Incorporating Group Problem Solving to Improve Student Learning in an Agricultural Genetics Class[1]

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Abstract

Genetics for the College of Agriculture is traditionally taught as a lecture-only course in the Department of Animal Sciences and Industry at Kansas State University. In fall 2010, a weekly group problem-solving activity was incorporated. The course was divided into four units. Unit one covered mitosis, meiosis, Mendelian inheritance, sex-linked inheritance, and pedigree analysis; unit two addressed linkage, chromosome variation, DNA structure and replication, and transcription; unit three comprised RNA processing, translation, gene expression, mutations, DNA repair, and biotechnology; and unit four covered genomics, quantitative genetics, and population genetics. Pretests were administered before each unit in fall 2009 and 2010. Improvement from pretest to posttest was used as a measure of student learning. For units one and two, student learning improved more when a group problem-solving activity was incorporated. Student learning did not differ for unit three; learning was greater with the lecture-only format for unit four. Although learning over all units was improved with a group problem-solving activity, the material covered appeared to affect which method maximized student learning.

Introduction

Cooperative learning has long been recognized as a method to increase student learning (Johnson and Johnson, 1974; Johnson, 1975; Johnson, 1979; Blumenfeld et el., 1996). In a 1999 meta-analysis of 37 studies that analyzed student achievement in science, math, engineering, and technology, Springer et al. (1999) reported that students who participated in group activities demonstrated higher achievement than students who did not have group learning opportunities. Dietz (1993) showed that beginning statistics students were able to 'discover' on their own several proven sampling methods through the use of group activities. More recently, Amstutz et al., (2010) showed that participation in peer-led study groups increased course grades in animal science courses. The objective of this study was to determine if group problem-solving activities enhanced student learning in agricultural genetics.

Materials and Methods

This study was found to be exempt by the Kansas State University Institutional Review Board. Kansas State University (KSU) is the land-grant institution for the state of Kansas, and it has a long history of education in the agricultural sciences. At KSU, genetics is taught in the Department of Animal Sciences and Industry for the entire College of Agriculture. The class is for three credit hours, and meets three times per week for 50 minutes. The course is divided into four units. In 2009 and 2010, unit one covered mitosis, meiosis, Mendelian inheritance, sex-linked inheritance, and pedigree analysis; unit two addressed linkage, chromosome variation, DNA structure and replication, and transcription; unit three included RNA processing, translation, gene expression, mutations, DNA repair, and biotechnology; and unit four taught genomics, quantitative genetics, and population genetics.

Before 2010, genetics was taught as a lecture-only course at KSU. In 2010, one day a week on non-exam weeks was designated as group problem day. This was in place of a lecture. Material was not removed from the course, but students were asked to do more out of class reading to compensate for lost lecture time. Groups of four were assigned at the beginning of the semester. Students were allowed to pick group members via an online survey if they chose. If not, groups were randomly assigned. Every week, a problem set that related to the topics of the week was posted on the online content management system. Students were expected to work the problems together outside of class, either by meeting in person or electronically. On group problem day, the instructor would randomly call a group number, and one member

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of that group would work the problem for the class. The instructor assigned points to the group based on correctly solving the problem. They were not given points simply for participation. The total number of points a group could potentially receive for problems throughout the semester was the same as for a unit exam. Part of those points were assigned based on the group members' evaluation of the participation of each member in the group.

In both 2009 and 2010, a pretest was given to each student at the beginning of each unit. The pretest consisted of questions from the previous year's unit exam. Two incentives were offered for students to participate in the pretest. First, if they completed the pretest, students were allowed to keep it as a study guide for the upcoming unit exam. Second, to encourage effort, students were given participation points for attempting all the questions. It was emphasized to the students that they would receive maximum participation points only if the instructor could tell that they had given a good effort on all the questions. Improvement from pretest to posttest was used as a measure of student learning.

Data analyzed included pretest score, posttest score, and the improvement in scores from the pretest to the posttest for all four unit exams. The dataset includes all students that completed all four unit exams in 2009 (n = 88) and 2010 (n = 80). Students were removed from the data if they failed to complete one or more of the unit exams (posttests), but not for missing a pretest. In each year, each student completed four posttests, but may have completed less than four pretests; therefore, each unit had different numbers of observations. Improvement from pretest to posttest was calculated within unit only for those students that completed both pretest and posttest for that unit. Pretest scores, posttest scores, and improvement from pretest to posttest were analyzed using the generalized linear model of SAS (Cary, NC) with year, unit, and year by unit interaction as fixed effects.

Results and Discussion

Students in 2009 averaged better scores on the pretest than students in 2010 (Table 1). Pretest scores were higher for units one and three than for the other units (Table 1). This indicates that those units contained more material that the students had learned in prerequisite classes. Unit one contains mitosis, meiosis, and Mendelian genetics, which are common topics in general biology classes. Unit three is transcription, translation, and gene expression, which would be expected to be less familiar to students, but pretest scores indicate that those topics are receiving some coverage in general biology classes. Unit two had the lowest pretest scores. This was somewhat surprising because DNA structure and replication, which should be covered in general biology, is included in this section; however, linkage analysis is also in unit two. This is a topic that most students have no experience with prior to class, and virtually all students receive zero points on those questions on the pretest. There was a significant interaction between year and unit in pretest scores ($P = 0.0391$) (Table 2). For units one, three, and four, students from 2009 scored approximately five points higher than students from 2010 ($P < 0.02$), however, for unit two, there was no difference in pretest scores between years ($P = 0.4699$).

There was no difference between students in 2009 and 2010 in posttest scores ($P = 0.3749$) (Table 1). This result indicates that, even though 2009 students were more knowledgeable coming into the class as demonstrated by their pretest scores, both years reached a similar level of understanding of the material. Posttest scores for the different units paralleled the pretest scores. Students had higher scores on units one and three than on units two and four (Table 1). Interaction between year and unit in posttest scores was significant ($P < 0.0001$) (Table 2). For units one and two, 2010 students performed better on the posttest, but 2009 students performed better for units three and four.

Overall improvement from pretest to posttest was greater in 2010 than 2009 (Table 1). These results indicate that students improved their scores and learned more when group problem solving was incorporated into the class. This agrees with results reported by Amstutz et al., (2010); Johnson and Johnson (1974); and Springer et al. (1999); however, there was a large difference in improvement in the different units. The least amount of improvement was shown in units one and three (Table 1). Most material in unit one (mitosis,

Table 1. LSMeans and Number of Students for Pretest Scores, Posttest Scores, and Improvement from Pretest to Posttest in 2009 and 2010 Averaged over Four Units, and for the Four Units Averaged over Years

	Pretest		Posttest		Improvement	
Year	n	LSMean	n	LSMean	n	LSMean
2009	332	34.88^a	356	70.37^a	332	35.73^d
2010	315	31.49^b	336	69.25^a	315	38.22^e
Unit	n	LSMean	n	LSMean	n	LSMean
1	168	39.91^a	173	71.77^d	168	32.14^a
2	156	23.28^b	173	66.41^e	156	43.69^b
3	163	39.89^a	173	73.41^d	163	33.83^a
4	160	29.65^c	173	67.60^e	160	38.23^c

[abc]LSMeans within a column with different superscripts are different ($P < 0.01$) using a generalized linear model.
[de]LSMeans within a column with different superscripts are different ($P < 0.05$) using a generalized linear model.

meiosis, Mendelian genetics) should have been covered in the prerequisite general biology class, or even in high school biology classes. As mentioned before, unit two contains linkage analysis, which most students have never learned before. Most students get zero points on those problems on the pretest, and then do much better on those problems after going over them in class, which accounts for the large amount of improvement in unit two. There was also a significant ($P < 0.0001$) interaction between year and unit. For units one and two, improvement was greater when group problem solving was incorporated into the class, which is similar to literature reports; however, for unit four, improvement was greater when class consisted of lecture only (Table 2). For unit three, improvement did not differ between years, which may indicate that students benefitted from the group work earlier in the semester but adapted to the lecture and teaching style by the end of the semester. Another explanation could be the material for the units. Mitosis/meiosis, Mendelian genetics, and DNA structure/replication, which are covered in units one and two, are commonly introduced topics in general biology classes. Students may have been better able to teach each other the more advanced details of those concepts in a group setting because they had some familiarity with the basic material. Unit four covers primarily the more advanced topics of genomics, quantitative genetics, and population genetics. Few students have previous exposure to these topics, so they were less able to draw on previous experience to help each other, which might account for the fact that the group work was not as helpful. The increased class time spent explaining these topics in the lecture-only format may have been more helpful than group time. Another possible explanation is the evolution of the group work over the semester. Toward the end of the semester, instructor observation indicated that more groups were dividing the problems and working them individually, as opposed to meeting and working through them as a group. This may negate the benefits of group work for those students. Perhaps providing some in-class time for groups to coordinate would encourage more collaboration.

Table 2. LSMeans, Number of Students, and Significance for Pretest Scores, Posttest scores, and Improvement from Pretest to Posttest for Units 1-4 in 2009 and 2010

Pretest Scores					
	2009		2010		
Unit	n	LSMean	n	LSMean	P-value[z]
1	88	42.41	80	37.41	0.0070
2	78	22.59	78	23.97	0.4699
3	82	42.44	81	37.33	0.0066
4	84	32.08	76	27.22	0.0105
Posttest Scores					
	2009		2010		
Unit	n	LSMean	n	LSMean	P-value[z]
1	89	69.48	84	74.05	0.0652
2	89	63.29	84	69.54	0.0117
3	89	75.58	84	71.23	0.0783
4	89	73.02	84	62.18	0.0001
Improvement					
	2009		2010		
Unit	n	LSMean	n	LSMean	P-value[z]
1	88	27.40	80	36.89	0.0001
2	78	41.33	78	46.05	0.0496
3	82	33.26	81	34.40	0.6281
4	84	40.93	76	35.53	0.0232

[z]P-values from a generalized linear model.

Summary

Although group problem-solving activities improved student learning through the entire semester, the amount of improvement appears to be dependent on the subject matter. Students improved more with group problem solving in units containing material that was most likely introduced in prerequisite courses. With new material, group problem-solving activities did not improve student learning. Changes in group dynamics through the course of the semester also may have diminished the effectiveness of the group problem-solving activity.

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