Learning from Collaboratively Observing Videos during Problem Solving with Andes

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Abstract. Learning by observation has long been a traditional method of learning. Recent work has pointed toward collaboratively observing tutoring as a promising new method for observational learning. Our current study tested this new method in the PSLC physics LearnLab where students were introduced to topic of rotational kinematics by observing videos while problem solving in Andes. The students were randomly assigned to a pairs condition that collaboratively observed a video of an expert tutoring or providing an example, or to a solo condition that observed a video of an expert worked example. Several robust and normal learning measures were collected, however, to date only multiple choice measures have been analyzed. Students' performance on the multiple choice questionnaires revealed significant pretest to posttest gains for all conditions. To date there no differences have been found among conditions. A trend in the data (p=.05) indicates a section effect that impacted the collaboratively observing of expert tutoring condition that still needs to be explored. However, if the non significant group differences stand, then one interpretation is that as long as students solved the problems correctly, it doesn't matter what kind of scaffolding they used; they will learn just as much with any kind.

Learning from observation is a common and natural method of human learning. Observation has long been seen as a key learning method for children when acquiring basic tasks such as language [1] and cultural norms [11]. Within psychology, research on human learning from observation dates to the preliminary work by Bandura [3] and over the years has been referred to under various titles such as observational learning, social learning, and vicarious learning (e.g., [3] [9]). Observational learning has been investigated in various settings such as using real time observations, video tapes of humans and cartoons, and listening to audiotapes ([4] [12]).

Observing tutoring has recently emerged as promising new focus in the literature on observation ([6] [7]). By observing tutoring, we mean that a student observes and overhears the dialogue between a tutor and a tutee. If students can learn as effectively from observing tutoring as from interacting with a tutor, then we would have an effective alternative for human tutoring, which is labor-intensive, and for intelligent computer tutoring (ITS), which is expensive to develop.

The evidence for the benefit of observing tutoring has been mixed, but systematic. Craig et al. ([7] Experiments 1) contrasted pretest to posttest gains of low-knowledge learners (tutees) who interacted directly with AutoTutor [10] to that of yoked low-knowledge solo observers. AutoTutor is a natural-language ITS that tutors 12 computer literacy topics. As tutees interacted with AutoTutor, the visual and auditory contributions of AutoTutor and the contributions of each learner were recorded. Students in the observing condition were shown these recordings. The results of immediate pretest to posttest showed that the tutees significantly outperformed the observers.

In a second experiment, Craig et al. ([7], experiment 2) attempted to improve learning by adding **a** third collaboratively observing condition because having the capability to collaborate has been shown to improve learning and provide a deeper understanding of the material (See 8). In the collaborative condition, two participants together at a computer monitor watched the video of an interactive AutoTutor session on computer literacy. The collaborative observers were encouraged to pause the video and talk to each other about information in the video. As in the first experiment, immediate pretest to posttest results showed once again the tutees outperformed the solo observers. While the collaborative observers' gains showed improvement over the solo observers, the difference was not significant enough to become reliable . However, the collaborative observer gains were elevated to the point that they were no longer significantly lower than the tutees' gains.

Chi et al. [6] investigated learning from observing tutoring using an expert tutor instead of an intelligent tutoring system and a more complicated topic, solving physics problems. The study compared the learning outcomes of five different instructional conditions; the three that are pertinent to this paper are: one-to-one tutoring with an expert tutor, observing tutoring collaboratively, and observing tutoring alone. Ten expert tutoring sessions were recorded, then the videos were studied either by pairs of students or by students working alone. Unlike the Craig et al. experiments, all participants in this study also solved the problems as they were observing them being solved. The collaborative observers' gains were not significantly different from the tutees' gains, and both were significantly greater than the solo observers' gains. The collaborative observers' gains were not significantly different from the tutees' gains, and both were significantly greater than the solo observers' gains.

Although this is exactly the same pattern of results as in the Craig et al. ([7], Exp. 2), Chi et al. found that collaboration did improve learning for collaborative observers over solo observers. One explanation for this discrepancy is the amount of collaboration. A follow up analysis of audio tapes of the Craig et al. Experiment 2 revealed that collaborative observers found that they had an average of 2.91 conversational turns per session with an average session lasting 35 minutes, whereas the collaborative observers in the Chi et al study produced on average 121.22 conversational turns per 35 minute interval. The increased level of collaboration was most likely due to the task demands of the study. While the Craig et al. study did not require learners to perform any task other than watching the video, learners in the Chi et al study performed a problem solving task while observing tutoring.

Chi et al. divided tutees into high ability and low ability, based on a median split on their pretest scores. The video tapes of the high ability tutees produced more gains from the collaborative observers than the video tapes of the low ability tutees. Because the videos of the high ability tutees had fewer tutee errors and remediation episodes than videos of the slow learners, this may have raised their effectiveness as scaffolding instruments. This suggests that a video that has no errors at all might be even more effective still. Such a tape would be essentially a worked example—a demonstration of a correct solution to the problem.

The study reported here took this methodology into the classroom and tested the scaffolding explanation. In doing so, we compared collaborative observers of a video of tutoring (Collaboratively observing tutoring condition) to collaborative observers of a video of a worked example (Collaboratively observing examples condition). A third condition, Solo observing examples condition, was comprised of solo observers of a video of a worked example, as this most closely matches the many studies of worked example studying in the literature. Since Chi et al. [6] did not find learning gains for individuals observing expert tutoring, the solo observing of expert tutoring condition was not taken into the classroom in order to avoid exposing students to an ineffectual learning condition.

United States Naval Academy (USNA) students (Age: 18-19; $N = 68$) from three sections of the PSLC physics LearnLab (www.learnlab.org) were randomly assigned to one of three conditions described above. They solved rotational kinematics problems using the Andes tutoring system while simultaneously watching a video showing the same problems being solved. A problem solving task during observing was chosen in order to increase active learning with the task as seen in the Chi et al study. The video showed either a tutorial dialogue with an expert physics tutor assisting a student who was solving Andes problems, or a worked example with the same expert solving the same Andes problems while explaining the steps orally. This acquisition phase occurred before the material was covered in the course. The students were assessed individually immediately after training using two multiple-choice tests that required knowledge transfer and three Andes transfer problems on rotational kinematics. The two multiple-choice tests were alternated between students as pretest and posttests. Long term measures of Andes logs from homework problems and classroom tests were also collected.

At this writing, only the multiple-choice tests have been analyzed. They show that all students gained significantly from pretest to posttest, $F(1, 65) = 14.987$, $p < .001$. However, there were no significant differences among conditions on the multiple choice tests. That is, the collaborative observers of tutoring, the collaborative observers of worked examples, and the solo observers of worked examples all seem to have learned the same amount. This lack of significance did not appear to be due to a ceiling effect among the conditions given the means (See Table 1). However, the data were highly variable and there is marginal evidence for a section effect within the collaboratively observing tutoring condition ($F(1,26) = 4.123$, $p = .05$) because one section ($M = -.07$) gained less than the other two sections ($M = 0.22$). Several outcome measures including the process data from training have not yet been analyzed, so the final results are still an open question.

Table 1. *Means and standard deviations for pretest, posttest and gain scores for the three conditions*

Condition	Pretest		Posttest		Gain scores	
	M	SD	M	SD	M	SD
Solo observing examples	.58	.23	.69	.18	.11	.20
Collaboratively observing examples	.57	.22	.65	.20	.08	.19
Collaboratively observing tutoring	.58	.19	.67	.17	.08	.16

However, if the non-significant group differences stand, then one interpretation is that as long as students solved the problems correctly, it doesn't matter what kind of scaffolding they used; they will learn just as much with any kind [2]. The tutees, including those working with Andes, always solved the problems correctly, so those conditions always tie. The collaborative observers who are both required to solve problems and have a video of a correct solution available will also tend to solve all the problems, unless the video is too cluttered with errors to bother with and thus occasionally gets ignored. Solo observers who are required to solve problems tend more frequently to "go it alone" and ignore the video, and thus more frequently fail to follow a completely correct solution path. Observers who only watch the video may not even attend to the solution path, and thus learn the least. However, this interpretation is only based on the multiple choice data and thus is still speculative at this point. This pattern could change when the learners process data from the task (e.g. level of collaboration, task engagement or video use) and long-term measures from the homework and tests are analyzed.

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