Exploring A Relationship Between Team Formation and Learning Outcome in Problem Solving

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[Abstract] This article tests the impact of three different group formation methods (student-formed teams, randomly selected teams, and teams formed through students' thinking style) on academic performance in an undergraduate course in statistics within a Historically Black University in Texas. Group 1 is made up of groups whose members are randomly selected with Excel's RAND function. Group 2 is made up of students' self-selected groups and Group 3 is made up of groups formed based on students' self-reported results from the Hemispheric Dominance Inventory Questionnaire. Average group scores from a problem-solving case in business statistics are analyzed using ANOVA and Kruskal-Wallis analysis of variance tests. The results suggest that team performance can be improved when team members are randomly selected.

[Keywords] active learning, group performance, Historically Black College or University (HBCU)

Introduction

Problem solving is one of the notable learning goals in many business schools around the world. He (2015) notes that the Association to Advance Collegiate Schools of Business (AACSB) International attaches a significant emphasis on problem solving in its *2013 AACSB Assurance of Learning Standards: An Interpretation*. One may be led to believe that problem solving is a concept within the preserve of business schools. Stockwell et al. (2017) report their exploratory research on the way undergraduate students tackle problem solving in a biochemistry class. To define problem solving, Daft (2014) focuses first on "problem" which is viewed as the discrepancy between existing and desired goals. The author then views problem solving as identification of the gap between reality and goals and an attempt to seek actions necessary to close the gap. Martinez (1998) argues that problem solving as a worthy goal of education is the process of getting to a goal whose path is uncertain.

Stockwell et al. (2017) report that the traditional perspective to learning is out of tune with modern day reality. Active learning and scientific teaching strategies are now in vogue. Moreover, the authors report the positive role of interactive teaching on learning outcome. They also report the findings of the National Research Council which suggest that learning is more effective when students work in small groups. Chase (2014) describes collaborative learning as a program which allows students to work together using scientific evidence to influence real policy changes. The author catalogs the benefits to include the achievement of deeper learning and course material engagement. Rusticus and Justus (2019) argue that teamwork promotes interactions among students and serves as a source of motivation for developing teamwork skills for future employability. This line of thought is emphasized by Chapman et al. (2006) who argue that businesses seek out potential employees who possess the skill to work efficiently and effectively with others in a group.

Team formation is a critical ingredient in achieving the benefits of team-based learning. Alberola et al. (2016) observe the absence of many studies on the key issue of team formation. Gencer (2019) notes that many researchers emphasize the importance of group formation in the development of attitudes and behavior of group members. Hansen (2006), Michaelsen et al. (2004), and Shimazoe and Aldrich (2010), argue that instructors should be guided in the formation and management of teams. They should be purposeful in reducing any barriers to team effectiveness and cohesiveness. Therefore, this research objective is to test the impact of three different group formation methods (student-formed teams, randomly selected teams, and teams formed through students' thinking style) on academic performance in an undergraduate course in statistics within a Historically Black University in Texas. Moreover, this study examines the possibility of achieving team cohesion and consequently team performance in homogeneous versus heterogeneous teams.

Teamwork in Education

The classroom environment is going through drastic changes and instructors are searching for different avenues to impart knowledge. Bonwell and Elson (1991) suggest an active learning approach which seeks the involvement of students and motivates students to think about what is being done. It is an instructional approach in which the focus is on the learner. Millis (2012) posits that active learning should appeal to instructors who desire students to learn. Berry (2008) identifies characteristics of active learning to include critical thinking, individual responsibility, participation in open-ended activities, and organization of learning activities by an instructor. McClellan (2016) reports a survey conducted by the Hart Research Associates on behalf of the Association of American Colleges and Universities in which employers overwhelmingly identified teamwork skills as critical. Pociask et al. (2017) list the benefits of collaborative learning to include improvement in critical thinking skill, improved test scores and improved course material retention.

Millis and Cottell (1998) note that educators often employ three types of group learning, namely: cooperative learning, problem-based learning, and team-based learning. Cooperative learning is student-centered when an instructor puts students in small groups and allows them to take the lead in completing an activity. Problem-based learning focuses on student learning in a hands-on way. This is also referred to as learning by doing because no prior instructor exposition to relevant course materials. Team-based learning is a structured teaching strategy that engages student, maximizes their practice time, and gives room for socialization.

Oakley et al. (2004) report several good outcomes when students are put in small groups. According to the authors, students' attention span is longer, and they retain more information leading to an achievement of better grades. Nokes-Malach et al. (2015) argue that groupwork gives students the opportunity to use previous knowledge of members, builds on complementary expertise and increases resources of memory and problem-solving. Mazzoitti et al. (2019) discuss a tradeoff between the benefits and costs of groupwork in the learning process. The costs manifest in terms of fear of evaluation by peers and social loafing. The authors make a strong case for a residual benefit of groupwork.

Many researchers including Greenlee and Karanxha (2010) argue that an effective team is one that is diverse in ability and other characteristics with potential for members to learn, increase members engagement and facilitate social interaction. Druskat and Wolf (2001) focus on effective group interaction process which they argued is connected with the role of emotion within the group. Rock and Gerkovich (2021) espoused the concept of a diverse team in terms of cognitive elaboration which allows the exposition and correction of faulty thinking while generating fresh and novel ideas. This process takes time to gain ground.

Chapman et al. (2006) investigate random versus self-selected team selection methods in several marketing classes in a business school in northern California. The authors note that a randomly selected team has a higher likelihood that all team members do not know each other when compared with a self-selected team. This means that a low degree of initial social connectedness exists in a randomly selected team. Their results indicate a better positive outcome is achieved by a self-selected team. The self-selected team members take pride in their work, they make more friends and enjoy working with the group because of their higher degree of social connectedness.

Rusticus and Justus (2019) compare teacher-formed and student-formed teams in an introductory psychology research methods course. They report results indicating a superior score earned by the student-formed group. However, they caution that team formation method should consider the purpose of using teams. Rusticus and Justus argue that teacher-formed teams are more diverse and transparent. This line of thought is supported by Parmelee and Hudes (2012) who state categorically that an instructor should not let students self-select. They argue that teams selected by an instructor are likely to have members from diverse background, interest and experiences. Rienties et al. (2014) note that students are essentially “forced” to work together when an instructor forms a group through randomization. The authors use a quasi-experimental study to compare student-formed group and randomized group. The results indicate that the randomized group member, are able to develop a strong internal group relations which put them at an advantage over the self-selected team.

Post et al. (2020) assesses the impact of two different methods of team formation in an introductory engineering course. The two methods employed are self-selected team and instructor-selected based student predicted performance. One of the key findings is the impact of the existence of a team member having a friend versus making new friends. The two groups report the same level of effort in making new friends. The self-selected team is more likely to have friends on the team. Moreover, the authors report a significant negative relationship between having friends on a team and team performance measures.

Farland et al. (2019) create four collaborative learning teams in the first year of a Doctor of Pharmacy degree program at the University of Florida. In fall 2015. Students are put in one of four groups based on their score on the CPSP-2 problem-solving style classification and campus location. The authors conclude that the team formation method has no effect on team performance.

Pociask et al. (2017) also compare three methods of team formation in an undergraduate general education course. The three teams are: self-selected, instructor-selected and randomly-selected teams. The most random team is the one selected by the instructor based on personality, class year, and gender. The results indicate the absence of any significant difference in student performance. Therefore, one is unable to decipher a clear indication of the effect of team formation method on student performance. The available evidence is mixed at best.

Method

To reap the benefits of collaborative learning through groupwork, Deibel (2005) argues that instructors should form groups that promote maximum interaction among members. In this study, three different group formation methods are examined in relation to learning outcome in a problem-solving case analysis. More importantly, the focus is to test if heterogenous teams record higher performance than homogeneous groups.

Study Participants

In four semesters within the 2018-2020 academic years, 240 students who enrolled in several sections of the undergraduate Business Statistics course in a southwestern United States' Historically Black University participated in the current study for extra credits. This research was exempt from Institutional Review Committee of the University because it was employed as a teaching-enhancement tool. Three-person teams numbering a total of eighty were formed. The descriptive analysis of the participants show 112 students were males and 128 females (see Table 1). There were 42 Accounting majors, 36 in Finance, 109 in Management, 15 in Management Information Systems and 38 in Marketing. Classification by class revealed that 162 were juniors and 78 seniors. It should be noted that participation in this project was completely voluntary.

Table 1
Students' Classification by Major and Gender

Major	Count	Male	Female
Accounting	42	20	22
Finance	36	17	19
Management	109	51	58
Mgmt Info System	15	7	8
Marketing	38	17	21
Total	**240**	**112**	**128**

Study Design and Procedures

A special case project which captures the key concepts in an undergraduate statistics course was administered to students enrolled in a south-eastern Texas HBCU. All the participants completed an introductory course in management information systems that covers Word, Excel, PowerPoint, etc. The students are divided into three groups. The case project is given to each group toward the end of the semester. The group case reports are graded by all the teaching instructors to remove grading bias. The scores are pulled together for analysis.

The first group (Group 1) is made up of groups whose members are randomly selected with Excel's RAND function. The second group (Group 2) is made up of students' self-selected groups. The third group (Group 3) is made up of groups formed based on students' self-reported results from the Hemispheric Dominance Inventory Questionnaire (HDIQ). The students in Group 3 were requested to visit the virtual Hemispheric Dominance Inventory platform of the Middle Tennessee State University to complete the questionnaire. Saleh (2001) and Ayadi et al. (2019) give a more descriptive analysis of hemispheric dominance. With the HDIQ results, students were placed in three sub-groups of left-brained, right-brained, and whole-brained. Margret and Lavanya (2017) report a relationship between hemispheric dominance and thinking style preferences. Therefore, following Margret and Lavanya (2017) the sub-groups in Group 3 are reclassified as Detail-Analytical for left-brained, Creative-Intuitive for right-brained and Homogeneous No Preference for whole-brained sub-groups. The number of sub-groups in Group 3 is made up of 22, 7 and 9 for Detail-Analytical, Creative-Intuitive and Homogeneous No Preference respectively. The total number of teams stands at 80 with 18 in Group 1, 24 in Group 2 and 38 in Group 3 (see Table 3). In view of the method employed to form the three groups, it is evident that Group 1 is a heterogenous group while Group 2 and Group 3 are homogeneous groups.

Results

A short summary of the data reveals that, out of a maximum possible score of 44, the average score of the randomly formed group (Group 1) is 34.1667, with a standard error of 2.60279, while the average score of the self-selection group (Group 2) is 22.5417 with a standard error of 3.20777. The average score difference of the two groups is 11.625 with a standard error of 4.13089. The 95% confidence interval for the mean difference is (3.27532, 19.97468) (Table 2).

Table 2

Confidence Intervals for the Mean Difference

Equal variance assumption	F	Sig	t-statistic	df	Sig (2-tailed)	Mean difference	Std error of Mean Difference	95% CI_{lower}	95% CI_{upper}
Assumed	11.270	0.002	2.678	40	0.011	11.625	4.341	2.852	20.398
Not assumed	-	-	2.814	39.872	0.008	11.625	4.131	3.275	19.975

Note. 95% CI refers to 95% confidence interval of the mean difference.

When we examined if there is a difference in performance on the special project between the two group formations, it turned out the average performance of the two groups is significantly different with a p-value of 0.008, which is consistent with the 95% confidence interval that appears in Table 2. In fact, the average score of the randomly formed group is higher than the self-selected group. The test for equality of the two population variances did not hold (Levene's test) with a p-value of 0.002, hence the two variances are assumed unequal in this analysis. The result appears in Table 2.

Since our aim is to identify a type of group formation that helps students to learn and do better, another group formation was included in the study and then performed multi-sample analysis. As stated earlier, the third group is based on brain dominance characteristics. This new Group 3 is also denoted as Hdbased. A summary of all the three groups and score distribution appears in Table 3.

Table 3

Group Descriptive Statistics

Group	N	Mean	Std. Deviation	Std. Error	95% CI_{lower}	95% CI_{upper}	Min	Max
1	18	34.1667	11.04270	2.60279	28.6753	39.6581	7.50	44.00
2	24	22.5417	15.71479	3.20777	15.9059	29.1774	4.00	44.00
3	38	22.0843	12.19786	1.83890	18.3758	25.7928	4.00	44.00
Total	80	24.7408	13.79542	1.48760	21.7831	27.6986	4.00	44.00

Note. 95% CI refers to 95% confidence interval of the mean difference. Group 1 = randomly assigned group. Group 2 = self-selected group. Group 3 = group based on brain dominance characteristics.

To examine if there is a difference in performance on the special project among the three groups, we first examined if the variances of the three populations from which the samples are taken are equal. Based on the data we have, there is strong evidence that the assumption of equal variances is not appropriate with a p-value of 0.003, based on means (Table 4). Thus, we resort to a non-parametric Kruskal-Wallis one-way analysis of variance test to see if the three average group scores are identical. Please note that here the ranks of the data are used in the analysis (Tables 5 and 6).

Table 4

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Based on Mean	6.170	2	80	0.003
Based on Median	5.155	2	80	0.008
Based on Median and with adjusted df	5.155	2	73.098	0.008
Based on trimmed mean	6.436	2	80	0.003

From the following summary (Table 5), the average of the ranks for the random Group 1 is 60.19, the self-selected Group 2 is 38.73 and the Hdbased Group 3 is 39.27. The number of observations per group are 18, 24 and 38, respectively. Based on the ranks, it seems there is a significant difference among the three groups with a p-value of 0.006 (Table 6). When one looks at Table 5 very closely, the average rank of the random group (Group 1) is considerably higher than both Group 2 (self-selected) and Group 3 (Hdbased). Thus Group 1 is significantly different from both. However, the other two groups are not significantly different from each other. Interestingly, the ANOVA results are consistent with the Kruskal-Wallis test results, even when equality of variances does not hold. It seems that the group whose membership is randomly formed (Group 1) can figure out how to work together and perform well while the members of Group 2 and Group 3 even though they are homogeneous because they have some things in common, did not seem to do relatively well.

Table 5
Average of the Ranks

Group	N	Mean Rank
1	18	60.19
2	24	38.73
3	38	39.27
Total	80	

Note. Group 1 = randomly assigned group. Group 2 = self-selected group. Group 3 = group based on brain dominance characteristics.

Table 6
Kruskal Wallis Test Statistics[a,b]

	All data
Kruskal-Wallis H	10.203
df	2
Asymptotic Significance	0.006

Note. a = Kruskal Wallis Test. b = Grouping Variable: Group ID

Discussion and Conclusion

This research sought to identify if the group formation process facilitates instructional delivery in a very productive way to enhance superior student performance in problem solving. Some researchers, including Stockwell et al. (2017) argue for a replacement of the traditional method of pedagogy in which students are left to learn individually and then subjected to listening to long instructors' lectures. The antagonists of the traditional pedagogy have become the proponents of group active learning which is noted to increase student academic performance. Rock and Gerkovich (2021) argue convincingly for adopting group learning strategies. In specific terms, the authors advocate for the use of heterogeneous teams to take advantage of cognitive elaboration. According to them, cognitive elaboration involves sharing, challenging, and expanding of thinking. The approach in this study is to test the impact of three different group formation methods (student-formed teams, randomly selected teams, and teams formed through students' thinking style) on academic performance in an undergraduate course in statistics within a Historically Black University in Texas. More importantly, an attempt is made to determine if a more diverse team achieves a higher academic performance than a homogeneous team.

The ANOVA and Kruskal-Wallis test results indicate a superior performance by a heterogeneous randomly selected Group 1. The results are consistent with Haq et al. (2021), Rienties et al. (2014), and Lambic et al. (2018) who report superior academic performance by heterogeneous teams relative to homogeneous teams. Moreover, the results are nevertheless consistent with Farland et al. (2019), and Briggs (2020), who found a weak impact of team formation method on group performance. The implication of this study's results is that a randomly selected heterogeneous team has a potential to achieve a higher academic performance in problem solving. But the results reported in this study are at variance with Chapman et al. (2006), Rusticus and Justus (2019) who report a better outcome with the self-selected team.

The results reported in this study should be interpreted with caution. The authors are aware that other factors contribute to team performance. For example, Cheng et al. (2008) and several other researchers identify the quality of the group process and team cohesion critical factors. Rusticus and Justus (2019) also identify other factors that can affect performance beyond team formation process. The factors include open and frequent communication, levels of motivation, positive team dynamics, and equitable workload distribution. Even if the team formation process is ideal, group tension and conflict can easily interfere with pursuing superior performance.

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