A Comparison of Hints vs. Scaffolding in a MOOC with Adult Learners

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Abstract. Scaffolding and providing feedback on problem-solving activities during online learning has consistently been shown to improve performance in younger learners. However, less is known about the impacts of feedback strategies on adult learners. This paper investigates how two computer-based support strategies, *hints* and *required scaffolding questions*, contribute to performance and behavior in an edX MOOC with integrated assignments from ASSISTments, a web-based platform that implements diverse student supports. Results from a sample of 188 adult learners indicated that those given scaffolds benefited less from ASSISTments support and were more likely to request the correct answer from the system.

Keywords: Feedback Strategies, Hints, Scaffolding, MOOC, ASSISTments.

1 Introduction

Studies have consistently demonstrated the potential of computer-based scaffolding in promoting learning gains during online learning [1–3]. A recent meta-analysis found a moderate effect in problem-based learning in STEM education across various learning contexts [4]. However, the implementation of tutoring strategies varies a great deal (e.g., by types of feedback, the number of levels, and timing) [5–9], resulting in questions about how well results generalize to new platforms and populations.

In this paper, we investigate the effectiveness of two types of tutoring strategies in the context of adult learners: hints and required scaffolds (see Section 2) – replicating the methods originally used by Razzaq and Heffernan [2]. Although we use the same platform as [2] (ASSISTments), our experiment differs from the prior study in two ways. First, our study focuses on adult learners, a comparatively underexplored population [3, 4]. Second, we explore how scaffolding strategies influence learners' interactions within a more open learning environment (a MOOC). As MOOCs become an increasingly complex form of content delivery, we sought to understand how feedback strategies influence adult learner's performance and self-regulation.

2 Method

This work leverages data collected from students enrolled in the edX MOOC Big Data and Education (BDEMOOC) [11]. The course provided eight weeks of content and utilized ASSISTments to deliver assignments each week.

Integration between edX and ASSISTments was made possible by Learning Tools Interoperability (LTI) standards [12, 13]. In each week of BDEMOOC, learners were given an assignment via ASSISTments including 10-11 problems. For each problem, learners could make multiple attempts and request multiple hints. In general, there were three to six levels of hints per problem, followed by the option to request the correct answer to the problem. Students received full credit for completed assignments regardless of the number of attempts or hints requested.

This paper focuses on Week 2 of the course, in which learners were randomly assigned to receive either *hints* or *scaffolding*. Problem content was the same across conditions. Learners in the *hint* condition could request hints on-demand for each problem, the same as all other weeks of the course. Learners in the *scaffold* condition received the same assignment but with scaffolding questions instead of hints. These learners could request to break the problem down before attempting to answer, (similar to requesting a hint). Alternatively, the sequence automatically started if their first answer was incorrect. Once the scaffold sequence was initiated in either case, learners were *required* to complete the entire sequence to proceed to the next problem.

Our dataset was comprised of 188 learners who completed the Week 1 assignment and at least started the Week 2 assignment. To analyze learning gains, we also considered a subset of this data: students that completed *both* weeks and received at least one hint/scaffold in Week 2 (see **Table 1**).

Table 1. Descriptive Statistics of Participants

	N Started Week 2	N Completed Week 2
Learners	188	144
Scaffold Condition	110	81
Hint Condition	78	63

2.1 Measures

From ASSISTments data [14], we derived prior knowledge (operationalized as the percentage of correct first attempts in the week 1 assignment) and two measures of learning performance: the percentage of correct first attempts and the number of times the student requested the correct answer. *Correct Answer Requests* was operationalized as the proportion of questions for which learners requested the correct answer (referred to as *bottom-out hints* in prior work [16]). It should be noted that these two measures have opposite implications: higher correct answer requests implies that the student gave up on a larger proportion of questions, whereas more correct first attempts indicate less need for assistance and thus better learning.

We also collected each learner's interaction and clickstream data from within the edX platform [15]. Based on prior work [16], we derived two measures: 1) time spent interacting with discussion forums, and 2) time spent watching video lectures. Both values (measured in seconds) were calculated from clickstream data by calculating the time between clicks. These durations were then summed per resource per learner. Click-events with durations of an hour or longer were treated as disengaged and were excluded from the sums.

3 Results

ASSISTments Data. We first considered if condition (*hints* or *scaffolding*) impacted assignment completion. An ANOVA test indicated no main effect of condition on assignment completion ($F(1, 186)=1.61$, $p=0.21$). However, we observed a significant interaction between prior knowledge ($M=0.80$, $SD=0.58$) and condition, ($\beta=0.59$, $p=0.01$, $df=184$), indicating that students with lower prior knowledge were significantly less likely to complete the assignment if they were in the *scaffold* condition.

The remainder of our reported analysis considers only students who completed both the Week 1 and Week 2 assignments and received at least one hint/scaffold in Week 2 (see **Table 1**). We first examined if prior knowledge was different between the groups. A t-test found no significant difference in prior knowledge by condition, $t(136.72)=-0.36$, $p=0.72$. Table 2 provides an overview of regressing two performance measures onto condition with prior knowledge as a covariate.

Table 2. Regression analysis of Week 2 performance measures: First Attempt (or the percentage of correct first attempts) and Correct Answer Requests.

	First Attempt		**Correct Answer Requests**	
Predictors	*std. β*	*p*	*std. β*	*P*
(Intercept)	0.07	**<0.001**	-0.15	**<0.001**
Condition [Scaffold]	-0.13	0.388	0.28	**0.053**
Prior	0.35	**0.003**	-0.38	**0.001**
Condition [Scaffold] * Prior	0.20	0.175	-0.25	0.083

No significant effects of condition were observed for correct first attempts. However, when predicting correct answer requests, our analyses showed main effects for both condition and prior knowledge (**Table 2**). Simple slopes analysis showed that less knowledgeable learners (1 SD below the mean) in the *scaffolding* condition tended to ask for the correct answer more frequently ($p<0.01$), as did average (at the mean) learners ($p<0.05$).

We next considered how the computer-based tutoring strategies impacted learners' interactions with two MOOC resources: lecture videos and the discussion forum. We regressed time spent on each resource during Weeks 2 to 8 onto condition (*hints vs. scaffolds*), including the respective time spent in Week 1 as a covariate to account for individual differences (**Table 3** & **Table 4**). No effects were observed beyond Week 5, so the regression results for these weeks are omitted from the tables.

We note no main effect of condition for use of either resource. We did, however, observe interactions between prior usage and condition when predicting future usage. Learners who previously spent more than average time viewing videos were less likely to do so in the future if assigned to the scaffolding condition. For forum use, learners that had previously high forum use were more likely to continue to have high forum use if in the scaffolding condition.

Table 3. Results from the regression analysis conducted on time spent (TS) on lecture video use from Weeks 2 to 5 of the MOOC.

	TS Videos Week2		TS Videos Week3		TS Videos Week4		TS Videos Week5	
Predictors	*std. β*	*p*	*std. β*	*p*	*std. β*	*p*	*std. β*	*p*
(Intercept)	0.10	0.212	0.09	0.867	0.19	0.816	-0.02	0.171
Condition [Scaffold]	-0.16	0.643	-0.13	0.529	-0.30	0.489	0.02	0.472
TS_Videos_Wk1	0.77	**<0.001**	0.86	**<0.001**	0.85	**<0.001**	0.41	**0.001**
Condition [Scaffold] * TS_Videos_Wk1	-0.08	0.526	-0.23	0.063	-0.41	**0.004**	0.16	0.286

Table 4. Results from the regression analysis conducted on time spent (TS) on forum use from Weeks 2 to 5 of the MOOC.

	TS Forum Week2		TS Forum Week3		TS Forum Week4		TS Forum Week5	
Predictors	*std. β*	*p*	*std. β*	*p*	*std. β*	*p*	*std. β*	*p*
(Intercept)	-0.04	**<0.001**	-0.13	**0.001**	0.05	**0.02**	-0.16	**0.030**
Condition [Scaffold]	0.06	0.377	0.22	0.482	-0.08	0.879	0.27	0.873
TS_Forum_Wk1	0.16	0.174	0.03	0.765	0.17	0.186	0.04	0.763
Condition [Scaffold] * TS_Forum_Wk1	0.36	**0.020**	0.55	**<0.001**	-0.08	0.632	0.48	**0.003**

4 Discussion and Conclusions

This study detailed how feedback strategies (*hints* and *required scaffolding* after errors) impacted adult learners' performance and interactions within a MOOC. Our results revealed that *scaffolding* was associated with poorer performance and that this influence was mediated by prior knowledge. Less knowledgeable learners in the *scaffolding* condition requested significantly more correct answers, indicating that they benefited less from scaffolds and failed to solve later problems. This is contrary to [19], which showed that middle schoolers with low prior knowledge benefited more from scaffolding.

One potential explanation might be the difference in learner groups. Scaffolding may hinder instead of support MOOC learners as it breaks the expected balance between external and internal regulation [20], especially for learners who may expect greater agency. For MOOC learners (typically adults) who value autonomy in regulating the learning process [21, 22], requiring them to complete scaffolds may negatively impact performance and future learning behaviors. Future work should investigate purely on-demand *scaffolding* (i.e., learners are not required to complete full sequences) to examine the learning differences that additional agency may afford.

As such, it will be important for future research to consider how and when feedback is delivered to adult learners. With increasing use of learning technologies by adult populations, it is important to consider what K-12 research generalizes to older populations with different learning demands. Although the implementation of *scaffolding* differs across learning systems, this work serves as an initial step towards developing effective feedback standards for adult online learners.

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