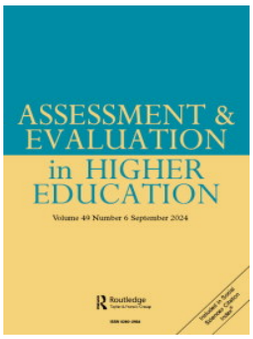

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# Operationalising critical thinking in postgraduate disciplinary writing: insights from corpus and cluster analyses of lecturer feedback

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**ABSTRACT**

Research has revealed that critical thinking (CT) can predict undergraduate academic performance well. It is essential for nurturing students' unique voice and creativity, especially in the era of Large Language Models (LLMs). LLMs can generate linguistically complex texts, potentially overshadowing students' authorial voices—particularly those still developing language skills and domain-specific knowledge. Despite this, research on CT within subject education contexts remains scarce, leaving disciplinary lecturers' expectations of CT in disciplinary writing largely unexplored. Our study analysed a 160,527-word corpus of lecturer feedback on 230 assignments from three education-related postgraduate programs to reveal their shared expectations of CT in disciplinary writing. We identified nine CT constructs, each illustrated with relevant feedback examples. Their intricate interrelationships were revealed through hierarchical cluster analyses. Drawing inspiration from Bloom's Taxonomy, we established a CT taxonomy to guide effective and consistent assessment of CT. Further studies and practical applications of the CT taxonomy within local educational contexts are needed to develop students' CT skills and empower them to retain their voice and creativity in an AI-empowered era.

**KEYWORDS**

Critical thinking; disciplinary writing; lecturer feedback; corpus analysis; Bloom's Taxonomy

## Introduction

The imperative of establishing effective pedagogy and assessment to enhance students' critical thinking (CT) has been consistently articulated by academics across educational settings (Fan and See 2022). CT becomes even more pronounced in light of Large Language Models (LLMs). LLMs can craft linguistically sophisticated texts, potentially overshadowing the authorial voice of language learners who are still developing their language and domain-specific knowledge. Neglecting to nurture their CT puts students at risk of losing their unique voice and writer agency.

The lack of systematic understanding and research on CT (Tanaka and Gilliland 2017) has resulted in inaccessible and uninspiring instruction and compromised the development of university students' CT skills (Chen 2017; Yang and Gamble 2013). To bridge this gap, the current study

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conducted a systematic qualitative corpus and quantitative cluster analysis of subject lecturers' feedback on CT to provide evidence-based recommendations for integrating critical thinking (CT) into assessment and instruction.

## *Defining critical thinking: its process and product*

The cognitive psychological approach to CT has highlighted its importance for developing thought, well-informed by criteria, purposes, reflection, and real-world application (Lai 2011). An expert panel from the United States identified six core cognitive skills of CT such as analysis and evaluation and emphasised considering domain-specific knowledge and methodologies in assessing CT (Facione 1990). Paul and Elder (2014b) propose three interwoven phases of CT: analysing, evaluating, and improving thinking. The Foundation of CT restates Scriven and Paul (2023) statement and conceptualises it as 'the intellectually disciplined process of actively and skilfully conceptualising, applying, analysing, synthesising, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action'.

Lipman (1988) adopted a product-process approach to explaining CT. He distinguished ordinary thinking from CT by viewing the product of CT as a self-correcting and context-sensitive judgment based on specific criteria, involving diverse cognitive skills (e.g. evaluating, hypothesising and offering opinions with reasons). Brookfield (2012) perceives CT as seeking and assessing the accuracy and validity of assumptions and seeing things from multiple perspectives before taking informed action based on evidence and conforming with rules. He cautions against treating CT as a personal trait which could lead to the misassumption that CT does not need to be taught or is impossible to be fostered.

The different approaches commonly reveal the complexity of cognitive processes underlying CT. This resonates with Bloom's Taxonomy, consisting of six categories with increasing cognitive complexity (Bloom 1956):

- Knowledge: recall specifics and universals, methods and processes, or a pattern, structure, or setting
- Comprehension: understand knowledge without necessarily relating it to other material or seeing its fullest implication
- Application: use abstractions in particular and concrete situations
- Analysis: break a communication into its constituent elements or parts such that the relative hierarchy of ideas is made clear and/or the relations between ideas expressed are made explicit.
- Synthesis: put together of elements and parts to form a whole
- Evaluation: judge the value of material and methods for given purposes.

The taxonomy was revised in 2001 to present an action-oriented framework, comprising *remember*, *understand*, *apply*, *analyse*, *evaluate*, and *create* (Anderson, Krathwohl, and Bloom 2001). It emphasises the critical role of *synthesis* in generating new products beyond the original resources put together by writers (Conklin 2005) by renaming *synthesis* as *create* (Krathwohl 2002).

The complexity of CT is exacerbated by its embedded contexts and cultural norms (e.g. Ennis 2015; Elder and Paul 2020; Zhan 2021). Therefore, CT needs to be understood and operationalized differently across disciplines which are constrained by domain-specific standards, procedures, and legitimate knowledge within each field (Brookfield 2012). In our study, we examined and operationalised CT in assessment within education-related disciplines.

### Research on critical thinking and writing

The research on CT and writing has unveiled the interdependent and interconnected nature of CT skills in professional writing (Yuan and Liao 2023). Underdeveloped CT skills impede the production of high-quality output by impairing argumentation quality. Yang and Gamble (2013) ascertain that English as a Foreign Language (EFL) learners who engage in CT-enhanced activities show significantly greater improvement in writing than those with non-CT-enhanced activities. CT skills depend on students' familiarity with the subject 'grammar' (Brookfield 2012, 140) as writing critically involves understanding alternative perspectives and evaluating the relative merits of scholarly text.

Varied factors affect the development of CT. Yuan and Liao (2023) systematic review identifies factors related to students, teachers, and contexts that impact CT. This imposes challenges of generalising participants' perceptional data from one instructional context to another. Brookfield (2012) argues the power of language in demonstrating CT, aligning with Vygotsky's work on language for thought within a social and cultural context (Vygotskiĭ and Kozulin 1986). By evaluating the language students use in disciplinary writing, lecturer feedback effectively reveals their expectations of CT. To better understand CT constructs within a specific context, analysing lecturer feedback on writing products is more reliable than relying solely on perception data.

### Knowledge gaps in research on CT and the current study

Existing research has predominantly used small-scale, qualitatively oriented, and interpretive research design, as revealed by Yuan and Liao (2023) systematic review of relevant studies between 2010 and 2020. Interviews are the commonly employed methods to reveal academics' expectations of written proficiency (e.g. Errey 2000). Quantitative studies on CT are based on students' scores of CT assessment with tapping into disciplinary specific CT skills (Macpherson and Owen 2010; Roohr et al. 2019). The lack of empirical studies on how CT is manifested in writing products resulted in discrepancies between the CT skills students need to develop and those provided in CT training. For instance, few studies on local interpretations of CT by students in China lead to the (perceived) gaps in Chinese students' criticality (Jiang, Sun, and Lin 2024; Fan and See 2022).

CT is often narrowly associated with argumentation due to the prevailing application of analytical philosophy and logic in truths (Brookfield 2012). For instance, Andrews (1995) regards CT as an argument with connected concepts to react to other stances in written work. Nevertheless, as posited by Fisher and Scriven (1997) and Blair (2019), CT extends beyond argumentation. CT is essential for interpreting and evaluating observations, communications, experience, and information.

Research on CT also suffers from a narrow research context. For instance, most relevant studies on writing have been carried out within EFL language classroom contexts. Few studies were conducted in EAP (English for Academic Purposes) contexts, despite the salient differences between disciplinary writing and writing in general language classes (Hyland 2013). This has brought about issues of assessing context-reduced CT skills, ignorant of the immediate setting of disciplinary writing that shapes CT and is governed by target community discourse and conventions (Hyland 2022).

### The current study

This study bridges existing gaps by offering a contextually relevant understanding of critical thinking (CT) and its application within a specific discipline. We systematically analyzed a 160,527-word corpus of feedback on postgraduate writing from 41 disciplinary lecturers in education. The corpus

approach has provided insights into educational lecturers' common expectations of CT and how it should be demonstrated in disciplinary writing. Therefore, it addressed the limitations of case studies which often depend on a few lecturers' perceptions, thus restricting the applicability of results to other contexts. It also addresses the limitations of perceptional data which may not fully misalign with assessment behaviours. Together with cluster analyses of the qualitative results from corpus analyses to disclose the interconnected relationships between different CT skills, it produced stronger evidence than perception-based results to reveal how to operationalise CT in learning, teaching, and assessment. Additionally, the analysis extended CT beyond argumentation essays, as feedback was provided on essays, portfolio assessments, poster presentations, research reports, and reflective logs. This enables findings to be applicable across genres.

Two research questions were answered in this study:

RQ1. What are the constructs and corresponding subconstructs of critical thinking revealed from subject lecturers' feedback?

RQ2. How are the different constructs related to each other?

The results offered an evidence base for learners and their learning partners (e.g. EAP tutors and learning advisors) to understand education lecturers' shared expectations of CT skills in disciplinary writing and facilitate their collaborative endeavours to improve students' CT competencies. This will address the current partial or misconceived understanding of CT among practitioners and the lack of pedagogical guidance to integrate CT into their teaching and assessment (Yuan and Liao 2023).

## *Methodology: constructing and analysing lecturer feedback corpus*

We created a teacher feedback corpus of approximately 161,000 words (Table 1).

To the best of our knowledge, it is the largest existing subject-specific corpus of lecturer feedback on postgraduate disciplinary writing. Feedback in the corpus was provided by forty-one module lecturers with varied academic experience (i.e. four professors, nine associated professors, twenty lecturers, and seven teaching fellows). We use 'lecturers' for all the academics involved in this study hereafter. Feedback constituted in-text comments on specific parts of writing and general comments on each assignment.

It was provided on 230 assignments, submitted by 116 international postgraduates who speak English as a second/foreign language. 90.5% of them were Chinese and the others were Vietnamese, Indonesian, Japanese, Persian, Malayalam, Spanish, Hindi, or Arabic. This is representative of student cultural backgrounds in education-related postgraduate programmes in the UK.

The assignments from 29 education-related modules typically ranged from 3,000 to 6,000 words, addressing different assessment tasks that education postgraduates are required to complete (i.e. thirteen essays, four portfolios and two posters, two reports, and two reflection logs). The distribution of scripts across score bands in Table 1 is representative of score distributions in UK higher education, with more scripts falling into the pass and merit category and fewer in the distinction and fail bands.

**Table 1.** Number of words across bands in the teacher feedback corpus.

| Student cohort | Fail (below 50s) | Pass (50s) | Merit (60s) | Distinction (70s) | High Distinction (80s) | Total |
|---|---|---|---|---|---|---|
| 2018–2019 | 0 | 0 | 751 | 1,169 | 0 | 1,920 |
| 2019–2020 | 0 | 0 | 1,920 | 2,571 | 0 | 4,491 |
| 2020–2021 | 2,297 | 20,574 | 36,269 | 28,541 | 787 | 30,182 |
| 2021–2022 | 3,879 | 28,205 | 25,681 | 10,407 | 0 | 68,172 |
| Total | 6,176 | 46,255 | 64,621 | 42,688 | 787 | **160,527** |

### *Qualitative analysis of the teacher feedback corpus*

Concordance analyses were conducted to offer insights into CT constructs commented on by education lecturers. A concordance is a list of all occurrences of a search word in the corpus displayed together with the words in its immediate context (Sinclair 1991) (see Figure 1).

The following six steps were followed to identify the constructs of CT (RQ1):

**Step 1. Identifying feedback terms used by lecturers to comment on CT**: The first and the third authors manually reviewed each teacher feedback file and identified specific terms used by lecturers to comment on CT.

**Step 2. Developed the key search word list for concordance analysis**: We created wildcards for each feedback term from Step 1 to cover base forms, inflected forms, and derived forms. For instance, we used the wildcard *analy** to cover the terms analyse (analysed/analysing), analyze (analyzed/analyzing), analytical, and analysis/analyses. A list embodying all terms was created (see examples in Appendix 1).

**Step 3. Revealing constructs of CT**: The first author used the search word list to generate corresponding concordance lines in the 'KWIC (key word in context)' feature and perform collocation analyses in the concordancing software AntConc 4.2.0 (Anthony 2023). We identified thematic patterns related to each feedback term and grouped the terms with similar focuses on CT skills to one construct. This resulted in nine constructs and related subconstructs, apart from generic comments on CT using terms criti* (i.e. criticise, criticize, critical, critically, criticality, criticism, critique).

**Step 4. Distinguish the nature of feedback:** The first author copied concordances from *AntConc* and pasted them to Microsoft Excel. She read through each concordance line and classified them into positive, negative, mixed, overlapping, or irrelevant feedback (see Appendix 1).

a. Positive feedback: Feedback commented on the strength of writing
b. Negative feedback: Feedback commented on the weakness of writing
c. Mixed feedback: Feedback that includes positive and negative comments on the same aspect within one concordance line

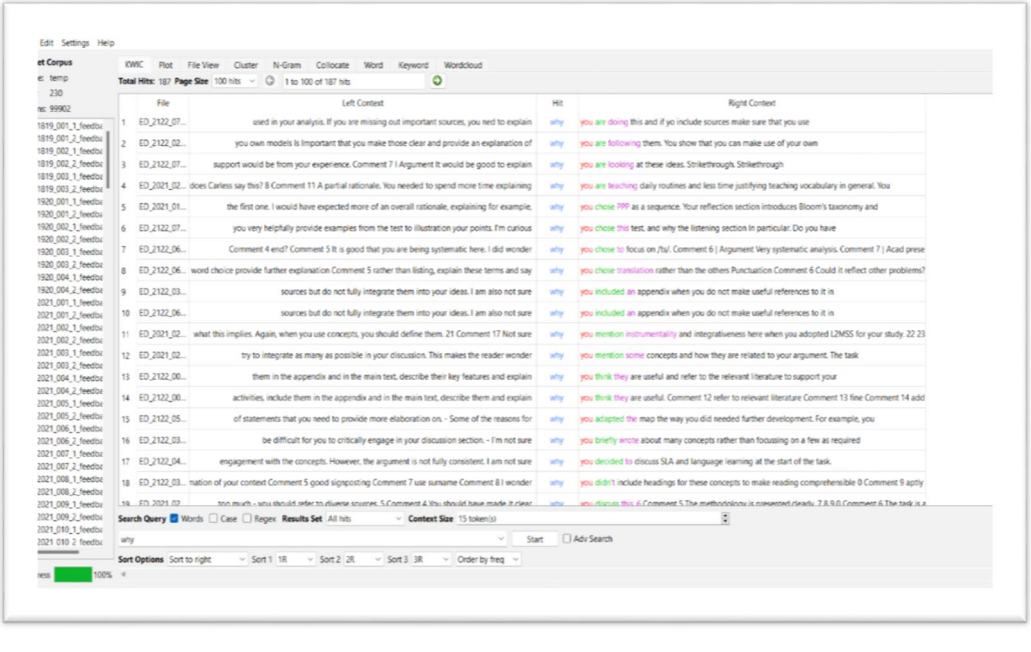


**Figure 1.** Examples of concordance with the key search word: **why**.

d. Overlapping feedback: Feedback which has been included in a construct on account of another term in the concordance line. For instance, why is a key search word for the construct: explaining. Using it as a key search word, AntConc generated a concordance line: 'If you are missing out important sources, you need to explain why you are doing this…'. This concordance has been added to the construct: explaining due to its inclusion of the key search word 'explain'. It was regarded as an overlapping feedback concordance and crossed out on the search word list to prevent artificial inflation of the hits of similar focuses.
e. Irrelevant feedback: Feedback in the concordance line with a key search word was not about CT. For instance, analy* is a search word for the construct: Analysing. The search for analy* in AntConcs returned hits such as 'Error analysis is no longer a popular framework' and 'The data analysis is presented very well'. However, neither concordance was about *analysing*. Both were highlighted in red as irrelevant feedback.

The third author independently analysed 10% of concordance lines from each construct. A full agreement was reached, attributed to the regular project meetings on the coding scheme. We counted and recorded the total number of positive, negative, and mixed feedback concordances related to each search term regarding each construct of CT on each assignment in nine Excel worksheets, representing the nine constructs.

### *Quantitative analysis of lecturer feedback*

We imported the data from Excel to SPSS version 28.0.1.1 for quantitative analysis to reveal interconnections between the nine CT skills (RQ2). Hierarchical cluster analyses were performed to identify which skills exhibit stronger associations with one another. We referred to the height of the Y-Axis of the Dendrogram to interpret the closeness (i.e. objects that are joined at lower heights are more similar to each other) (Moisl 2015). The effectiveness of using cluster analyses to assist corpus analysis in identifying patterns and the closeness among facets has been extensively discussed in Moisl (2015), in particular, in terms of its role in bolstering objectivity.

We adhered to the fundamental tenet of constructivism, which posits that new knowledge is constructed upon learners' existing knowledge (Phillips 1995; Bruner and Gil 1972). Therefore, we performed cluster analyses exclusively on positive lecturer feedback regarding the CT skills exhibited in student writing. We aimed to ascertain whether a student proficient in one skill also demonstrated proficiency in another, thereby revealing the interdependence of these constructs.

Moisl (2015) suggests minimising the constraint of cluster analyses and subjectivity of interpreting cluster analysis results by comparing the results between the Single Linkage method and the other methods. After comparing the results across methods, we selected the average linkage methods considering they generated more distinctive clusters of CT skills, thus serving pedagogical design better in terms of the feasible number of CT skills within a cluster which can be covered within class time and across clusters within a programme.

## Results

Due to space constraints, we only included the concordance lines essential to understanding a specific construct and reported other relevant feedback examples in Appendix 1.

### *Constructs and sub-constructs of critical thinking (RQ1)*

The concordance analyses revealed, apart from generic feedback on CT ($N = 233$, SD =1.23), that education lecturers most frequently commented on two specific constructs: *explaining* ($N = 1{,}424$, SD =2.72) and *evidencing* ($N = 1{,}019$, SD =4.01) (Figure 1). *Analysing* ($N = 496$, SD = 2.75) and

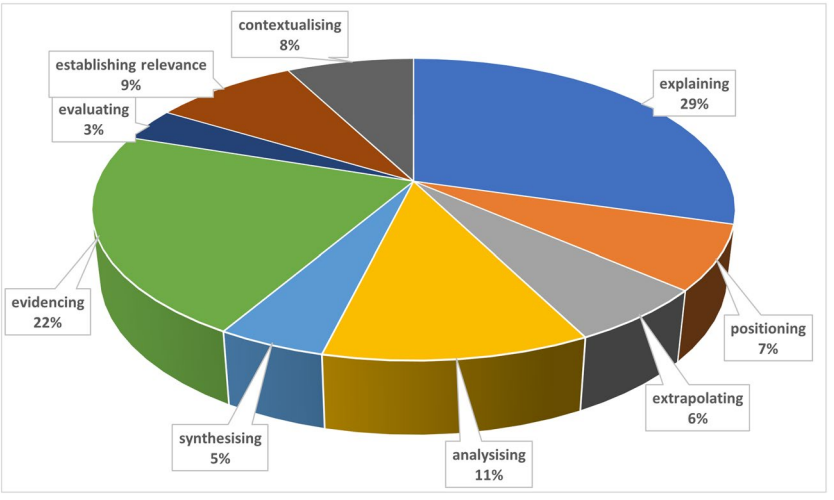


**Figure 2.** Distribution of feedback across constructs.

*establishing relevance* ($N = 408$, SD = 2.05) were also commonly addressed. The small Standard Deviation (SD) indicated a relatively even distribution of feedback across the 230 written assignments, suggesting their representativeness in student writing. Comments on other CT constructs occurred less frequently: *contextualising* ($N = 361$), *positioning* ($N = 324$), *evaluating* ($N = 253$), and *extrapolating* ($N = 192$) (Figure 2).

When the nature of feedback was examined, more negative than positive feedback was provided on all constructs except *positioning*. This indicates the necessity of developing other constructs in disciplinary writing. Occasionally, lecturers offered mixed feedback to acknowledge their strengths before pinpointing undeveloped CT skills.

## *Relationships among constructs of critical thinking (RQ2)*

Using the division line which created the largest number of clusters, seven clusters in the order of distance revealed in Figure 3:

- Cluster 1: extrapolating and synthesising
- Cluster 2: extrapolating, synthesising, and establishing relevance
- Cluster 3: evaluating
- Cluster 4: contextualising
- Cluster 5: explaining and positioning
- Cluster 6: analysing
- Cluster 7: evidencing.

The results showed a close relationship between *extrapolation* and *synthesising* and their relationships with *establishing relevance* and between *explaining* and *positioning*. Below, their definitions were explained with relevant examples.

## *Cluster 1: extrapolating and synthesising*

Cluster 1 suggests a close relationship between *extrapolating* and *synthesising,* supplemented by results from concordance analyses of both constructs.

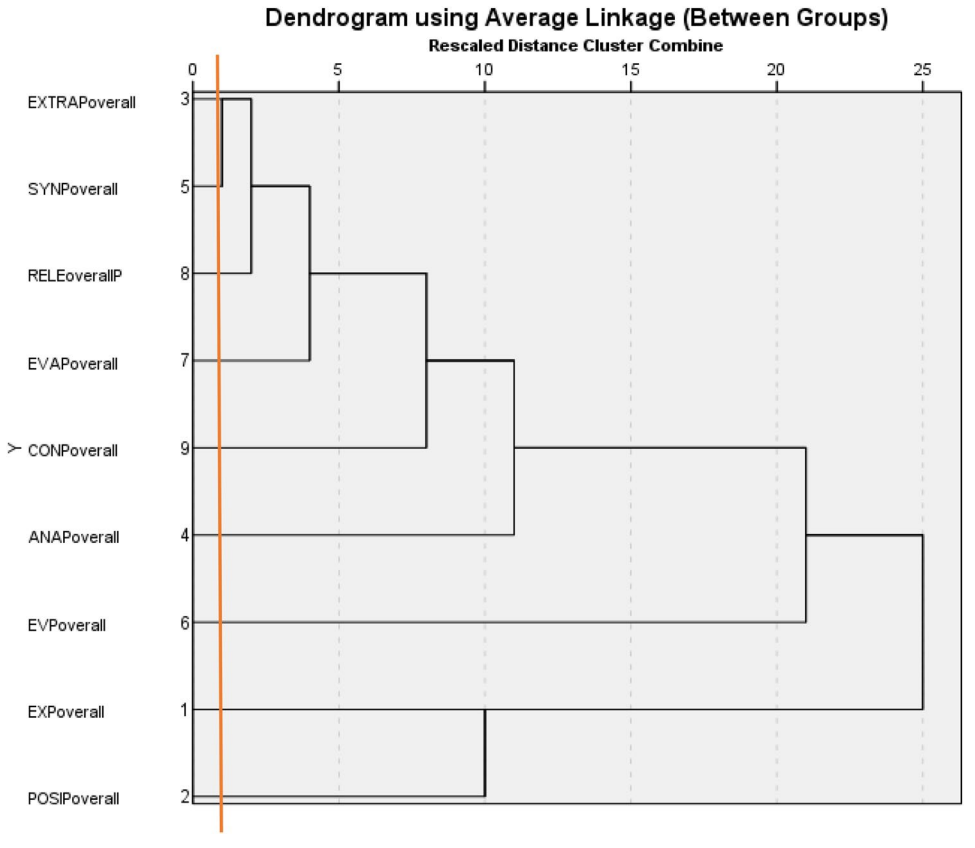


**Figure 3.** Dendrogram using average linkage.

## *Extrapolating*

Disciplinary lecturers expected postgraduates to extrapolate information in a few ways. They encouraged them to consider the implication of knowledge across domains or in practical contexts by applying:

- knowledge gained from reading to analyse real cases
- analysis to inform practice, and
- data to explain findings.

Students were encouraged to ask 'so what' questions to extrapolate implications:

> There is some good analysis but the implications part (the discussion) can be developed more. For example, In the motivation task, you fit the theory to the data well but there needs to be more 'discussion' of what it all means – the 'so what?' question.

> Include more implications in the main body of the discussion – so what? What does this mean? Avoid just applying the theory as this is insufficient for the master's level.

Collocation analyses revealed that *extrapolating* also involves applying concepts, frameworks, and theories to analyse data and inform practice. However, when extrapolating knowledge to practice, students were suggested to consider reality constraints and avoid over-generalisation. Additionally, they were reminded to elude overinterpretation and instead, approach information

thoughtfully and refrain from making assumptions without due care. In summary, *extrapolating* is operationalised *via*:

- eliciting implications from reading to analysis, analysis to practice, and data to findings within contexts and reality constraints
- applying concepts, frameworks and theories to analyse data and inform practice
- integrating and expanding knowledge into another context
- avoiding over-generalisation
- avoiding over-interpretation without critically questioning assumptions and feasibility.

### *Synthesising*

Lecturers required postgraduates to synthesise different lines of literature, argument and analysis, and viewpoints. Lecturers highlighted *synthesising* to avoid overly descriptive literature reviews, analysis, discussion, and conclusions as that hinders the development of argument: e.g. 'There is some critical engagement with ideas and sources, but most of your work is descriptive and it is difficult to see an argument in your writing'. Feedback on *synthesising* was provided most frequently regarding reviewing relevant literature.

Lecturers suggested integrating and interweaving different sources, perspectives, and different parts of writing to realise *synthesising*. Unlike *extrapolating* which involves applying knowledge to practical situations or across domains, *synthesising* requires students *to* integrate strands of knowledge and argument.

In summary, *synthesising*, as shown in Appendix 1, demands skillfully discovering the relationships between diverse sources to identify their commonalities, moving beyond description, and coherently interweaving them to supplement each other. This process facilitates the development of knowledge, argument, and practice within specific theoretical and practical contexts. It is operationalised in disciplinary writing as

- synthesising different lines of literature on a topic
- synthesising argument, positionality, analysis, and literature
- avoiding being too descriptive without depth, and
- integrating different resources, perspectives, and parts of writing.

The illustration of *extrapolating* and *synthesising* based on feedback concordances revealed that both skills require students to process information from varied resources or across domains. This explains their likeness revealed in cluster analysis.

### *Cluster 2: extrapolating, synthesising, and establishing relevance*

Cluster 2 revealed *establishing relevance* as a shared cognitive skill required for *extrapolating* and *synthesising*. Among the various skills related to *establishing relevance*, the most frequently reiterated one was creating links, accounting for 31.9% of the total number of concordance lines.

From collocation analysis and concordance reading, links need to be established between:

- literature and real cases
- literature and (research) topics
- literature and analysis
- literature and solutions

- literature and positionality
- positionality and personal experience
- positionality and context
- reflection and personal experience
- solutions and context
- implication and context
- different methods
- different tasks

Establishing relevance stresses the significance of using literature selectively in writing, as highlighted by feedback with search terms *relevan**, *connect**, and *relat**. Selection needs to establish the relevance between

- literature and argument
- literature and topic
- literature and analysis
- literature and context
- argument and writing tasks
- context and writing tasks, and
- analysis and topics

*Establishing relevance* demands students to *connect** between

- different lines of argument
- different lines of literature
- literature and analysis
- argument and writing tasks
- implication and context
- literature and practice, and
- different parts of writing.

Students were also required to relate writing to topics, contexts, tasks, analysis, and context and stay focused on relevant literature, the topics under discussion, task requirements, and designated contexts.

To sum up, lecturers expected postgraduates to *establish relevance* by connecting their work with others' and their contexts and linking different facets of their work (e.g. different parts of analysis and between analysis and solutions). It is operationalised in writing *via*:

- creating links with relevant literature, personal experience, and context
- highlighting relevance and connection
- establishing relevance to related topics, contexts, and tasks, and
- keeping focused on relevant issues.

These sub-constructs reveal that *establishing relevance* ensures the validity of extrapolating and synthesising information.

### *Cluster 3: evaluating*

Disciplinary lecturers expected postgraduates to evaluate the information provided in writing ($N = 253$, SD = 1.45). Collocation analyses and reading the concordances of *discuss** revealed the evaluation targets including findings, analysis, theories, concepts, examples, and contexts. 76 out of the 98 concordance lines of *discuss** were negative feedback, suggesting students' insufficient

engagement with discussing information from varied perspectives. *Evaluating* requires reflection on:

- knowledge to improve practice
- existing literature to develop knowledge
- practice to improve knowledge
- practice in one context to improve practice in another or future context
- feedback to improve practice.

Another essential skill in *evaluating* is to measure a target with a tool/scale or statistical methods, applying multiple measurements. It is paramount to 'Try to be more precise and explicit about the measurements you were using'.

As revealed in Appendix 1, *evaluating* is operationalised *via*:

- critiquing findings, analyses, theories, concepts, and examples
- evaluating the sources that were used in the writing
- reflecting knowledge to improve practice, practice to improve knowledge, existing knowledge to develop knowledge, practice in one context to another or future contexts
- measuring with one or more qualitative and quantitative tools/scales, and
- weighing information.

### *Cluster 4: contextualising*

87.2% of concordances related to *contextualising* were provided by *context**, supplemented by other concordances regarding providing overview, background, and framework. Lecturers highlighted the importance of *contextualising* through

- setting the scene for discussion
- identifying problems within a context
- strengthening analysis by referring to relevant contexts
- presenting implications within specific contexts
- locating discussions within theoretical contexts
- locating discussion about practice within its context, and
- performing reflections within a context.

Additionally, *contextualising* requires students to set out rationale, topics, and issues.

To sum up, *contextualising* is operationalised through

- providing theoretical and practice contexts for discussion, problematising, analysis, implications and reflection
- offering overviews of relevant literature and contexts, and
- establishing the rationale and aims.

### *Cluster 5: explaining and positioning*

Cluster 5 suggested a close relationship between *explaining* and *positioning*.

#### *Explaining*

Lecturers used 27 feedback terms to comment on *explaining*, revealing diverse approaches to manifesting it in disciplinary writing. The relevant concordances indicated that effective

explanation involves not only explaining and illustrating meanings but also discussing points of view, literature, sources, claims, and accounts through:

- defining concepts or terms
- provide the rationale and reasons
- identifying knowledge gaps
- specifying details and expanding assertions to avoid listing and reporting without elaboration
- comparing different perspectives, contexts and tasks, and
- summarising resources and own work.

### *Positioning*

Disciplinary lecturers encouraged students to express their authorial voice about issues under discussion. Most of the relevant feedback was provided using the term: *point*. Most feedback instances were positive *(N = 127, SD = 2.03)*, praising writers' criticality, with a few examples of negative ($N = 6$, SD = 0.16) and mixed feedback ($N = 5$, SD = 0.15).

Authorial positionality needs to be justified, revealed by feedback with *justif** and *why*. A similar number of positive and negative feedback was provided on *justif** ($N = 39$: 19 positive and 20 negative feedback); yet, all feedback with *why* was negative feedback, suggesting its absence yet the necessity of operationalising positionality in writing. Positionality also requires students to present their suggestions and develop their positionality through *hypothesi**, *predict**, *challenge*, and *problematise* issues under discussion.

As revealed in Appendix 1, *positioning* is operationalised in writing *via*

- articulating their own views, authorial voices and stances
- justifying own point of views
- presenting authorial suggestions
- making hypotheses
- challenging assumptions
- making predictions
- problematising current issues.

Analysing the subconstructs of *explaining* and *positioning* revealed that students need to explain the sources in diverse ways before developing their unique perspectives.

## *Cluster 6: analysing*

Collocation analysis revealed the targets that need to be analysed entail tasks, lessons, data, and language in materials. It also uncovered that *analysing* should be detailed and supported, as revealed by positive feedback: e.g. 'The analysis is quite detailed and supported with both the data and the literature'. *Analysing* requires writers to illustrate literature, examples, add-ons (e.g. diagrams), justification (why), and approaches (how). It also requires interpreting phenomena, analysis, and findings with references and research questions with boundaries to avoid over-interpreting.

As revealed in Appendix 1, *analysing* is operationalised in writing as:

- analysing tasks, lessons, data and language in materials
- exploring literature, examples, add-ons, justification, and approaches that were presented, and
- interpreting phenomena, analysis and findings by referring to resources and related questions.

### *Cluster 7: evidencing*

Lecturers used a variety of terms to provide feedback on *evidencing*, suggesting the multifaceted nature of this CT skill. They suggested drawing upon multiple resources to evidence, inform, support, and illustrate their writing, as revealed from the collocation analysis of *draw**.

Unsurprisingly, existing literature emerged as the most crucial form of evidence, constituting 41.8% of the concordances related to *reference** and *literature*. Concordances containing *source** accounted for another additional 18% of the relevant concordances. An additional 7% pertained to theories, quotations and frameworks from studies. The results emphasised the critical role of reading in producing disciplinary writing.

Other types of evidence suggested by disciplinary lecturers embody feedback to support reflection, research data to support analysis and interpretation, examples from relevant cases, and materials to address problems and support discussions. Lecturers also recommended appendixes and personal viewpoints/experience as other types of evidence.

The statistical and corpus analyses and Appendix 1 revealed that students need to substantiate their writing from multiple perspectives drawing upon diverse types of sources, including reading, quantitative and qualitative data, the materials that were analysed, personal viewpoints, and experience. Although students do not need to use all types of resources to evidence their writing in one assignment, they are expected to use these sources in coping with different assessment tasks to operationalise *evidencing* through

- substantiating arguments with readings
- supporting reflection and interpretation with data
- exemplifying problems and analysis
- supporting writing with effective use of appendixes and personal viewpoints, and
- avoiding claiming without evidencing validity.

The seven clusters have generated a comprehensive picture of how different CT constructs relate to one another and provided evidence-based implications for instructions about CT. It is essential to know that the positions of the constructs in the Dendrogram (Figure 3) hold little inherent meaning and cannot be used to sequence the CT skills in curriculum design. When applying them to design assessment and instruction, existing cognitive development models, student characteristics, assessment purposes, and other practical constraints (e.g. teaching objectives and programme duration) should be considered.

## *Theoretical and pedagogical implications for operationalising critical thinking*

Bloom's (1956) taxonomy is the most widely used model to guide curriculum design and develop cognitive skills in educational settings. We use it and its revised taxonomy (Anderson, Krathwohl, and Bloom 2001; Krathwohl 2002) as a theoretical framework to apply the different CT skills for assessment and instruction.

### *Comparing Bloom's taxonomy and the CT constructs in this study*

Table 2 compares Bloom's Taxonomy and the constructs of CT identified in this study. To differentiate between the two studies, we used gerunds to describe each construct and bare verb forms to depict subconstructs. This is also to reinforce that CT skills are not innate but rather require deliberate development through thoughtfully designed instructions and assessment.

Our feedback corpus included two subcategories that align with Bloom's *Level 1: Understand*, namely, *evidencing* and *explaining*. Rather than categorising *extrapolating* as a subskill of *understand*, our analysis suggests that it aligns better with Bloom's Level 2: *Apply*. This can be

**Table 2.** Comparison between the revised taxonomy and subconstructs of CT skills.

| Bloom's taxonomy (Krathwohl 2002; Bloom 1956) | Corresponding CT constructs and subconstructs in this study | |
|---|---|---|
| 1. Understand<br>• Interpreting<br>• Exemplifying<br>• Classifying<br>• Summarising<br>• Inferring<br>• Comparing<br>• Explaining<br>• Extrapolating | Evidencing | • Substantiate arguments with readings.<br>• Support reflection and interpretation with data.<br>• Exemplify problems and analysis.<br>• Evidence writing with effective use of appendixes and personal viewpoints.<br>• Avoid claiming without evidencing validity. |
| | Explaining | • Define concepts and terms.<br>• Provide the rationale and reasons.<br>• Identify knowledge gaps.<br>• Specifying details and expanding assertions to avoid listing and reporting without elaboration.<br>• Compare and contrast different perspectives, contexts and tasks.<br>• Summarise resources and own work. |
| | Contextualising (new construct) | • Provide contexts to<br>  • set the scene<br>  • identify problems<br>  • strengthen analysis<br>  • present implications<br>  • locate the discussion within a specific theoretical and practical context<br>  • perform reflection<br>• Provide overviews of relevant literature and contexts.<br>• Set out the rationale and aims. |
| | Establishing relevance (new construct) | • Create links with literature, personal experience, and context.<br>• Highlight relevance.<br>• Highlight connection.<br>• Establish relevance to related topics, contexts, and tasks.<br>• Keep focused on relevant issues. |
| 2. Apply<br>• Executing<br>• Implementinga procedure in a given situation | Extrapolating | • Apply reading to analysis, analysis to practice, and data to findings within contexts and reality constraints.<br>• Apply concepts, frameworks and theories to analyse data and practice.<br>• Integrate and expand knowledge to another context.<br>• Avoid over-interpretation without critically questioning assumptions and feasibility. |
| 3. Analyse<br>• Differentiating<br>• Organising<br>• Attributing | Analysing | • Analyse tasks, lessons, data and language in materials.<br>• Explore literature, examples, add-ons, justification and approaches.<br>• Interpret phenomena, analysis and findings with references and research questions. |

(*Continued*)

**Table 2.** Continued.

| Bloom's taxonomy (Krathwohl 2002; Bloom 1956) | Corresponding CT constructs and subconstructs in this study | |
|---|---|---|
| 4. Evaluate<br>• Checking<br>• Critiquing | Evaluating | • Critique findings, analyses, theories, concepts, and examples.<br>• Evaluate the sources that were used in the writing.<br>• Reflect on existing knowledge to improve practice, existing practice to improve knowledge, existing knowledge to develop knowledge, and existing practice in one context to future different contexts.<br>• Measure with one or more qualitative and quantitative tools/scales.<br>• Weigh information. |
| 5. Create<br>• Generating<br>• Planning<br>• Producing | Synthesising | • Synthesise different lines of literature.<br>• Synthesise argument, positionality, analysis, and literature.<br>• Avoid being too descriptive without depth.<br>• Integrate different resources, perspectives and parts of writing. |
| | Positioning | • Articulate own point of view, voice, and stance.<br>• Justify own point of view.<br>• Present authorial suggestions.<br>• Make hypotheses.<br>• Challenge assumptions.<br>• Make predictions.<br>• Problematise current issues. |

illustrated by its subcategories: although *extrapolating* requires good understanding, it involves executing and implementing readings, analysis, data, and findings across different theoretical and practical contexts. Likewise, concordance analyses indicated that *interpreting* should be considered a sub-category of *Analyse* rather than *Understand*. This is because *interpreting* involves analysing with reference to readings and research questions.

Our analysis uncovered two new categories which have not been identified in Bloom's taxonomy: *contextualising* and *establishing relevance*, echoing the Paul and Elder (2014a)'s stress on relevance as a CT skill. As for Bloom's Level 4: *Evaluate*, our feedback corpus revealed additional sub-categories beyond the two in the revised taxonomy. These include measuring, weighing, and reflecting to develop cognitive and metacognitive knowledge.

Aligned with the revised taxonomy, CT skills at Level 5: *Creating* emphasise generating new knowledge. This involves *synthesising* or *integrating* information beyond mere comparison and contrast in the cognitive process of *explaining*. A new sub-category of *Creating* from our study is fostering authorial positionality (i.e. *positioning*) through varied approaches including justifying, suggesting, hypothesising, predicting, challenging, and problematising.

It is unsurprising that some levels of CT constructs diverge from those in Bloom's taxonomy, given that the features of CT skills depend on the specific subject area to which they apply (Lipman 1988; Brookfield 2012), and students' prior learning experience (Bloom 1956) and subject knowledge (Seddon 1978). Case (2013) argued that higher-order cognitive skills overshadow lower-order skills in certain tasks in different situations. Therefore, he highlighted the consequences of rigidly adhering to

taxonomy levels without considering the task under discussion. Wineburg and Schneider (2010) illustrated the same issue, using history lessons as an example. They asserted that applying a hierarchical order without accounting for actual learning processes can hinder knowledge development.

### *Establishing a taxonomy of critical thinking*

After comparing the two models, we established the CT taxonomy depicted in Figure 3. While Adams (2015) argued that critical thinking starts at Level 3: *Analysis* in the revised taxonomy, we argue that critical thinking starts from students collecting relevant information for their writing because they must consider readers and writing purposes when planning their writing. Therefore, we regard this as Level 1.

Aligning with the argument made by Wineburg and Schneider (2010), an inverted pyramid is adopted to highlight the natural cognitive processes of preparing and composing disciplinary writing. The inverted pyramid also signifies the possibility of the decreasing prevalence of low-order to higher-order constructs in writing products, due to the escalating cognitive complexity.

In a typical scenario depicted by Figure 4, students engage in critical thinking for writing following

- **Gathering Knowledge and Information**: Writers collect relevant information from diverse sources (including experience), taking into account their writing topics, purposes, and audience.
- **Understanding**: Writers demonstrate their understanding by explaining or using the gathered information to support/evidence their writing.
- **Contextualising**: Writers connect gathered information to their writing tasks, ensuring that it aligns with the intended audience and purpose. Contextualisation helps writers make informed decisions about what to include and how to present it.
- **Analysing and establishing relevance**: Within both theoretical and practical contexts, writers break down information into components and analyze their content to establish relevance to their writing.

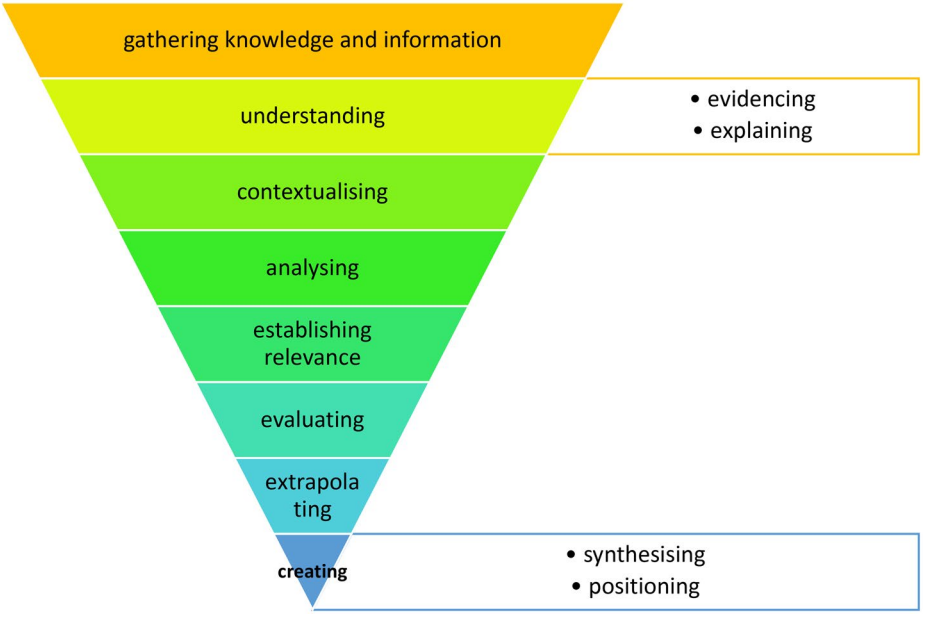


**Figure 4.** Critical thinking taxonomy.

- **Evaluating**: Writers assess the relevance of their content against selected criteria. They consider whether the information supports their arguments effectively. This step involves evaluating the quality and significance of the information.
- **Extrapolating**: Writers extrapolate their insights beyond the immediate context to other situations.
- **Creating**: Writers synthesise information and develop their positionality to create new knowledge and contribute authoritatively to their field or discipline.

### *Application of the CT taxonomy to assessment and instructions*

When adopting the framework, it is essential to consider a few key points to prevent overinterpretations and ensure proper application in assessment and instructional contexts.

Firstly, the taxonomy should be interpreted alongside Appendix 1 to facilitate shared understanding among educators and between educators and learners. Bloom's taxonomies are criticised for their generic description of the cognitive processes (Seddon 1978), resulting in diverse and sometimes biased interpretations and difficulty in applying them in instructional and assessment design (Anderson, Sosniak, and Bloom 1996; Bloom 1994, 1956). To address this, this study has defined each construct and related subconstructs, illustrated with exemplar concordances from the lecturer feedback corpus (Appendix 1). Referring to relevant concordance lines in Appendix 1 can help communicate how to apply the taxonomy effectively for teaching, learning, and assessment. Additionally, using the verbs that describe constructs can provide consistent terminology, reminding writers of the diverse CT skills needed for assessment tasks.

Secondly, the constructs in Figure 3 are not discrete skills in real-world writing practice. Rather, some constructs exhibit stronger relationships with one another. As evidenced in cluster analyses, *extrapolating* and *synthesising* are closely related, both requiring the ability to consider contrasting information from different angles or across various contexts. Similarly, *explaining* and *positioning* are interconnected CT processes within a cluster. This suggests that students must possess a solid understanding of their existing knowledge to effectively establish their positionality. Furthermore, how each construct intertwines with the others will depend on learners' prior knowledge and learning experiences (Bloom 1956). This reinforces the importance of applying the taxonomy flexibly, considering cognitive complexity and learners' specific needs.

Thirdly, certain CT skills are prerequisites for the operation of others, as evidenced by the cluster analyses. For instance, *contextualising* is essential for *analysing*, *evaluating*, and *extrapolating* as knowledge is intricately tied to both theoretical and practical contexts. *Positioning* enhances our understanding of literature beyond merely *explaining* and *evidencing*. Case (2013) and Wineburg and Schneider (2010) have exemplified the risks of applying each level in Bloom's taxonomies discretely without considering the learning process and the task requirements, leading to confusion and underdeveloped students' CT skills. In practice, CT skills do not rigidly follow a hierarchical order; instead, they often operate cyclically as depicted in Figure 5 or co-exist within the same cognitive process.

## Conclusions

Critical thinking is a fundamental skill that empowers individuals to move beyond passive acceptance of information at face value and make informed judgments of its values for issues under scrutiny. Its significance becomes more pronounced in the AI-enabled world where learners' voices can be suppressed without thinking critically about AI responses. The current study explored the intricate terrain of critical thinking based on education lecturers' feedback. Through rigorous corpus analyses and hierarchical cluster analyses, the multifaceted, multistaged, and interwoven nature of CT constructs is revealed. Drawing upon Bloom's Taxonomy and its revised

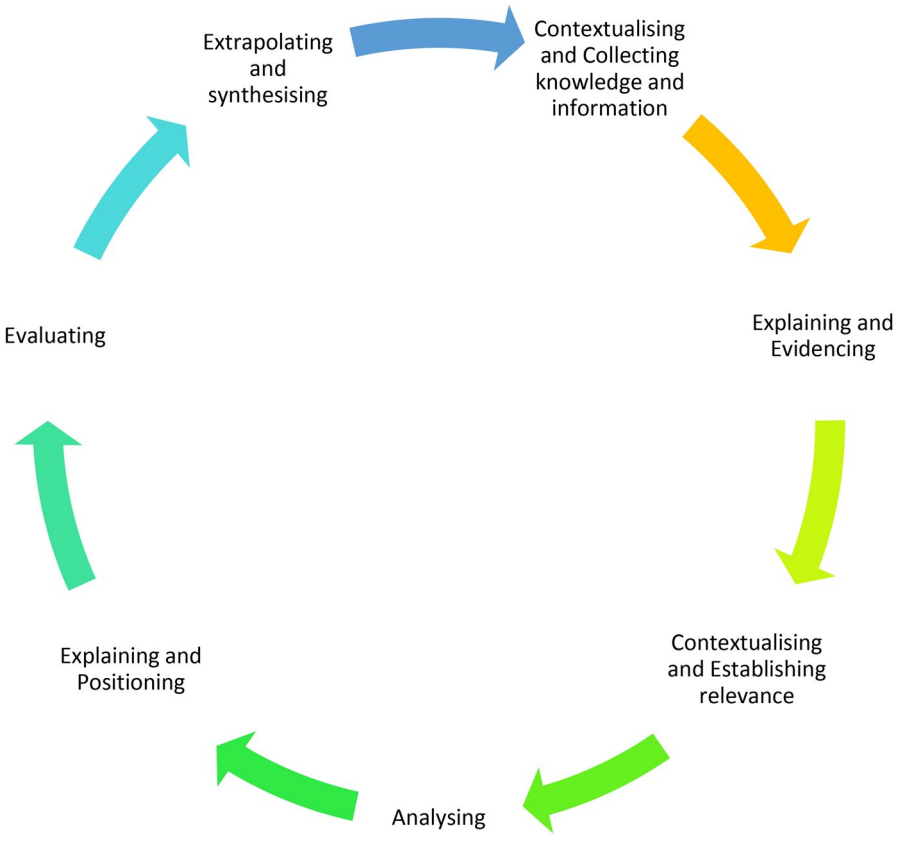


**Figure 5.** The cyclical structure of CT skills.

version, we presented a taxonomy of critical thinking and suggested its possible application for CT instructions and assessment. The definitions of nine CT constructs alongside example lecturer feedback offer foundations for the uses of the taxonomy. CT is context-sensitive and instructing it requires a collective endeavour to test, refine, and adapt this taxonomy across diverse educational settings. More research informed by the application of the taxonomy is needed.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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