

## **Online adaptive tutorials that support learning in data interpretation and scientific reasoning**

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A small-group learning activity on the topic of the thyroid gland physiology is run as a laboratory class for stage two (second year) science and medical students as part of the endocrinology component of their courses (PHSL2201/2502/2221 and MFAC1522). The aims of this active learning class are: 1) to reinforce the general principle of negative feedback mechanisms in endocrine physiology; 2) to provide a deeper understanding of thyroid physiology; and 3) to cultivate an understanding of data interpretation, deductive reasoning and scientific evidence. Originally, the activity used glass slides for the histology sections of the thyroid gland and paper-based tasks performed by students in the class. By moving some of the activities to online adaptive tutorials, more time can now be focused on facilitating the groups to formulating a well-reasoned hypothesis to explain the data they have analysed.

Adaptive tutorials are employed at three key stages in the task: for preparation before the class, for delivery of histology and cell morphology data during the class, and for self-assessment of the concepts following the class. The pre-class tutorial revises the concepts of negative feedback regulation and thyroid hormone synthesis, with a series of short questions and associated adaptive feedback. This was completed with a median time of 13 minutes. The histology and morphology tutorial provides easy access to digital histology sections during the class, facilitating the observation and interpretation of the key features. This was achieved with a combination of directed questions and adaptive feedback. This use of adaptive tutorials allowed more time during the class to facilitate the interpretation of the data, formulating a hypothesis that is supported by the data, and seeking additional evidence from the published literature. Within the groups of students, peer teaching occurs when individuals propose a hypothesis and explain the reasoning to the other members of the group. The hypothesis is tested to see if it is consistent with the data and further rounds of discussion and interpretation may result, all facilitated by the demonstrator. A class discussion is held at the end of the activity, allowing the groups to share their hypotheses and explanations. The final adaptive tutorial provides a self-assessment task on the interpretation of the data, the reasoning and the evidence that supports the hypothesis. This is provided after the class and allows the students to confirm their understanding, with any misconceptions corrected by adaptive feedback (median time to complete: 14 minutes).

The impact of this approach was assessed by comparing the performance in a multiple-choice question exam of the science student cohort in 2015 (435 students) with a previous cohort that did not have adaptive tutorials (394 students). Across four questions (out of 27), there was an improvement of 3 to 20% in selecting the correct answer. Student feedback highlighted the value of the interaction and adaptive feedback of the tutorials in supporting their learning. Students also acknowledged the value of developing an understanding of linking evidence to the conclusions reached.

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