these tools can be programmed so students receive automated feedback with each activity's completion. These comments should be specific: identify strengths/weaknesses, refer to the formula learned, and recommend next steps in connection to an upcoming writing assignment. In addition, collaborative online activities and forums create opportunities for peer feedback, which should involve some procedural scaffolding to ensure comments are useful to recipients.

Conclusion

This paper examined the effect of a customised lecture on engineering students' application of critical reading skills in academic writing. Analysis found that, even when such a lesson is fully embedded in the course and discipline, students new to engineering writing conventions require ongoing practice to meet the associated expectations for tertiary-level studies. Engineering lecturers could adopt the recommended approaches to ensure the teaching and assessment of vital communication skills align better with the pedagogical principles of the academic literacies model. However, the scope of this study is limited and does not incorporate the ethnographic data associated with said model. Future publications on the broader research project will offer greater insights into this field of inquiry as applied in an engineering classroom. In the meantime, it is highly recommended that engineering lecturers pursue collaborations with language, literacy, and e-learning experts at their institutions to develop an embedded approach.

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Appendix A: Critical Reading Rubric

ASSESSMENT CRITERIA:	ACHIEVED WITH EXCELLENCE	ACHIEVED WITH MERIT	MODERATE ACHIEVEMENT	ACHIEVED WITH FAULTS	EXPECTATIONS NOT ACHIEVED
Chosen Sources & their Quality	Two or more sources were used in this text. All of them are relevant and appropriate, meeting the requirements of the assignment.	Two or more sources were used, but they are not all appropriate and/or relevant. Most of the assignment's research requirements were met.	One source was used in this text. It is relevant and appropriate. The writer should have spent more time looking for additional sources to use.	One source was used, but its appropriateness and/or relevance is questionable. The writer did not use enough sources of quality in the text.	All sources are irrelevant, inappropriate, or missing. Research requirements were not met.
Conventions of Using Source Content	Paraphrasing integrates source content seamlessly into the text. A position is presented clearly, with experts' viewpoints providing excellent support to the writer's ideas. A maximum of one quotation is included.	Source content is integrated well, but paraphrasing needs minor improvement. The support it offers to the writer's ideas is strong, but analysis of source content could be improved slightly. There is one too many quotations in the text.	Sentences featuring source content are sound, but paraphrasing needs revision. It is not always clear how source content supports an idea. Deeper analysis would clarify the writer's position versus experts' viewpoints. Several quotations are included in the text.	The integration of source content features many errors and/or flawed paraphrasing. Source content offers weak support to the writer's ideas. Analysis rarely follows experts' viewpoints, which weakens the position. Quoting may be used extensively.	Source content is not integrated throughout the text. Most or all of it is disconnected from the writer's ideas, and the quality of analysis does not meet the level required. Quoting may be used primarily instead of paraphrasing.
In-text Citations and Reference List	Correct presentation of in-text citations, as well as alignment between the in-text citations and the reference list. Reference list reflects correct referencing conventions.	In-text citations and the reference list are mostly correct. Minor errors in conventions in the text and/or reference list are noted. All sources cited in the assignment are in the reference list.	Several errors in the presentation of in-text citations and the reference list. Not all sources are cited in the body, or a source is missing from the reference list.	The writer has not followed citation rules in the majority of the text. The reference list is missing or incomplete.	The writer has not made any attempt to cite sources in the body, and the reference list is missing.
Evidence of Plagiarism	The text exhibits no evidence of plagiarism, including collusion.	There is no plagiarism, but minor errors in the writer's paraphrasing and/or quoting technique are evident.	Minor plagiarism is noted. A review of the rules on using source content needs to be undertaken.	Significant evidence of plagiarism is noted.	Serious evidence of plagiarism is noted, with 40% or more of the text being stolen content.
Organisation of Source Content	The text is organised logically with all source content appearing in appropriate places.	Source content within the text appears in appropriate places, but minor errors are evident in the text's logic.	There is some evidence of organisation and logic, but source content appears in a topic sentence or concluding sentence.	Source content appears in inappropriate places more than once. The resulting text has weak logic due to several organisational errors.	Source content is dropped into the text in many inappropriate areas. There is no evidence of the level of organisation required.

Appendix B: Feedback Comment Library

Assessment Criteria & Feedback Comment Names	Corresponding Feedback Comment
Chosen Sources & Their Quality	
Excellent Sources	You chose excellent sources to use in this text. Keep following the formula's guidance when seeking relevant sources for future writing tasks.
Source Appropriateness	A source you've used isn't quite appropriate for this writing task. You would benefit from spending more time on Phases A and B of the formula to ensure you find more relevant sources in the future.
Not Enough Sources	You didn't use enough sources in this text. It is important to include viewpoints from multiple experts to ensure your position is well supported. In the future, dedicate more time to Phase C of the formula so you'll collect enough sources.
Faulty Source Choice	Ensure that your sources are more relevant and appropriate, too. More effort must be applied to satisfy research requirements and address all aspects of the task instructions.
Lacking Quality Sources	Your text did not meet the research requirements. Please follow the critical reading formula more closely for the next writing task to ensure you meet the expectations of university study.
Conventions of Using Source Content	
Skilled Paraphrasing	You're very skilled at paraphrasing! Source content is seamlessly integrated while keeping details accurate. Continue to dedicate considerable time to Phase D for future writing tasks because engineers tend to favour paraphrasing over quoting.
Deeper Analysis Needed	Your sources lend strong support to your position, but your analysis could have been deeper. Remember that source content is used to support your own voice, not speak for you. Spending a bit more time on Phase D of the formula will help you. Engineers tend to favour paraphrasing over quoting.
Quote Less	Try to include fewer quotations in future writing tasks. If the source content is key to your position, paraphrase it instead. Engineers tend to favour paraphrasing over quoting.
Problematic Integration	The way you've integrated source content in this text needs revision. There are some issues with your paraphrasing skills, so you need to practice this more as part of Phase D of the formula.
Weak Paraphrasing	Your paraphrasing skills are weak, leading to many errors in the integration of source content. Spend more time on Phase D of the formula and consider seeking help with this skill before attempting future writing tasks.
Too Many Quotations	You're relying on quotations too much in this text. In the future, most source content should be paraphrased instead since this is favoured in the engineering field.
Lacking Analysis	Experts' viewpoints seem to dominate this text, leaving little space for your own analysis. More space must be dedicated to your own analysis in the future to ensure you establish a strong voice as a writer.
Integration Not Achieved	It seems you've spent little effort on Phase D of the formula because source content is not well connected to your ideas. Where is your own analysis? What is your position in this text? You should book a CeTTL consultation to get help with academic writing skills because you haven't met university expectations here.
In-text Citations and Reference List	
Excellent Referencing	You've done an excellent job of citing sources, and you've followed conventions correctly in your reference list. Everything aligns and appears accurate. Keep following the tips from Phase D and other guidance on referencing sources when composing future texts.
Strong Referencing	This is a strong attempt at following referencing conventions, but there are minor errors in your citations and/or reference list. Review the tips from Phase D and pay closer attention to every detail when using this referencing system in the future.
Missing Source & Errors	You forgot to identify a source in the body/reference list. There are some other referencing errors throughout the text, too. You need to review Phase D of the formula and the conventions of this referencing system. Seek help by booking a CeTTL consultation and/or using online resources as a guide.
Faulty Referencing	Most of your text doesn't follow referencing conventions. In academia, this is a serious error that could result in consequences if repeated. Please review Phase D and the rules of this referencing system and seek help from a CeTTL expert.
Referencing Not Attempted	You've made no attempt to cite your sources in this text. Where is your reference list? You must acknowledge the work and ideas of others in everything you do. Please book a CeTTL consultation to learn how to fulfil this responsibility. Otherwise, future academic violations like this will be met with consequences.
Evidence of Plagiarism	
No Plagiarism	There is no evidence of plagiarism in this text. Great job on following academic conventions! Continue using the formula to avoid plagiarising in future work.
Improve P/Q Technique	You need to improve your paraphrasing/quoting technique slightly to avoid possible issues with plagiarism in the future. Reviewing Phase D of the formula could help in this regard.
Minor Plagiarism	You plagiarised some content in this submission, but the offence is minor. It's recommended that you review Phase D of the formula and seek guidance from online resources to learn more about your ethical responsibilities as part of academic learning.
Sig. Plagiarism = Warning	You've plagiarised a significant portion of this text instead of demonstrating your own writing ability. This is a warning; future offences could involve additional consequences. Please book a CeTTL consultation to learn more about the types of plagiarism and how to avoid it.
40%+ Plagiarism	At least 40% of this text was plagiarised, meaning you've stolen a significant amount of content instead of demonstrating your own writing ability. The paper's convenor has been notified of this offence. You should book a CeTTL consultation to learn more about the types of plagiarism and your ethical responsibilities as a student.
Organisation of Source Content	
Excellent Organisation	You've done an excellent job of organizing this text in a logical way, using sources appropriately to express your position.
Improve Logic	Your text uses source content in appropriate places, but its logic could be improved. You could consider glancing at CeTTL resources on academic writing before your next assignment.
Improve Org. & Logic	The organisation and logic of your text could use improvement, especially where sources are concerned. Please avoid using source content in a topic/concluding sentence. It may help to review model texts shared in class and/or refer to CeTTL resources on academic writing.
Support Ideas + Fix Logic	In the future, be sure to refer to brainstorming notes while working on Phase D to ensure source content helps you answer questions and support your own ideas. Also, ensure each paragraph follows a linear logical progression with every sentence there to support your position.
Faulty Organisation	You've used source content in a few inappropriate places here. This has negatively affected the text's organisation, making the logic of your position hard to follow.
Organisation Not Achieved	Your text needs significant revision to improve its organisation and repair its flawed logic. A big part of the problem here is that you're inserting source content in many inappropriate places. You should book a CeTTL consultation to learn how to structure an academic text using secondary research.