Metacognitive Sophistication about Desirable Difficulty: Implications for Learning Complex Material

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Abstract

	Investigated	Found
(1)	Whether three "desirable difficulties" (Bjork, 1994) remained desirable when applied to learning typical classroom material	
	Interleaving (between) -	No effect.
	Contextual Interference (between) -	No effect.
	Teaching by Testing (within) -	Material tested during learning was better retained.
(2)	Students' awareness and understanding of desirable difficulties	Only 31% of participants reported that they normally use tests as learning tools.
(3)	Whether (2) predicted students' retention of educational materials.	The above participants' retention was superior.

Conclusion (3): potential positive relationship between metacognitive sophistication and cognitive ability.

Desirable Difficulties

Desirable Difficulties: unintuitive conditions of learning

WORSE ACQUISITION BETTER RETENTION

Shown in motor tasks or with short retention intervals

Interleaving: Learn items P and S by studying each several times.

Arrangement	Example	Immediate Recall	Delayed Recall
Blocked	S,S,S,S,P,P,P,P	better	worse
Interleaved	S,P,S,P,S,P,S,P	worse	better

Contextual Interference: (e.g., Shea & Morgan, 1979) Proximity of similar items in different topics (when interleaved).

Amount of Contextual Interference	Example
More CI	P1,S1,P2,S2,P3,S3,P4,S4
Less CI	P1,S3,P2,S4,P3,S1,P4,S2

—where S1 and P1 are, say, information about Star formation and Planet formation that relate to the same concept.

Teaching by Testing: (e.g., Hirshman & Bjork, 1988)
TEST > STUDY

Metacognition

Metacognitive Sophistication: Accurate comprehension of one's own cognitive processing (e.g., *I won't remember this on the midterm next week unless I study it more.*). That a learning difficulty can be desirable in the long run is counterintuitive; students and instructors typically conflate immediate performance with long-term learning and therefore strive to avoid impediments to performance (e.g., Nelson & Narens, 1994). If such self-assessments (particularly with respect to desirable difficulties) are accurate, the learner is said to be metacognitively sophisticated.

Purpose

To examine desirable difficulties in educationally realistic material.

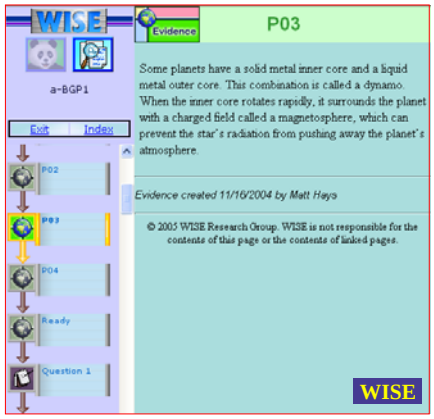
A glance at any textbook's table of contents will reveal that each concept is presented in its entirety before the next is broached. Teachers spend extra time resolving confusion between related topics. Pop quizzes (that measure performance during instruction) are designed to estimate the efficacy of instruction rather than to supplement it. Desirable difficulties findings are robust; why are they not in use? Because desirable difficulties have not been shown in educationally realistic material.

Are Desirable Difficulties Relevant to Classroom Material?

Materials:
12 paragraphs in each of 2 topics (Star formation and Planet formation) presented via the Web-based Inquiry Science Environment.
10 Embedded Assessment Prompts (EAPs), which consisted of a fill-in-blank question and two judgment of learning (JOL) questions (designed to assess metacognition).

Design: 2x2x2 mixed design.
- Between-subjects: (Blocked | Interleaved)
- Between-subjects: (Greater CI | Less CI)
- Within-subjects: whether a presented concept was tested during learning.

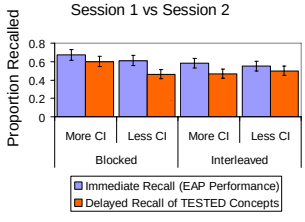
The set of 10 concepts tested during learning was counterbalanced across participants randomly within each combination of the two between-subjects factors, to which participants (71 UCLA undergraduates) were also randomly assigned.



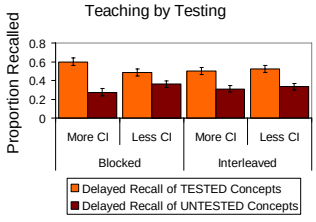
Procedure and Measures:
→ TIME →

Session 1 Part 1	Session 1 Part 2	Delay	Session 2
24 paragraphs 10 EAPs **Immediate Recall**	Survey: use and understanding of desirable difficulties **Metacognitive Sophistication**	48 hours	Post-Test: All 20 EAPs **Retention**

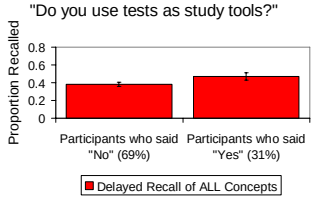
Results



Interleaving: No effect.
Contextual Interference: No effect.



Tested material was better retained.
$F(1,1392) = 63.4$, $p < .05$



Participants who reported using tests as learning events outperformed their less metacognitively sophisticated peers.
$F(1,71) = 4.1$, $p < .05$

Discussion

The retention advantage enjoyed by tested material indicates that pop quizzes should be used for instruction.

The superior performance of participants who use tests as learning events suggests a positive relationship between metacognitive sophistication and overall cognitive ability.

At first glance, our results portray interleaving as neither difficult nor desirable. However, in making our paradigm more educationally relevant, we diverged from traditional desirable difficulties investigations, which have presented verbatim repetitions of learning events (in a blocked vs. interleaved arrangement). We presented several unique pieces of information from each of two *topics*—not the same two pieces of information (one per topic) over and over. This added dimension of interleaving produces a need for review of our manipulation of contextual interference: confusability yielded by similarity.

We also diverged from prior desirable difficulties studies in our measure of tests as learning events. Typically, studies of the effect of generating an answer will compare participants who generate an answer (e.g., to a fill-in-blank question) to participants who read the correct answer; the only difference is the modality of the learning event. We chose to instead preserve narrative coherence and not re-present already-studied material. Importantly, because all participants received 10 EAPs, this manipulation does not detract from our finding of a positive relationship between memory and metacognitive sophistication about desirable difficulty.

References

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