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Beyond "Remember" and "Understand": Can Online Homework Tools Augment Students' Higher-Order Thinking Skills?

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Introduction

Repeated testing improves memory for concepts (Carpenter, Pashler, Wixtead & Vul, 2008; Roediger & Karpicke, 2006), even under low-stakes testing conditions (Grison, Luke, Watson, & Shigeto, 2011). Online homework is a new way to achieve this goal. However, research has not yet investigated best-practice for using these tools. This study explored student performance and affective ratings for an online homework tool in Introductory Psychology with respect to two domains known to influence student learning: 1. thinking skills targeted by a question, and 2. the interactivity of a question.

Question Level

Was varied based on the Revised Taxonomy of Cognitive Skills (Anderson et al., 2001; Bloom, Engelhart, Furst, & Hill, 1956).

- Best practice uses the taxonomy to develop thinking skills and to assess learning (Pusateri, 2009).
- Remember & Understand questions only use lower-order thinking skills (LOTS) (Figure 1).
- But Apply & Analyze questions require higher-order thinking skills (HOTS) (Figure 1).

Figure 1: Revised Taxonomy of Cognitive Skills (Anderson et al., 2001)

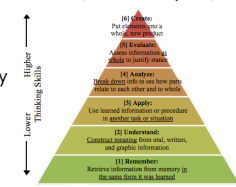


Figure 2: Example of a Drag and Drop Question ("Apply" Level)

The aim here is to apply the global workspace model to this new situation where you are walking on the beach on a warm summer day. Please click on the 5 statements that reveal awareness and show what brain region allows you to be conscious of that information by placing it on the correct red target.

1. There's no space to lie down on the beach.
2. I can see the blue sky and bright sun.
3. The waves sound just crashing on the beach.
4. It's hot so I will get water at the restaurant soon.
5. I am aware that I am walking on sand.

Question Type

Was varied based on interactivity of the questions (Chickering & Gamson, 1991):

- Drag and Drop (Figure 2)
- Fill-in-the-blank
- Matching
- Multiple Choice (MCQ)
- Multiple MCQ
- Order
- Table

Research Questions

This study examined the following questions about effectiveness of an online homework tool for introductory Psychology.

1. What is the effect of Question Level (cognitive difficulty) on:
 - a) accuracy in answering a question, and
 - b) rating the quality of the question?
2. What is the effect of Question Type (nature of interactivity) on:
 - a) accuracy in answering a question, and
 - b) rating the quality of the question?

Method

Participants

- 41 undergraduate students at UIUC.

Materials & Design

- Students had 12 questions on Introductory Psychology topics.
- Each question had one or more parts ("items") (see Figure 2).
- Questions varied by Level and Type in an incompletely crossed design (Tables 1 and 2).

Procedure

- Testing occurred online in one 2-hour session.
- Five attempts were allowed per question.
- Feedback was given for both incorrect and correct responses.
- Accuracy on last attempt was: (Num Items Correct / Total Items).
- Students rated each question's quality (1–Poor to 5–Excellent).

Table 1: Level of Cognitive Difficulty

Level	Number of Questions
REM	47
UND	49
APP	110
ANA	48

Table 2: Degree of Interactivity

Type	Number of Questions
Drag and Drop	46
Fill-in-the-blank	38
Matching	62
MCQ	46
Multiple MCQ	8
Order	12
Table	42

Results for Research Question 1

- A repeated measures ANOVA did not show any effect of Level on accuracy for final attempts on questions ($p = .28$) (Figure 3).
- Students' rated REM questions as "Average" (Table 3).
- But they gave higher ratings to questions that were not definitional (e.g., UND, APP, and ANA) (Table 3).

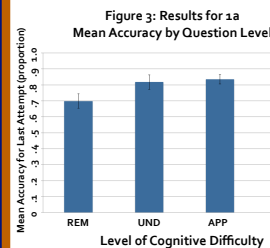


Table 3: Results for 1b
Mode Quality by Question Level

Level	Modes
REM	3
UND	5
APP	4
ANA	3, 5

Results for Research Question 2

- A repeated measures ANOVA did reveal a main effect of Type on accuracy for final attempts on questions ($p < .01$) (Figure 4).
- Students performed better on MCQs (Figure 4).
- Students rated items where they typed answers as "Average" (e.g., Table) or "Above Average" (Fill-in-Blank) (Table 4).
- But they rated questions that were interactive (e.g., Drag and Drop) or multi-part (e.g., Multiple MCQ) as "Excellent" (Table 4).

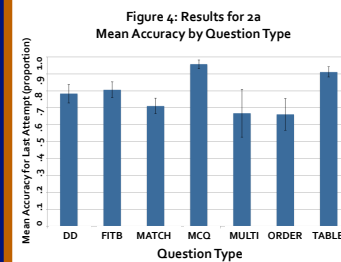


Table 4: Results for 2b
Mode Quality by Question Type

Type	Modes
Drag and Drop	5
Fill-in-the-blank	4
Matching	4, 5
MCQ	4
Multiple MCQ	5
Order	3, 4, 5
Table	3

Discussion

The results of this exploratory study provide insight into how to design online homework questions for repeated low-stakes testing.

- Students were just as accurate in answering questions across all levels of cognitive difficulty, but they preferred less definitional questions (UND, APP, ANA), so...
 - online homework should include questions that are more cognitively difficult than REM questions (Figure 1).
- Students were more accurate in answering MCQs versus other types of questions, and they preferred interactive types like Drag and Drop (Figure 2), so...
 - online homework should use interactive questions (NOT requiring typed responses) to increase engagement and positive affect, and
 - just use "bland" MCQs for online quizzes to prepare for MCQ tests.

Implications and Future Directions

Research that investigates the effectiveness of online homework tools can help teachers and educational product developers improve student engagement, performance, and ultimately, learning. To that end, our future studies aim to:

- Investigate whether positive student attitudes are associated with perseverance (i.e., time on task) on online homework questions.
- Determine whether online homework can improve learning in terms of thinking skills (i.e., does development of HOTS depend on LOTS).
- Explore whether even more interactive questions types (videos, labs) impact performance, affective ratings, and learning.