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Recommended Citation

Harrison W. Straley & Lauren Dupee, "One + One > Two: The Effects of Pair Quizzes on Student Attitudes and Perceptions," *Journal of Humanistic Mathematics*, Volume 7 Issue 2 (July 2017), pages 318-339. DOI: 10.5642/jhummath.201702.16. Available at: <https://scholarship.claremont.edu/jhm/vol7/iss2/16>

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One + One > Two: The Effects of Pair Quizzes on Student Attitudes and Perceptions

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Synopsis

Pair Quizzes are cooperative pop quizzes, taken by a pair of students working together for the same grade. The first author, Chuck, had used pair quizzes in many of his courses through his tenure teaching and was interested in determining their perceived effect on student learning and attitude toward mathematics. To this end, we designed a questionnaire and distributed it to all students currently taking and who had taken two different mathematics courses within a span of four years. Responses from those who chose to complete the survey seem to indicate that the pair quizzes had a positive effect on students’ perceived learning and on their perceived attitude toward mathematics, as we had originally hoped.

1. Introduction

Several researchers have looked at the relationship between study habits and GPA of college students. For example, Born *et al.* found that students who worked in groups while studying the same material seemed to have improved test performance [4]. Bruce Sacerdote looked at the effects of peers on academic performance and found that an individual’s peers have an impact on the individual’s GPA [19]. However, far fewer researchers seem to have

examined the impact that studying in groups has on perceived learning of mathematics and perceived attitude toward mathematics. The purpose of this study is to examine the effects of studying mathematics in groups on students' perception of how well they do in the class and on their perception of their attitude toward mathematics.

Jaramillo [10] states that "Vygotsky stressed that the mind and the body of the subject are joined", and that this connection is further expressed between the subject and objects in his environment. The subject develops his own "interpretative meaning of an act while communicating with others." Johnson, Johnson, and Smith [15] suggest that college students learn better if "check points occur in small cooperative groups" (pages 5–18). Ruhl, Hughes, and Schloss [18] conducted a study in which short pair discussions used as part of college lectures improved retention of material. The lecturer would pause for a few minutes (12 to 18) in which time the students would discuss the lecture with a partner and together modify their notes. The students who spent the time discussing the lecture learned more than did a control group.

Moll [17, page 168] reports that the great majority of research studies examining the effect of cooperative learning with group rewards found those who were grouped did much better than those who worked individually. While most of these studies were done on elementary students and in some cases secondary school students, the authors contend there is little reason not to expect similar results from college students. Johnson, Johnson, and Smith [15] discuss many ways to get college students to work together on various projects. They contend, with significant evidence, that students who work together learn more than students who are not in some form of learning group setting. Their results imply that when students work together on a question to the point of consensus the group discussion enhances each member's learning.

Bilsky-Torra [2] and Jensen, Johnson, and Johnson [11] have concluded that assigning a group grade can increase motivation and performance. Ewald [7] reported that students who participated in a group testing situation "expected to perform better and feel more confident on future assessment tasks".

Ewald also notes that teachers avoid using "collaborative work in assessment contexts" because teachers must submit individual grades. Clearly it is impossible to accurately measure the individual learning of each of two partners

if both contributed to answering the questions that were posed. Therefore it is important that the impact of the shared grade on the final grade be small. In this paper, we propose that such collaborative activities may well increase both students' learning and perhaps even improve their attitude toward the subject being studied. We also suggest that the portion of the final grade associated with our proposal be in the neighborhood of 2%.

In this paper, we describe an assessment tool that both evaluates instructional progress and also helps students learn the material. The assessment tool is a direct result of Chuck's experience with cooperative learning when he was a secondary school mathematics teacher. During that time, he learned about cooperative learning and included "pair quizzes" (an alternative name is "partner quizzes") as part of his instructional strategies in ninth grade Algebra I classes as well as in Algebra II, Pre-Calculus, and AP Calculus classes. Pair Quizzes are cooperative pop quizzes, taken by a pair of students working together for the same grade. In Chuck's high school classes students did most of their in-class work with a partner. Partners were reassigned every two or three weeks. When he began teaching at the college level Chuck continued to include pair-quizzes as an integral part of his courses. After years of using pair quizzes in many different classes, he eventually decided to explore more systematically their perceived effect on student learning and attitude toward mathematics. Lauren, a first-year math major in Chuck's Introductory Statistics course at the time, volunteered to help with this research because of her interest in other students' perception of mathematics.

In our college setting students pair off with a different partner each quiz time to take a pair-quiz or a partner quiz. The pair-quizzes are administered every two or three classes and count for about 2% of each student's course grade. The graded pair quizzes are returned at the next class meeting.

These quizzes have two primary purposes. The first is to help the instructor monitor student progress and assess how well students have grasped important concepts. Students who do poorly on a pair quiz are encouraged to see the instructor or attend "drop-in" tutoring sessions that are available during the late afternoons and evenings. If many student-pairs do poorly the content of the pair-quiz is re-taught to the entire class. The second purpose is to provide an environment where students can teach each other and learn from each other. In these situations we contend that both the "tutor" and the "tutee" benefit.

This paper examines students' reactions to pair-quizzes in two different mathematics courses: Introductory Statistics and Mathematics for Elementary Teachers; both taught by Chuck at a small liberal arts college, Wheaton College in Norton, Massachusetts. The number of students in each section of these courses was about thirty.

We should also note that Chuck's teaching methodology includes many opportunities for small groups of students (2 to 4) to interact and discuss among themselves. In fact, this process is an integral part of his instructional strategies. Hence, the students are expected to share with each other during class time and the use of pair quizzes is a natural extension of these class procedures.

2. Procedure and Results

The subjects of this study were students in either of the above-mentioned courses over a four-year period, Fall 2006 through Spring 2010. Students in the first four semesters (Fall 2006 through Spring 2008) were contacted through email and asked to answer the questionnaire shown below. Students in the Fall 2008 through Spring 2010 answered the questionnaire on the last day of class. In order to keep Chuck, who was the instructor of the course, unaware of which students had responded to the survey as well as their actual responses, Lauren did all the emailing and recording of the survey responses. She, at no time, identified which students responded and how a particular student answered the various survey questions. Students were free to ignore the survey and many certainly did. A few students were in both the Math for Elementary Teachers and the Statistics class; these students were asked to respond to the survey for only the course they took first. This procedure yielded a return of 203 out of a total of 351 possible students, a 58% return.

A facsimile of the survey is shown on the following pages; a full copy is provided in the appendix as well. The number of responses to each question/option is shown as an ordered triple representing the number of responses from students in the Math for Elementary Teachers course, then the number of responses from students in the Statistics course, then the total number of responses (this ordered triple is denoted: (MET, Stat, Total). These numbers are in bold italics. The reader will note that some students did not answer all questions so there are fewer than 203 total responses for some of the questions.

The investigators categorized the “free response” answers to the last question into three groups depending upon the perceived effect of pair quizzes on learning. The first group, denoted as the positive group, consisted of those responses indicating that the respondent felt that pair quizzes had a positive influence on learning and/or mathematics attitude. The second group consisted of those responses that made no reference to the effect of pair quizzes on learning and/or attitude, or consisted of both positive and negative influences of pair quizzes on learning and/or attitude. This group of responses is referred to as the neutral group. The third, negative, group consisted of those responses that indicated pair quizzes had a negative influence on learning and/or attitude.

Much of following analysis depends upon the accuracy with which students were able to report their personal perception of how their individual mathematics attitude and their individual learning were affected by the “pair quiz experience”. Many authors consider such self-perceptions to be reasonably accurate [1, 6]. On the other hand others (see for instance [20]) argue with considerable support that self-perception is not particularly accurate. It is not the purpose of this paper to argue the accuracy of self-perception. We recognize there may be problems associated with the accuracy of self-perception, especially as it may be related to “attitude toward mathematics”.

Our question regarding attitudes asked each responding student to reflect upon the effect of pair quizzes on their attitude toward mathematics. We did not ask the students to rate their attitudes. Also, each student was free to simply not answer the question and hence not participate in the study. Each responding student’s perception is what we measure and we must admit that we do not know the accuracy of these perceptions. Similarly, with regard to the effect of pair quizzes on a student’s learning, we measure the student’s perception, not the accuracy of these perceptions.

Survey on Pair Quizzes for Math for Elementary Teachers and Introductory Statistics

A1) *Gender:*

— Female (**55, 96, 151**)

— Male (**2, 48, 50**)

— Other (**0, 2, 2**)

A2) *Course:*

- Math for Elementary Teachers (**57**)
- Stats (**146**)

A3) *Your school year when you took this course:*

- First Year (**26, 12, 38**)
- Sophomore (**23, 96, 119**)
- Junior (**4, 30, 34**)
- Senior (**4, 7, 11**)

A4) *Which of the following best reflects your work (grade) in this course:*

- I did well (**34, 85, 119**)
- I did OK (**20, 53, 73**)
- I did poorly (**3, 8, 11**)

Please answer each of the following by ENTERING AN "X" AFTER THE APPROPRIATE RESPONSE:

B1) *Rate your ATTITUDE toward math at the BEGINNING of the course:*

- 1 (Very Negative) (**7, 18, 25**)
- 2 (**17, 34, 51**)
- 3 (Neutral) (**17, 47, 64**)
- 4 (**8, 31, 39**)
- 5 (Very Positive) (**8, 16, 24**)

B2) *Rate your ATTITUDE toward math at the END of the course:*

- 1 (Very Negative) (**3, 2, 5**)
- 2 (**8, 25, 33**)
- 3 (Neutral) (**18, 52, 70**)
- 4 (**16, 49, 65**)
- 5 (Very Positive) (**12, 18, 30**)

B3) *Select the statement that best indicates how YOUR ATTITUDE toward math was influenced, if at all, by the pair quizzes.*

- The pair quizzes caused me to have a MUCH MORE POSITIVE attitude toward math. (**2, 7, 9**)
- The pair quizzes caused me to have a MORE POSITIVE attitude toward math. (**17, 34, 51**)
- The pair quizzes DID NOT CHANGE my attitude toward math. (**35, 99, 134**)
- The pair quizzes caused me to have a MORE NEGATIVE attitude toward math. (**2, 5, 7**)
- The pair quizzes caused me to have a MUCH MORE NEGATIVE attitude toward math. (**0, 0, 0**)

B4) *Select the statement that best indicates how YOUR LEARNING of the material was influenced, if at all, by the pair quizzes.*

- The pair quizzes GREATLY HELPED my learning of the material. (**2, 17, 19**)
- The pair quizzes HELPED my learning of the material. (**36, 103, 139**)
- The pair quizzes HAD NO EFFECT on my learning the material. (**15, 21, 36**)
- The pair quizzes HINDERED my learning of the material. (**3, 3, 6**)
- The pair quizzes GREATLY HINDERED my learning of the material. (**0, 0, 0**)

B5) *Select the statement that best indicates how STRESSFUL you found the pair quiz experience.*

- Taking pair quizzes was a VERY STRESSFUL experience. (**2, 6, 8**)
- Taking pair quizzes was a STRESSFUL experience. (**9, 24, 33**)
- Taking pair quizzes was a MINIMALLY STRESSFUL experience. (**29, 73, 102**)

— Taking pair quizzes was NOT AT ALL STRESSFUL. (**16, 40, 56**)

B6) *Was the NUMBER of pair quizzes appropriate?*

- 1 (Way Too Many) (**1, 8, 9**)
- 2 (**12, 42, 54**)
- 3 (About Right) (**34, 77, 111**)
- 4 (**9, 16, 25**)
- 5 (Way Too Few) (**0, 0, 0**)

B7) *Enter an X after ALL answers that apply to CHANGING PAIR QUIZ PARTNERS.*

Changing pair quiz partners:

- was a waste of time. (**8, 30, 38**)
- helped me to meet different students. (**26, 73, 99**)
- helped me to understand multiple ways of solving a given problem. (**21, 43, 64**)
- helped remove some of the “quiz” pressure. (**27, 63, 90**)
- allowed me to learn from students who better understood the material. (**36, 88, 124**)
- allowed me to help students who understood less than I did. (**24, 63, 87**)

C1) *Please tell us in your own words, what you think of the practice of using “pair quizzes”.*

Thanks again for taking the time to respond to this survey. We appreciate your time and effort.

3. Analysis

The responses to certain questions are analyzed in the following paragraphs. Note that the numbers in bold italics are the number of responses associated with each choice. In some cases the number of responses do not sum to 203 because some subjects did not respond to all questions.

Questions B1 and B2 are indicated below:

B1) *Rate your ATTITUDE toward math at the BEGINNING of the course:*

- 1 (Very Negative) (**7, 18, 25**)
- 2 (**17, 34, 51**)
- 3 (Neutral) (**17, 47, 64**)
- 4 (**8, 31, 39**)
- 5 (Very Positive) (**8, 16, 24**)

B2) *Rate your ATTITUDE toward math at the END of the course:*

- 1 (Very Negative) (**3, 2, 5**)
- 2 (**8, 25, 33**)
- 3 (Neutral) (**18, 52, 70**)
- 4 (**16, 49, 65**)
- 5 (Very Positive) (**12, 18, 30**)

The sample's before mean attitude had a value of 2.93 while the after mean attitude had a value of 3.4. Using the null hypothesis

$$H_0 : \mu(\text{beginning math attitude}) - \mu(\text{end of course math attitude}) = 0,$$

and a paired-t test, we calculate a t value of -4.33 which yields a P value $< .0005$. We therefore reject H_0 and conclude that there is sufficient evidence to indicate that:

$$\mu(\text{beginning math attitude}) < \mu(\text{end of course math attitude}).$$

In other words there is sufficient evidence to indicate that the mean student self-perceived mathematics attitude at the beginning of the course is less

than at the end of the course. We can, with some justification, assume the students' attitudes toward mathematics improved from the beginning to the end of the course. This is, of course, quite flattering, but we cannot conclude that the pair quizzes contributed to this perceived attitude improvement.

In order to test the perceived impact of pair quizzes on mathematics attitude, we examine the responses to question B3 below. The numbers in parentheses “()” indicate the numeric value assigned to that response. We are well aware that we are assigning ratio values (actually real number values) to ordinal data. However, this is a common practice.

B3) *Select the statement that best indicates how YOUR ATTITUDE toward math was influenced, if at all, by the pair quizzes.*

- (+2) The pair quizzes caused me to have a MUCH MORE POSITIVE attitude toward math. (**2, 7, 9**)
- (+1) The pair quizzes caused me to have a MORE POSITIVE attitude toward math. (**17, 34, 51**)
- (0) The pair quizzes DID NOT CHANGE my attitude toward math. (**35, 99, 134**)
- (-1) The pair quizzes caused me to have a MORE NEGATIVE attitude toward math. (**2, 5, 7**)
- (-2) The pair quizzes caused me to have a MUCH MORE NEGATIVE attitude toward math. (**0, 0, 0**)

Note that 60 of 203 students felt that the pair quizzes helped them develop a more positive attitude toward mathematics while only 7 felt the pair quizzes diminished their attitude toward mathematics.

The sample mean score was 0.31, about one-third of the way from “did not change my attitude toward math” to “caused me to have a more positive attitude toward math”. Using the null hypothesis:

$$H_0 : \mu(\text{attitude was influenced by pair quizzes}) = 0,$$

(that is, μ “did not change”) and a 1-t test, we calculate a t value of 7.15 and a P value $< .0005$. We, therefore, reject H_0 and conclude there is sufficient evidence to indicate that $\mu > 0$. In other words there is sufficient evidence to

conclude that “pair quizzes caused [students] to have a more (or much more) positive attitude toward mathematics”. This result seems very encouraging and gives the authors hope that pair quizzes may positively impact attitude toward mathematics and other disciplines as well. The self-evaluation may be questionable, especially since the scale (much more positive to much more negative) may be too vague. On the other hand the results are quite significant, $t = 7.15$ is difficult to ignore.

The above results deal with attitude and not learning; we now examine the perceived relationship between pair quizzes and learning referred to in question B4 below.

B4) *Select the statement that best indicates how YOUR LEARNING of the material was influenced, if at all, by the pair quizzes.*

- (+2) The pair quizzes GREATLY HELPED my learning of the material. (**2, 17, 19**)
- (+1) The pair quizzes HELPED my learning of the material. (**36, 103, 139**)
- (0) The pair quizzes HAD NO EFFECT on my learning the material. (**15, 21, 36**)
- (-1) The pair quizzes HINDERED my learning of the material. (**3, 3, 6**)
- (-2) The pair quizzes GREATLY HINDERED my learning of the material. (**0, 0, 0**)

We note that 158 of the 200 students who chose to answer this question felt that pair quizzes helped them learn the material while only 6 felt that the pair quizzes negatively affected their learning.

The sample mean score was 0.86, about three quarters of the way from “had no effect on my learning the material” to “helped my learning of the material”. Using the null hypothesis:

$$H_0 : \mu(\text{pair quizzes had an effect on my learning the material}) = 0,$$

(that is, “The pair quizzes DID NOT CHANGE my attitude toward math”) and a 1-t test, we calculate a t value of 19.72 which yields a P value $< .0005$. We, therefore, reject H_0 and conclude that there is sufficient evidence to indicate that μ (learning was influenced by pair quizzes) > 0 . In other words

there is sufficient evidence to indicate that the mean student self-perceived mathematics learning improved as a result of the pair quizzes. This result is very encouraging and gives the authors hope that pair quizzes do positively impact both learning and attitude. Once again, the self-evaluation may be questionable, especially since the scale (“much more positive” to “much more negative”) may be too vague. On the other hand the results are very significant as $t = 19.72$ is very hard to ignore.

We next evaluate the stress on students who take pair quizzes, by analyzing the 199 responses to (B5).

B5) *Select the statement that best indicates how STRESSFUL you found the pair quiz experience.*

- (3) Taking pair quizzes was a VERY STRESSFUL experience. (**2, 6, 8**)
- (2) Taking pair quizzes was a STRESSFUL experience. (**9, 24, 33**)
- (1) Taking pair quizzes was a MINIMALLY STRESSFUL experience. (**29, 73, 102**)
- (0) Taking pair quizzes was NOT AT ALL STRESSFUL. (**16, 40, 56**)

We find that the 95% confidence interval is (.86, 1.07). In other words the range is from a little less than minimally stressful to a little more than minimally stressful. One can conclude with 95% confidence that the stress of a pair quiz is in the neighborhood of minimally stressful.

Next we analyze the 199 responses to the question regarding the appropriate number of pair quizzes, (B6).

B6) *Was the NUMBER of pair quizzes appropriate?*

- 1 (Way Too Many) (**1, 8, 9**)
- 2 (**12, 42, 54**)
- 3 (About Right) (**34, 77, 111**)
- 4 (**9, 16, 25**)
- 5 (Way Too Few) (**0, 0, 0**)

We find that the 95% confidence interval is (2.66, 2.87), which implies that the students found the number of pair quizzes to be “a little” too many. Most experienced teachers will not be surprised by these results, nor would they let these results modify their professional judgment as to when and how often to use quizzes or pair quizzes.

We now evaluate the responses to question (B7) in which the students could choose several options regarding “Changing Pair Quiz Partners”.

B7) *Enter an X after ALL answers that apply to CHANGING PAIR QUIZ PARTNERS.*

Changing pair quiz partners:

- ___ was a waste of time. (**8, 30, 38**)
- ___ helped me to meet different students. (**26, 73, 99**)
- ___ helped me to understand multiple ways of solving a given problem. (**21, 43, 64**)
- ___ helped remove some of the “quiz” pressure. (**27, 63, 90**)
- ___ allowed me to learn from students who better understood the material. (**36, 88, 124**)
- ___ allowed me to help students who understood less than I did. (**24, 63, 87**)

64 students (32% of all students) felt pair quizzes helped them “understand multiple ways of solving a given problem”. 90 students (44% of all students) felt pair quizzes “helped remove some of the quiz pressure”. 124 students (61% of all students) felt the pair quizzes allowed them “to learn from students who better understood the material and 87 students (43% of all students) felt pair quizzes allowed them “to help students who understood less than I did”. Overall it seems that many students found these pair quizzes helpful, and in a range of ways, just as we had hoped.

Of course it is possible to see these percentages and wonder about the complements; what did the students who did not choose these items think? But seeing that the lone negative item was selected by a small minority (38 out of 203, or 19% of all students), we can feel comfortable with our positive interpretation of the remaining numbers.

We classified the open ended responses (C1) as positive when we felt these students indicated that they considered the pair quizzes to have a positive impact on learning. We classified the open ended responses as neutral when we felt the student's response was both positive and negative with regard to pair quizzes impacting learning or when the student did not appear to judge pair quizzes and learning. Of the 203 responses, we classified 97 as positive, 96 as neutral (59 of these were blank), and 10 as negative with regard to pair quizzes impacting learning.

Examples of various responses to the open ended question (C1) are shown below.

The following are examples of positive student responses regarding the impact of pair quizzes on learning:

"I thought the pair quizzes were a nice and unstressful way to be tested. If you were unprepared someone could help you, and if you knew the info you could help someone else. Definitely a great learning experience. Might work better if partners were better regulated."

"Pair quizzes are useful because you can collaboratively learn the material with a partner. Sometimes one partner may be comfortable with one topic and other times the other partner may be more comfortable. If one student regularly struggles if he tries he/she should begin to learn the thinking process of his partner. Theoretically a student could just coast through not learning the material, but he just won't learn it and will do poorly on the individual assignments."

"I think that they were an effective manner in which to test material with less pressure. There were instances when I felt like I was doing all of the work but because we had to switch partners no one got stuck with a 'bad' partner every time. I think that rotating partners makes this a fair method of testing."

"I think the pair quizzes are a great way to enhance you[r] own understanding of the topic in two ways; by helping someone who doesn't fully understand the material as you, you further deepened your own understanding of the work by working it through again, and secondly having someone who understood the work better than

you help you during the quizzes no doubt helps your own understanding of the material. By doing it with a different person each time gave you the ability to see new approaches to solve a problem that may have been easier or more thorough than you own method, and it helped in creating a cohesion among the students in the class."

The following are examples of neutral student responses regarding the impact of pair quizzes on learning:

"Finding a partner could be stressful. I didn't have any friends in the class so it felt like I was always the last one standing, looking around for a partner. Also, it felt like "smart" partners went fast and some students would deliberately choose a partner who would allow them to coast and/or do the work for them. Could partners be assigned?"

"Pair quizzes were good because they took away some of the pressure of the quiz but they were also bad because you could get stuck with the kid who doesn't do the work or try to understand or who skips class all the time."

The following are examples of negative student responses regarding the impact of pair quizzes on learning:

"Depending on the partner for the pair quiz, I thought they were extremely stressful. Although the quizzes did help boost my grade, I felt as though most of the time my partner knew more than I did and thus I received a grade that wasn't mine. When working with someone I knew, it was less intimidating, but I still felt as though I wasn't a big help in solving in the quiz."

"Complete waste. All it means is that 9 out of 10 people don't learn how to do anything, and they just rely on people who study really hard and put in a huge amount of effort to try and understand. It just divides people into 2 groups: the people who care, and the people who don't, and then the people who don't care get a good grade anyway by mooching, which really isn't fair."

We examined all of the responses of the six students who selected the option "The pair quizzes HINDERED my learning of the material" in question B4.

Of these six students three said they did well in the course, two did “OK” and one did “poorly”. One of these students entered and left the course with a very positive attitude toward math, two entered and left with a neutral attitude, two entered with a negative attitude and left with a neutral attitude while one entered with a negative attitude and left with a very negative attitude toward math. Three of these six students indicated no change in their math attitude; two left the course with a more positive attitude and one with a more negative attitude. We do not see any particular correlation between any of the variables for these students who felt the pair quizzes hindered their learning.

4. Conclusion

In this study we have, in part, analyzed pair quizzes as a student to student teaching vehicle. We have found that pair quizzes are perceived by students as a vehicle for improving both their attitudes toward mathematics and their learning of mathematics. Such results are very encouraging and we plan to continue our research into the effectiveness of pair quizzes as both an attitudinal assessment and a learning tool.

One of the possible limitations of this study is the fact that the student responders were known to Lauren. They therefore may have felt some pressure to “tell us what we wanted, not what they thought”. While this is certainly a potential contaminant to this study, the straightforward replies to the “open ended” questions indicate that the students were under no pressure to answer in a positive manner.

This paper does not examine the relationships between attitudinal and learning changes as related to gender, course taken, or self-perceived success in the course. Analysis of each of these topics could prove very interesting. It is also suggested that possible interactions between effect of pair quizzes on attitude and on learning should be studied. Furthermore, it is also possible that students who were doing better in the courses were more likely to respond to the questionnaire, and more likely to say that the pair quizzes improved their math attitudes. One could also conjecture that individual quizzes may have a similar effect as pair quizzes. Such a question was not included in this research. We have also not examined the courses, levels, and topics that would be appropriate for the use of pair quizzes.

Clearly there exist a handful of confounding variables that were not considered, and of course there are more questions to explore. Nonetheless we believe that our work here contributes to the exploration of student attitudes and perception in relation to cooperative work; we also hope that instructors will consider pair quizzes as a neat instructional and evaluative tool. Our study also suggests the need for analysis of the use of pair quizzes in other disciplines and content areas. Would the use of pair quizzes in foreign language, history, science, etc. have a similar impact on the attitude toward these areas or the learning in these areas? If the results are similar to those found in this study then ways to encourage the use of pair quizzes should be vigorously pursued.

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A. Appendix — Full Instrument

Here we include a copy of the full questionnaire we used.

Survey on Pair Quizzes for Math for Elementary Teachers and Introductory Statistics

A1) *Gender:*

Female Male Other

A2) *Course:*

Math for Elementary Teachers Stats

A3) *Your school year when you took this course:*

First Year Sophomore Junior Senior

A4) *Which of the following best reflects your work (grade) in this course:*

I did well I did OK I did poorly

Please answer each of the following by ENTERING AN "X" AFTER THE APPROPRIATE RESPONSE:

B1) *Rate your ATTITUDE toward math at the BEGINNING of the course:*

1 2 3 4 5
 Very Negative Neutral Very Positive

B2) *Rate your ATTITUDE toward math at the END of the course:*

1 2 3 4 5
 Very Negative Neutral Very Positive

B3) *Select the statement that best indicates how YOUR ATTITUDE toward math was influenced, if at all, by the pair quizzes.*

- The pair quizzes caused me to have a MUCH MORE POSITIVE attitude toward math.
- The pair quizzes caused me to have a MORE POSITIVE attitude toward math.
- The pair quizzes DID NOT CHANGE my attitude toward math.
- The pair quizzes caused me to have a MORE NEGATIVE attitude toward math.
- The pair quizzes caused me to have a MUCH MORE NEGATIVE attitude toward math.

B4) *Select the statement that best indicates how YOUR LEARNING of the material was influenced, if at all, by the pair quizzes.*

- The pair quizzes GREATLY HELPED my learning of the material.
- The pair quizzes HELPED my learning of the material.
- The pair quizzes HAD NO EFFECT on my learning the material.
- The pair quizzes HINDERED my learning of the material.
- The pair quizzes GREATLY HINDERED my learning of the material.

B5) *Select the statement that best indicates how STRESSFUL you found the pair quiz experience.*

- Taking pair quizzes was a VERY STRESSFUL experience.
- Taking pair quizzes was a STRESSFUL experience.
- Taking pair quizzes was a MINIMALLY STRESSFUL experience.
- Taking pair quizzes was NOT AT ALL STRESSFUL.

B6) *Was the NUMBER of pair quizzes appropriate?*

___ 1 ___ 2 ___ 3 ___ 4 ___ 5

Way Too Many

About Right

Way Too Few

B7) *Enter an X after ALL answers that apply to CHANGING PAIR QUIZ PARTNERS.*

Changing pair quiz partners:

- ___ was a waste of time.
- ___ helped me to meet different students.
- ___ helped me to understand multiple ways of solving a given problem.
- ___ helped remove some of the “quiz” pressure.
- ___ allowed me to learn from students who better understood the material.
- ___ allowed me to help students who understood less than I did.

C1) *Please tell us in your own words, what you think of the practice of using “pair quizzes”.*

Thanks again for taking the time to respond to this survey. We appreciate your time and effort.