

## Electronic Supplementary Information

for the manuscript:

### **Metacognitive problem solving: Exploration of students' perspectives through the lens of multi-dimensional engagement**

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Contents: Thematic analysis codebook

<b>Theme</b>	<b>Description</b>
<b>Theme 1: Engagement with structured problem solving</b>	
<i><b>Cognitive sub-themes</b></i>	
Assessed quality and depth of solution	Students evaluated the accuracy and comprehensiveness of their problem-solving attempt.
Identified cognitive processes to use in the future	Students recognised and noted the mental strategies employed during problem-solving tasks for potential application in future challenges.
Identified flaws in solution	Students pinpointed errors or weaknesses within their solution that were problem-specific or related to their problem-solving process.
Recognised progress in problem-solving skills	Students acknowledged improvements or advancements in their ability to tackle and resolve chemical problems.
Identified specific mistake that led to the wrong answer	Students identified and highlighted particular errors or misconceptions that resulted in incorrect solutions.
Identified strategies for future improvements	Students devised plans or techniques to enhance their problem-solving proficiency in subsequent problems.
Identified benefits of using the scaffold	Students recognised advantages such as clearer communication, a methodical approach, and a helpful starting point facilitated by the problem-solving scaffold.
<i><b>Emotional sub-themes</b></i>	
Felt confident	Students reflected on experiencing a sense of assurance or self-belief in their ability to effectively utilise the problem-solving scaffold.
Felt positive about their performance	Students commented on maintaining a positive outlook regarding their problem-solving efforts and outcomes while utilising the scaffold.
Helps to deal with stress	Students noted that engaging with problem-solving scaffold aided in managing feelings of stress or pressure associated with solving chemical problems.
<i><b>Behavioural sub-themes</b></i>	
Demonstrated problem-solving elements	Students commented on effectively demonstrating problem-solving elements during chemical problem-solving activity.
Evaluated their work	Students noted that they actively assessed or reviewed their problem-solving efforts and outcomes.
Slowed down problem-solving process for deliberate and methodical action	Students reflected on deliberately pacing their problem-solving approach, ensuring careful and systematic consideration of each step while utilising the scaffold.
Used expert solution as a checklist to confirm correctness	Students stated that they used expert-provided solutions as a reference or guide to validate the correctness and depth of their own problem-solving processes or outcomes.

<b>Theme 2: Non-engagement (disaffection) with structured problem solving</b>	
<b><i>Cognitive sub-themes</i></b>	
Cognitive challenge	Students noted encountering difficulties or complexities in utilising the problem-solving scaffold effectively.
Struggled to use the scaffold	Students commented on facing obstacles in employing the problem-solving scaffold during chemical problem-solving activities.
Unfamiliar with the scaffold	Students reflected on a lack prior knowledge or experience with the problem-solving scaffold, which deterred students from engaging with the scaffold.
Surface level use of the scaffold	Students stated using the problem-solving scaffold in a superficial or cursory manner, without delving deeply into its potential benefits.
Own preferred or established method	Students noted opting to rely on personal or familiar problem-solving techniques rather than utilising the provided scaffold.
Scaffold use was not necessary	Students reflected on perceiving the problem-solving scaffold as not essential to solving the problem.
Structured problem-solving was assumed knowledge	Students presumed structured problem-solving techniques were a given which resulted in students not explicitly demonstrating problem-solving processes.
Scaffold use required extra time and/or effort	Students stated that employing the problem-solving scaffold demanded additional time or exertion compared to their usual problem-solving methods.
Did not want to make mistakes	Students reflected on a reluctance to encounter errors or faults during their problem-solving attempt, which impacted their engagement with the scaffold.
<b><i>Emotional sub-themes</i></b>	
Lack of self-confidence	Students noted experiencing a deficiency in self-belief in their ability to navigate chemical problem-solving tasks with the scaffold.
Felt stressed	Students reflected on feelings of unease during problem-solving activities, which can impact their level of engagement with the scaffold.
Felt over-critical of their performance	Students stated exhibiting a tendency to excessively scrutinise or judge their problem-solving performance once exposed to the expert solution.
<b><i>Behavioural sub-themes</i></b>	
Skipped problem-solving steps	Students reflected on omitting certain steps within the problem-solving process.
Completed problem-solving steps but did not show them	Students commented on executing all required problem-solving steps but failed to demonstrate or document their completion while utilising the scaffold.
Forgot	Students noted struggling to remember to use the scaffold, potentially leading to oversight or omission of crucial problem-solving steps with the scaffold.
Rushed problem-solving	Students acknowledged hastily approaching problem-solving tasks that potentially led to sacrificing thoroughness or accuracy in their problem-solving efforts.