Data-Driven Scaffolding in Biosciences Education via Smart Worksheet Analytics

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Background

- Mastering biosciences content requires conceptual reasoning, data interpretation, and procedural fluency that often challenge undergraduate learners. Traditional didactic methods offer limited opportunities for immediate formative feedback and independent problem-solving (Manchester & Roberts, 2025).
- Digital Smart Worksheets offer interactive, feedback-rich tasks that scaffold learning through prompts and adaptive support, helping students progress from foundational knowledge to complex applications
- Integration of platform analytics capture engagement patterns, misconceptions, and skill gaps. Analytics-enhanced scaffolding enables educators to identify learning gaps early, tailor interventions, and foster more personalized, evidence-informed teaching.

Objectives

- To evaluate student engagement and performance using Smart Worksheets across two biosciences modules.
- To identify learning gaps through platform-generated analytics.

Implementation

- **Study Design:** Two Smart Worksheets were deployed in two bioscience modules via learning platform. Delivery was compulsory and positioned after exposure to relevant theory as formative assessment.
- **Study subjects:** School of Biosciences undergraduates (Year 1 Sem 1, n=25; Y2 Sem 4, n=17)
- **Data collection:** The platform analytics recorded completion rates, raw and adjusted scores, autosolved usage, and score efficiency (adjusted/raw ratio).

Outcome and Discussion

Smart Worksheet: Introduction to Food Tests

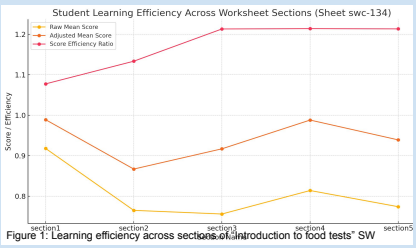

Figure 1: Learning efficiency across sections of "Introduction to food tests" SW

- **Raw vs. Adjusted Scores** Consistent improvement across sections.
- The **Score Efficiency Ratio** increases across Sections 3–5
- Strong engagement, but also imply that later sections more difficult and benefit from additional scaffolding or instructional reinforcement.

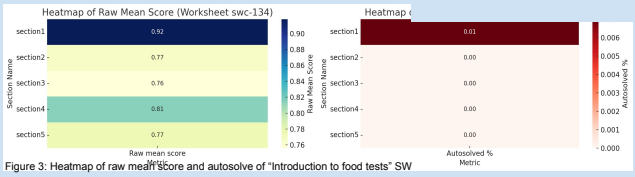

Figure 3: Heatmap of raw mean score and autosolve of "Introduction to food tests" SW

Raw Mean Score Heatmap: Sections 2–5 more challenging
Autosolve % Heatmap: Students relied on their own understanding even in more difficult sections.

Students were confident applying conceptual knowledge independently, gradual declined in attempt rates signals cognitive fatigue, implying that sustained engagement requires scaffolding

Smart Worksheet: Determine an unknown concentration of acid by titration

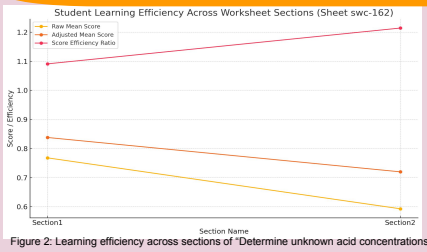

Figure 2: Learning efficiency across sections of "Determine unknown acid concentrations" SW

- **Raw vs. Adjusted Scores** Section 2 reduced performance.
- The **Score Efficiency Ratio** decreasing.
- Section 2 lower engagement and performance - likely due to challenging applications like titration curve interpretation or pKa calculation.

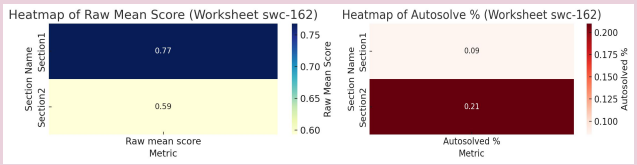

Figure 4: Heatmap of raw mean score and autosolve of ""Determine unknown acid concentrations" SW

Raw Mean Score Heatmap: Section 2 implies higher difficulty.
Autosolve % Heatmap: Students struggled and required system support (Section 2).

Tasks outpaced students' existing knowledge structures.
A gap between theoretical exposure and the practical reasoning required. Early scaffolding or preparatory tasks are necessary to support procedural reasoning.

Learning Analytics Inform Teaching Practices and Scaffold Student Support

Reinforce conceptual understanding in later sections
→ **Targeted pre-tasks or videos:**
→ Begin these sections with easier scaffolded problems to build momentum.
→ **Link to real-world context:** Tie content in later sections to practical or clinical applications to increase engagement and motivation.

Strengthen cognitive endurance
→Micro-chunk sections
→ Embed "Pause & Reflect" tasks

Use Analytics for Personalized Support
→ Identify at-risk students early.
→ Adaptive intervention

Instructional Follow-Up and Alignment
→ Review common errors in class:
→ Align worksheet sections with lessons

Section 1: Higher performance, Lower support dependency
a. **Maintain current structure**
b. **Introduce minimal scaffolding**: independent exploration and critical thinking
c. **Stretch activities**: Add extension or application problems to high performers

Section 2: Lower performance, High support dependency
a. **Pre-worksheet refresher**
b. **Scaffolded Questions**: Break problems into smaller sub-steps with guided hints
c. Collect feedback to inform future revisions.
d. **Instructor-led walkthrough**

→ Task complexity and student experience shaped engagement patterns, underscoring the need for differentiated instructional support across modules.
→ Analytics serve as feedback loop for teaching strategy, ensuring alignment between instructional design, cognitive readiness, and learner support.

Future Direction

- Extend to other biosciences modules as formative checkpoints throughout the semester with careful calibration by taking account into students' developmental stage.
- Progressive scaffolding could be embedded: Early-stage modules focusing on guided procedural fluency, advanced modules emphasising independent problem-solving and critical reasoning.
- Longitudinal use of analytics may allow educators to track whether interventions close recurring gaps or whether persist, signalling deeper instructional misalignment.
- Shift from gap-spotting to curriculum shaping, informing the cognitive scaffolding of bioscience learning with student development.