Examples of how PRO was used to help students learn specific content

Chemistry Lesson on ionic bonding

Students observed an experiment on the electrical conductivity of sodium chloride. A circuit with a light bulb was connected across solid sodium chloride. Initially, the light bulb did not light up but as the sodium chloride was heated and melted, the bulb lit up. The students were asked to explain what happened, in particular why sodium chloride cannot conduct electricity in the solid state but can do so in the molten state.

The teacher introduced the PRO structure to help students construct a scientific explanation (table 1):

Principle	What do you know about the compound in terms of structure and bonding?
Reasoning	What is happening at the microscopic level? Consider forces of attraction and charged particles
Outcome	What is the observable property of the compound? (in this case, its conductivity)

Table 1: Scaffolding questions to elicit PRO for the Chemistry Lesson

The explanation with the PRO structure is provided in Table 2:

P	In solid state, sodium chloride have a giant ionic crystal lattice structure where oppositely charged ions are held tightly by strong electrostatic forces of attraction.
R	There is no free mobile ions to conduct electricity.
O	Sodium chloride cannot conduct electricity in solid state (1^{st} observation when the bulb did not light up)
P	When sodium chloride is melted, the strong electrostatic forces of attraction has been overcome and the oppositely charged ions are held less tightly.
R	The ions can now move freely to conduct electricity.
O	Sodium can conduct electricity in molten state (2^{nd} observation when the bulb lit up)

Table 2: The explanation with the PRO structure

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Physics lesson on density

Students observed an experiment in which raisins were put into a beaker of soda water. The raisins sank and floated repeatedly a number of times.

The teacher walked the students through how to construct a scientific explanation of the observed phenomenon using the PRO structure for the three outcomes observed (raisin sank, then floated, then sank again). Table 3 shows the scaffolding questions asked:

Principle	What is the key principle behind what happened? (formula of average density)
Reasoning	What was happening when the raisin sank? What was happening next when the raisin floated? What was happening when the raisin sank again?
Outcome	What did you observe about the raisins? (the raisins sank, then floated, then sank again)

Table 3: Scaffolding questions to elicit PRO for the Physics Lesson

The explanation with the PRO structure is provided in Table 4:

P	Density is mass per unit volume
R	The density of raisins is higher than the density of water
O	Thus, the raisins sink (1st observation of raisins sinking)
R	The gas attach themselves to the raisins, the volume increases, the average density decreases
O	The raisins with the air bubble float up (2nd observation of raisins floating)
R	Once they reach the surface, gas bubbles escape, and thus the density returns to the original value which is denser than water
O	Therefore, the raisins sink again (3rd observation)

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General Tips

a. Although the PRO strategy is presented as a linear and sequential model, it does not mean that students must rigidly follow this linear sequence in crafting their explanation
b. Teachers may also use the PRO strategy to teach the students how to construct an explanation in a non-sequential way – e.g. by first identifying the outcome and relevant premise, and then working backwards to construct the reasoning.
c. When teachers first introduce the PRO structure, it is useful to provide more prompts, guiding questions and sentence starters, particularly when students are just learning the content of the topic. However, as the students become familiar with the PRO structure/after they have learnt the content, the teacher may want to provide fewer scaffolds. In addition, if students are confident in organising their own answers, allow them to do so without needing to follow the sequential PRO structure.
d. The PRO strategy can be used as a form of diagnostic assessment to analyse the difficulties students have in constructing scientific explanations – whether they have problems mainly with P, R or O? Note that the problem area may differ depending on the specific content.

Adapted from the following sources:

Tang, K.-S. (2015). The PRO instructional strategy in the construction of scientific explanations. *Teaching Science, 61*(4), 14-21

Tang, K. S. 2016. "Constructing scientific explanations through premise-reasoning-outcome (PRO): an exploratory study to scaffold students in structuring written explanations." *International Journal of Science Education*,38, 1415-1440.

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