



UNIVERSITY OF
BIRMINGHAM

Critical Thinking in STEM(M)

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Baleap STEM Sig Event May 16 2023

Session Focus

- What is 'critical thinking' in STEM(M)? - Personal reflections and observations (and a few bug bears)
- How can we best support STEM(M) students with critical thinking in terms of language?
- Please bear in mind: I am sharing experience, not research findings!

Being a 'Fly on the Wall'

- Exam Skills Assessment Support for 2nd Year BSc Biosciences (Cellular & Developmental Biology)

Assessment criteria - SAQ

Mark	Criteria
100, 95, 90	Gives all relevant information with <u>no errors or omissions</u> . <i>The answer must contain:</i> Figures where these are appropriate to answer the question. Significant evidence of higher order understanding i.e. synthesis, critical analysis or evaluation.
85, 80	Gives all relevant information with <u>only minor omissions</u> and no factual errors. <i>The answer should contain:</i> Figures where these are appropriate to answer the question. Significant evidence of higher order understanding i.e. synthesis, critical analysis or evaluation.
75, 70	Gives most relevant information with only minor omissions or factual errors. Answer demonstrates that the topic is clearly understood with some limited evidence of higher order understanding i.e. synthesis, critical analysis or evaluation.

Assessment criteria - Essay

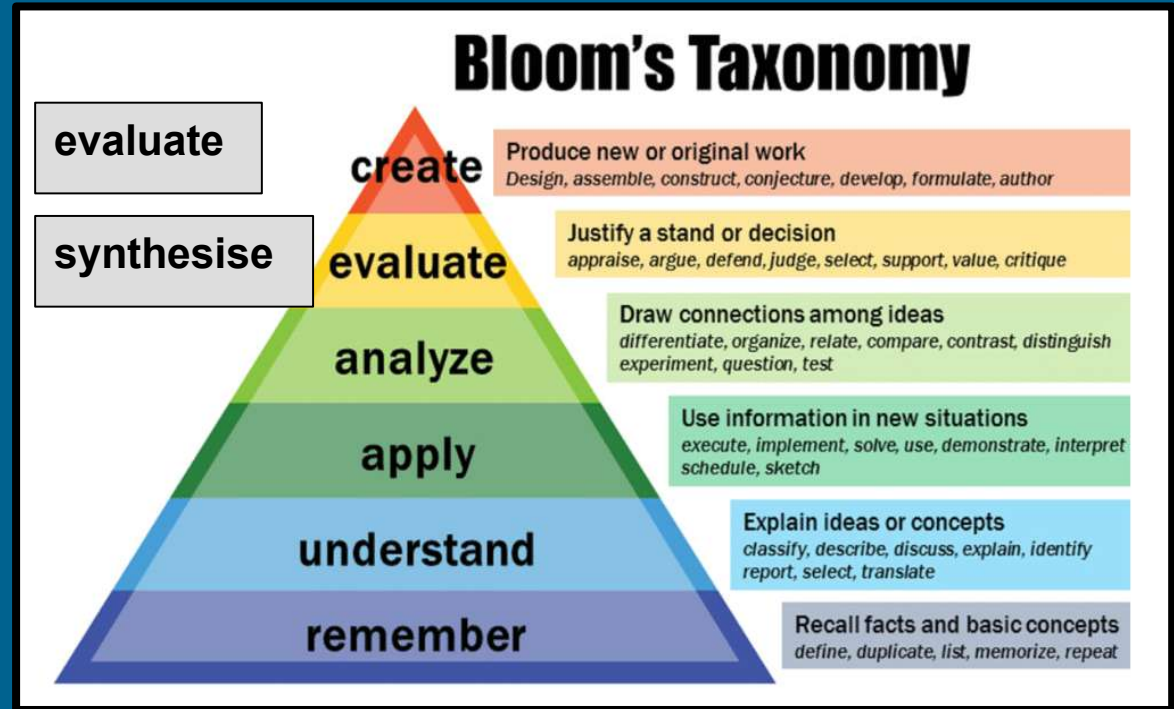
Mark	Criteria
100, 95, 90	Includes all of the major points given in the course material. Flawless reasoning and in-depth understanding. Evidence that recommended reading has been used effectively to answer the question and demonstrate full understanding. Substantial synthesis of material as well as critical analysis. Excellent presentation and structure, with effective use of informative diagrams or figures as appropriate. No irrelevant material.
85, 80	Includes all of the major points given in the course material with only minor omissions or errors. Shows clear reasoning and thorough understanding . Evidence that recommended reading has been used effectively where appropriate to answer the question and demonstrate thorough understanding. Clearly discernible synthesis of material as well as critical analysis . Excellent presentation and structure with effective use of informative diagrams and figures as appropriate. No irrelevant material.
75, 70	Includes most major points given in the course material with few errors or omissions. Demonstrates sound reasoning and thorough understanding. Includes material from recommended reading. Elements of synthesis of material and/or critical analysis. Effective presentation and structure supported by use of informative diagrams and figures as appropriate. Some material may address the question only indirectly.

1,000 word
essay (10h online
open book)

What is the anaphase-promoting complex/cyclosome (APC/C)?
Using diagrams, explain how APC/C regulates cell-cycle progression.

- Where might this question have scope for showing 'higher order thinking'?

Krathwohl & Anderson's (2001)
revised taxonomy. Image:
Salisbury University



What the lecturer mentioned

- You need to give your opinion, not just describe what something is.
- You need to explain how something works and why it is important.
- You need to justify scientifically and give reasons for your answers.
- You need to support statements.
- You need to make connections.
- You need to refer to additional reading, not just the core texts.
- You don't need to be innovative but you should indicate gaps in knowledge and why they exist.

Can you give us some examples of how to include critical analysis in the answer?

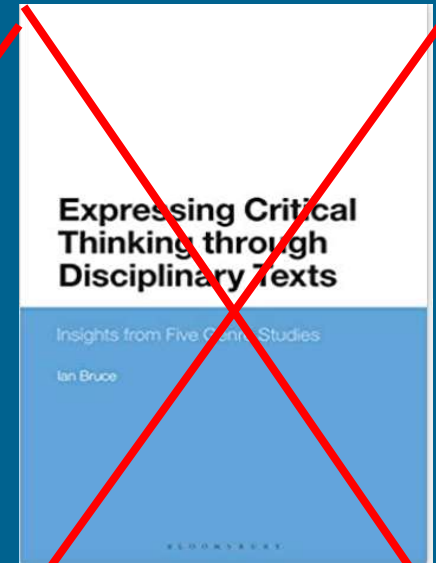
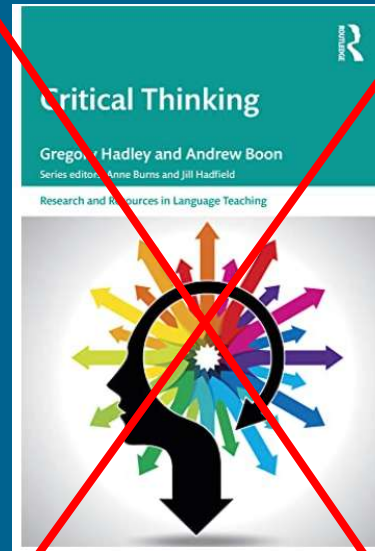
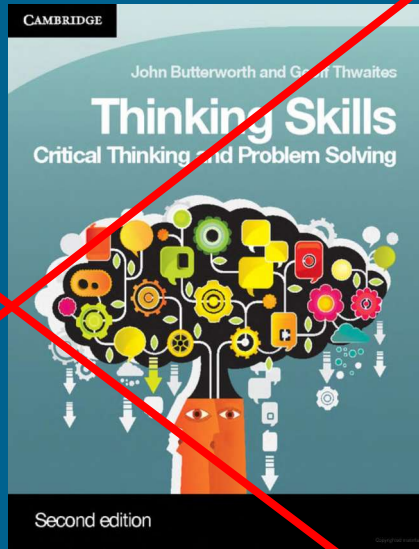
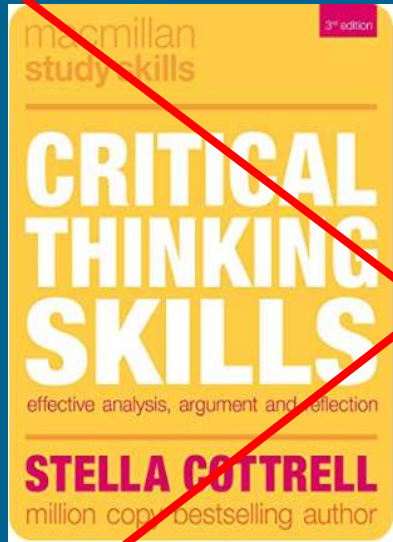
How can I show my own opinion when the science is based on facts?

After the lecture...a list

- Explaining not just what, but how and why
- Indicating why something is important or significant (e.g. the varying degrees of importance of the role of an enzyme in different contexts)
- Giving reasons
- Pointing out differences and similarities, linking knowledge across different subjects (synthesising)
- Making connections
- Giving your opinion of the current understanding
- Pointing out gaps in our current understanding
- Justifying an interpretation
- Highlighting unanswered questions
- Suggesting what we need to find out in the future
- Highlighting areas of good practice
- Suggesting a variety of applications
- Indicating limitations
- Making recommendations

Where I went next

- I needed to find out more about critical thinking in STEM(M) disciplines.



Some studies are available

- Kwan, B.S., Chan, H. and Lam, C., 2012. Evaluating prior scholarship in literature reviews of research articles: A comparative study of practices in two research paradigms. *English for Specific Purposes*. 31(3), pp.188-201.
- Sorry, I couldn't be there for the 3-minute paper session...
- The paper seemed to focus on 'moves' and types of critical comment.
- For me, the most interesting parts were the examples but... basing examples of writing on published papers does not reflect the real kind of writing done in assignments.
- UG and PG assignments are genres in their own right. (Bug bear alert!)

Suggestion for Practitioners: Magpie Mode (1)

- Collect assessment remits and criteria
- (but be aware that these may not be especially informative)



Why might this be confusing?

- 1st Year Lab Reports in Mechanical Engineering

	Content (40%)
85%	An excellent written report that is interesting and develops ideas well. Evidence of critical analysis of the literature.
72-78%	A very well written report that is interesting and develops ideas well. The report will link with the published literature.

There are two main differences here that can take you from a grade in the 70s to one in the 80s. First is the quality of the writing - being excellent rather than just well written. Secondly, and more significantly, the literature used in the report should be “critically analysed” rather than just linked to your work. Critical analysis means discussing or questioning the reliability and accuracy of the literature that you use.

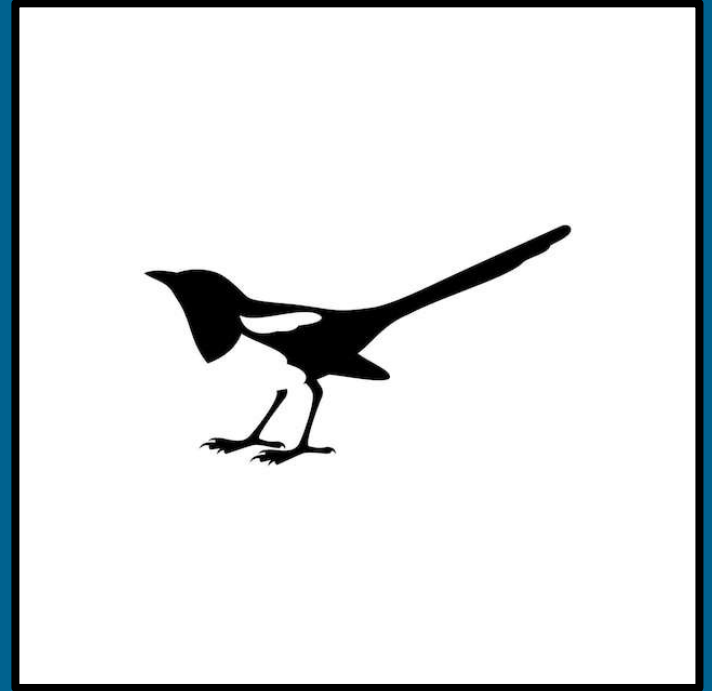
A more informative example

Final Project Marking Criteria: MSc Toxicology

<i>Quality indicators</i>	<i>Presentation</i>	<i>Content (substantial flaws in these indicators will lead to a mark <60%)</i>	<i>Originality/Insight (required for marks >70%)</i>
	<ul style="list-style-type: none">● Clear graphical organisation of text and display elements in terms of fonts, font size, line spacing, subheadings and appendices (where relevant).● Clear writing with proper punctuation and grammar.● Accurate scientific terminology.● Clear logical organisation of the report, and of each individual section.● Informative figures and tables that effectively support the narrative of the main text.● Self-explanatory figure/table legends, complete annotation of	<ul style="list-style-type: none">● In-depth understanding apparent from quality of reasoning, breadth/depth of detail (e.g. molecular, cellular, theoretical), ability to articulate key ideas with precision.● Factual accuracy maintained throughout● Introduction includes account of project-relevant literature and identifies knowledge gaps.● Hypothesis/research question is clearly stated.● Results/data analysis accurately and accessibly presents observations made during the project. Includes statistical analysis where	<p>Synthesis – novel insights derived from experimental work/data analysis with reference to literature precedent.</p> <ul style="list-style-type: none">● Synthesis – in the form of proposals for meaningful future studies, with clear articulation of what question they could answer and how.● Critical analysis of literature in terms of established consensus, controversies and unknowns● Critical appraisal of project results, drawing on<ul style="list-style-type: none">○ Literature precedent○ Limits of methods/design○ Limits of resources

Suggestion for Practitioners: Magpie Mode (2)

- Ask for access to view real students' writing and feedback comments/ annotations
- Use the examples to find opportunities to design activities to help students with the language used to signal criticality
- If you are that way inclined, build and analyse a corpus



Your turn

- Use the writing samples taken from a first year BSc Biosciences Personal and Academic Development: 2,000-word take home essay.
- What kind of language-focussed activities do these suggest might be helpful for students?
- I'll ask one person per group to feedback some ideas after your discussion.
- **Please do not replicate, share or use these examples beyond this session as they refer to students who are still enrolled at UoB.**

A few suggestions

- Lexical nuance e.g. have not always been successful v have failed
- Ways to introduce examples e.g. One way of doing this is... An example to consider is... X is a possible example of Y.
- Ways to introduce explanations and consequences, e.g. cause/effect language
- Qualifiers and hedging language; boosters & softeners
- Correct use of 'because/since/as'
- Choice of appropriate sources
- How (much) when and what to reference
- Evaluative language to highlight importance/timeliness/novelty
- Expressing stance/ opinion using appropriate personalised/ depersonalised language
- Concession and contrast clauses
- Expressing likelihood/probability
- Comparing & contrasting

What have I concluded?

- What is considered 'critical thinking' differs from discipline to discipline, for different types of assignment/assessment and for different levels (UG, PGT, PGR).
- Particularly in STEM(M), criticality is not *always* separable from what we might see as a 'justified explanation'.
- Students need clear examples that show the language of 'criticality' and be taught how to use critical signals.
- We can help to improve *how* students communicate their thoughts and ideas, but is the EAP teacher's remit to develop *what* those thoughts and ideas about their subject are?