

# The Relationship Between Active Learning and Long-Term Retention in an Introductory Statistics Course

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## 1. Active Learning Methods

In statistics, *active learning* (AL) methods include projects with class participation and hands-on experiments. Projects might involve sampling, regression analysis, experimental design and the analysis of variance. Cooperative learning is a form of AL in which small group interaction leads learning via peer instruction. Johnson and Johnson (1975) discuss various situations in which cooperative learning helps to create an environment where students are more inclined to question the concepts that appear unclear to them. It is not fully known how AL methods effect long-term memory. Current beliefs about long-term memory are based models for which the meaningful stimuli are processed by the brain at a deep level. These models attribute long-term memory to our ability to process semantic knowledge deeply by associating the recalled items according to their meaning, rather than the frequency it was reinforced. Craik and Tulving (1975) showed that deeper processing of a memorized word occurred when the subject was asked about the word's meaning versus being asked about the word. This suggests that long-term memory is enhanced by using methods where the student is familiarized with the material through understanding real examples, rather than studying only mathematical concepts.

We compare the effects of cooperative learning methods to the effects of traditional learning methods in teaching two sections of an undergraduate statistics course. Student projects were the main application of AL methods into the lectures, and are further detailed in Kvam (1998). The first class was taught using traditional lecture-style learning methods, while the next class was taught stressing AL methods. We investigate the teaching effect on the students' *long-term ability* to retain the material learned in class by testing students immediately after the course concluded, and then having them return eight months later to be tested again, to see retention. Details of the 18-point test are discussed in Kvam (1998), and the results of the experiment are listed in Table 1 below:

Traditional Lecture Class (23 students)	Active-Learning Class (15 students)
(18,11), (14,14), (14,6), (18,16), (18,14), (15,12), (18,17), (18,16), (18,13), (9,1), (15,10), (12,6), (17,14), (18,6), (15,14), (13,7), (17,14), (18,12), (14,7), (13,6), (16,11), (14,8), (15,13)	(14,14), (15,10), (18,11), (16,8), (17,17), (12,9), (17,11), (15,13), (17,12), (14,13), (17,14), (13,11), (15,11), (18,15), (14,9)

**Table 1.** Exam scores for students in traditional and active learning classes. First value in pair is score on first exam. Second value is the same student's score on the second (retention) exam.

## 2. Results of Data Analysis

To measure student retention, we used the ratio of the student's second exam score over their first exam score, and used the arcsine function as a variance-stabilizing transformation. A linear model using teaching method (active vs. traditional) and test (two similar versions) as inputs reveals that the test version had no significant bearing on the transformed output of the experiment. Also, there is no sign of interaction between the test version and the teaching method; p-values for hypothesis tests concerning both model terms were greater than 0.7. The teaching method factor was more significant in this model, but the p-value associated with this term in the model was 0.17. The average retention is greater for the AL group, but a one-sided t-test comparing teaching

methods (assuming unequal variances) also produces a somewhat inconclusive p-value of 0.08. There is insufficient sample evidence to champion the AL methods, in any case.

The data suggest that differences between the two groups are not well explained from these tests because students who scored well on the first test exhibited equal abilities in remembering the course material for the second exam, no matter what method of teaching was applied. In Table 2, the claimed effect that poor students from the AL class have better retention can be seen; the odds ratio for the first table is 17 times higher than that of the second table. However, according to the log-linear model, the data do not lend sufficient evidence that AL has a significant effect on the interaction between the test and score categories; the p-value associated with this term is 0.11.

	<u>Traditional Learners</u>		<u>Active Learners</u>	
	Low, Test 2	High, Test 2	Low, Test 2	High, Test 2
Low, Test 1	7	1	2	3
High, Test 2	2	13	2	8

**Table 2. Cell frequencies for students in traditional and active learning classes. A low score on the first exam is defined as a test score of 80% or less. A low score on the second exam is defined as a test score of 60% or less.**

The results of this experiment indicate that AL methods might be helpful to the average student in our introductory statistics course. Unfortunately, insufficient data prevented us from making any strong statistical claim to this effect. It can be argued that with a well-written textbook and an effective lecturer, good students can assimilate course material well enough. After all, most university instructors learned college course material this way during their period of study, and generally met with success. However, instructors may fail to empathize with the relatively mediocre students under their tutelage, and consequently might not understand their need for illustration and repetition in learning the class concepts. AL methods present a way to offer this supplemental support to the students who fail to grasp the course material from the traditional lectures.

## FRENCH RESUME

Une expérience a été exécuté pour examiner les effets à long terme de méthodes actives qui apprennent sur la rétention d'étudiant dans une classe de statistique d'introduction qui construit. Deux classes d'étudiants ont participé dans l'étude; une classe a été enseignée l'utilisation conférence traditionnelle apprentissage basé, et l'autre classe les projets de groupe accentués et l'apprentissage coopératif méthodes basées. La rétention a été mesurée en examinant les étudiants immédiatement après le cours fini, et d'autre part huit mois plus tard.

## REFERENCES

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