ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #40882

Assigning Individualized Grades on a Team Capstone Project

Dr. Gafar Abbas Elamin P.E., The Citadel

Dr. Gafar Elamin is an assistant professor in the Department of Mechanical Engineering at The Citadel. He earned his PhD and Master of Science in Mechanical Engineering from North Carolina A & T State University, and his Bachelor of Science in Mechanical Engineering from University of Khartoum in Sudan. Before his current position, Dr. Elamin has worked for the University of Wisconsin-Platteville, King Faisal University in Saudi Arabia, and Bechtel Power Corporation in Frederick, Maryland. Dr. Elamin teaches courses in the Thermal/Fluid and Heat Transfer areas as well as introductory engineering courses. His research interests include computational fluid dynamics and algorithms development. Dr. Elamin is a registered professional engineer in Maryland State.

Dr. Nathan John Washuta P.E., The Citadel

Dr. Nathan Washuta is an Assistant Professor in the Department of Mechanical Engineering at The Citadel in Charleston, SC. He received both his B.S. and Ph.D. in Mechanical Engineering from The University of Maryland â€" College Park. His primary research

Dr. James Righter, The Citadel

James Righter is an Assistant Professor of Mechanical Engineering in the School of Engineering (SOE) at The Citadel. He earned his BS in Mechanical Engineering at the U.S. Naval Academy, his MS in Military Studies from the Marine Corps University Command and Staff College, and his PhD in Mechanical Engineering from Clemson University. His research interests include engineering leadership, design methods, engineering design education, and manufacturing.

Dr. Kevin Skenes, The Citadel

Kevin Skenes is an assistant professor at The Citadel. His research interests include non-destructive evaluation, photoelasticity, manufacturing processes, and engineering education.

Assigning Individualized Grades on a Team Capstone Project

Abstract

In undergraduate engineering programs, ABET criteria requires a capstone or integrating experience to allow students to develop competencies in technical and non-technical problem solving. These capstone experiences typically take the form of a year-long or semester-long project that requires a group of senior students to work as a team to identify, define, design, prototype, and test their final product to solve an engineering problem. Ideally the students on these teams contribute fairly and equitably to the project so that each individual can develop their skills, but it is not unusual to see students on the team who do not contribute their fair share. Often, graded assessments in these capstone courses are team submissions and assigning separate grades to individual students is a difficult task. To overcome this grading challenge, the Mechanical Engineering senior capstone course instructors at the Citadel have adapted an effective mechanism for awarding a fair grade to each student on the senior design project team based on actual performance and contribution to the project success. This grading scheme is a combination of group assignments, individual assignments, teamwork, and leadership evaluation. The course instructors, faculty advisors and observers, and peer evaluations all contribute to the student's overall grade.

Keywords

Capstone Project; Individual Assignment; Grade Distribution

Purpose of the Study

The purpose of this study is to demonstrate the effectiveness of using a combination of group and individual assignments to assign a fair grade for each student on a senior design (SD) project. The analysis was performed on the grade distribution and the average score based on group assignments, individual assignments, and the combination of both assignments. The main objective here is to demonstrate the important role that the individual assignments played in adjusting the overall score for each student since the group assignments awarded the same grade to all students on the team. First, the analysis was performed based on data from one SD team. Then the results were validated by performing the analysis on data from three different SD teams. Finally, to check the effect of the sample size, the analysis was extended to include six SD teams from two different academic years.

Literature Review

Numerous studies have been conducted on the best ways to teach and assess the capstone projects. Most of these studies showed that the strategies and techniques for teaching senior design course seemed to be in closed harmony, but there is a huge difference in the assessment process. In general, the senior design is evaluated through meetings with advisors, written reports, and oral presentations. The evaluation normally was based on team performance and the

evaluator judgment which might vary from one evaluator to another. To minimize the discrepancy in the evaluation process, much research has pointed to the need for effective and fair tools for senior design project evaluation. For example, Estell and Hurtig [1] presented evaluation rubrics for each stage of their senior capstone project. They designed one rubric for the project proposal development, one rubric for prototype development and verification, and another rubric for the final report. In reference [2], the author discussed an assessment method that required all project teams to prepare and maintain an electronic copy of a project binder that included meeting minutes, copies of presentations, design specifications, project plans, design reviews, engineering reports, design output such as drawings, test reports, and analyses. They stated that their project assessment was based on the completion of these deliverables in addition to another separate assessment on the quality of communication skills which was typically assessed by a final report or design review. For fair assessment of capstone projects and after several meetings with faculty and students, Bringula [3] developed a two-versions rubric. The project proposal stage was evaluated by the first version of the rubric and the project completion was assessed by the second version of the rubric. Similar rubrics were developed and used in many other studies [4], [5], [6]. The rubrics developed in all these studies were effective tools for evaluating the different components of the project but they depended on the evaluator judgment and assigned the same grade for all students on the project. In another study [7] the authors discussed the subjective nature of grading the oral presentations as compared to the written reports and the associated dilemma of assigning individual grades. This study used a non-numeric rubric for grading briefings, a more objective rubric for grading written documents, and input from course directors to standardize the grading process. A similar study [8], proposed a triangulation assessment model to address the subjectivity and non-standardization of the capstone project assessment method presented in reference [9]. Gosselin and Golick [10] introduced an approach of using a poster rubric and student questionnaires to evaluate a capstone research course. The poster rubric and the questionnaires were used by students who worked across a variety of disciplines and collected efficient and systematic data from posters. They reported that the students' feedback provided informed reflective instructional practice to enhance the capstone project teaching and assessment process.

The Course Grading Scheme

At the Citadel, the senior capstone project takes the form of a two-semester course sequence. The first phase is offered during the Fall semester and the second during the Spring semester. Each course is graded separately and contributes three credit hours to the fulfillment of the mechanical engineering degree. During the first phase of the project students identify, define, select concept design, perform engineering analysis, prototype, finalize their detailed design, prepare a full bill of materials, and order the product parts. During the second phase of the project students fabricate/purchase the product parts, assemble components, and test their final product. In addition to these activities, students are required to hold regular meetings with an assigned faculty advisor, submit written reports, and present their work periodically to faculty review panels. While the aforementioned activities are graded as group assignments, our grading scheme also includes individual assignments such as an ethics reflective essay, resume preparation, a reflective paper on newly acquired knowledge, and FE exam preparation. Individual grades are also assigned through peer and faculty advisor evaluations related to teamwork, professionalism, and leadership. Since the grading schemes at our institution for both

phases of the project are similar, the analysis in this study was based on data from the first phase of the course. Table 1 displays the weight of each component of the grading scheme for the first phase of the senior design project at the Citadel.

Table 1: Assignments Weights

Expected Performance Criteria	% of Grade
Assignments	35
Final Report/Presentation	25
Review Panels	10
FE Prep	10
Leadership and Teamwork	15
Faculty Advisor Meetings	5
Total	**100%**

Assignment Type and Evaluator

Based on the grading scheme presented in Table 1, the course instructors, faculty advisors, faculty review panels, and peer evaluations all contribute to the student's overall grade. The grading of each of these components fall on different evaluators, based on the assignment, which further contributes to differentiated grades from person to person within a team. These evaluators are as follows:

Instructor: The course instructors normally grade the group written interim and final reports, and all the individual assignments. While this burden falls on the faculty advisor at some institutions, the course instructor carries the primary grading burden in the Senior Design sequence at the Citadel.

Faculty Panels: Throughout the course, students are required to present their design process to faculty members at three different occasions. The purpose of these panels is for the team to communicate their design process and demonstrate that they have used sound engineering analysis throughout. Students also are required to perform a final presentation at the end of the semester to the faculty panel. Each faculty member on the panel uses a prepared rubric to submit his/her grade recommendation to the course instructor. These panels typically include the instructors as well as other faculty members from within the department, but sometimes include faculty from the English department who focus on communication styles or lab technicians that focus on practical aspects of design concepts.

Peer Evaluation: Each team should select a group leader to coordinate the project tasks. Group leaders rotate approximately every three weeks. Each group member must be group leader at least once and group leaders cannot repeat until every member has been leader at least once. Group leaders are evaluated by all team members at the end of their term through an online questionnaire assigned by the course instructor. The team members also evaluate each member's overall contribution to the project through mid-semester and end of the semester online survey assignments.

Faculty Advisor: Team members of each group must meet with their faculty advisor at least once every two weeks. The purpose of this meeting is to track the project progress and provide technical advice to the students. Faculty advisor grade recommendations for each individual student on the team are coordinated with the course instructor to provide an individual evaluation of team member participation and preparedness for these meetings.

Results and Discussion

To demonstrate the effectiveness of the process illustrated in the methodology section above, the analysis was started by using the data of one team senior design team. Then, to check and validate the results, data from three different teams was combined and analyzed. Finally, the analysis was extended to include six teams from two years to see if there is a significant difference in the grade distribution between one, three, or six difference teams. The analysis was performed on the grade distribution and the average score based on group assignment, individual assignments, and the combination of both assignments.

The results from the data of one senior design team are presented in Table 2, Table 3, and Figures 1 and 2. Table 2 shows the assessment types and the contribution of different evaluators in the grade assigning process for one senior design team. Table 3 displays how these evaluations were combined in group, individual, and overall grades.

Table 2: Assessment Types and Evaluators

Evaluator	***Instructor***		***Students***	***Faculty Panel***
Assessment type	Individual Assignments	Group Assignments	Teamwork and Leadership	Group Presentations
Team 1	100.00	94.23	92.17	88.58
	36.99	94.23	89.67	88.58
	47.95	94.23	86.18	88.58
	46.58	94.23	87.10	88.58

Table 3: Grade Distribution Based on Group, Individual, and Overall Assignments

Assessment Type	**Group**		**Individual**		**Overall**	
	Score	Letter grade	Score	Letter grade	Score	Letter grade
Team 1	91.41	**A**	96.08	**A**	93.74	**A**
	91.41	**A**	63.33	**D**	77.37	**C**
	91.41	**A**	67.06	**D**	79.24	**C**
	91.41	**A**	66.84	**D**	79.12	**C**
Average	91.41	**A**	73.33	**C**	82.37	**B**
STDEV	0.00		13.22		6.61	

Figure 1 compares the students' grade distribution based on group and individual assignments. The figure also shows the effect of the combination of both assignments in adjusting and assigning the final overall grade for each student on the team based on his/her actual contribution to the project. The team consisted of four students. When the grade was assigned based on the group

assignments, all students received an "A" grade. However, based on the individual assignments, only one student obtained "A" and the other three students had "D" grades. The combination of the group and the individual grades adjusted the final grade as "A" for one student and "C" for the other three students on the team.

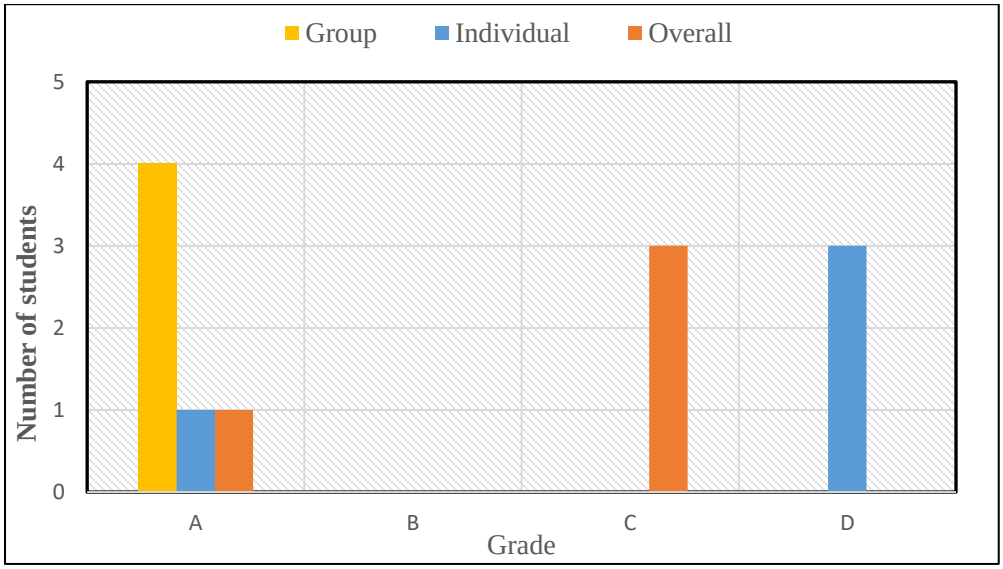

Fig. 1: Grade Distribution of One Senior Design Team

Figure 2 illustrates the variation of the average score of the four students on the group and the individual assignments. As shown in the figure the average score for the group assignments was 91.41% while the average score on the individual assignments was 73.33% with significant variation in the data (13.22%). The combination of both scores adjusted the overall score of the group to 82.37% and the variation to (6.61%).

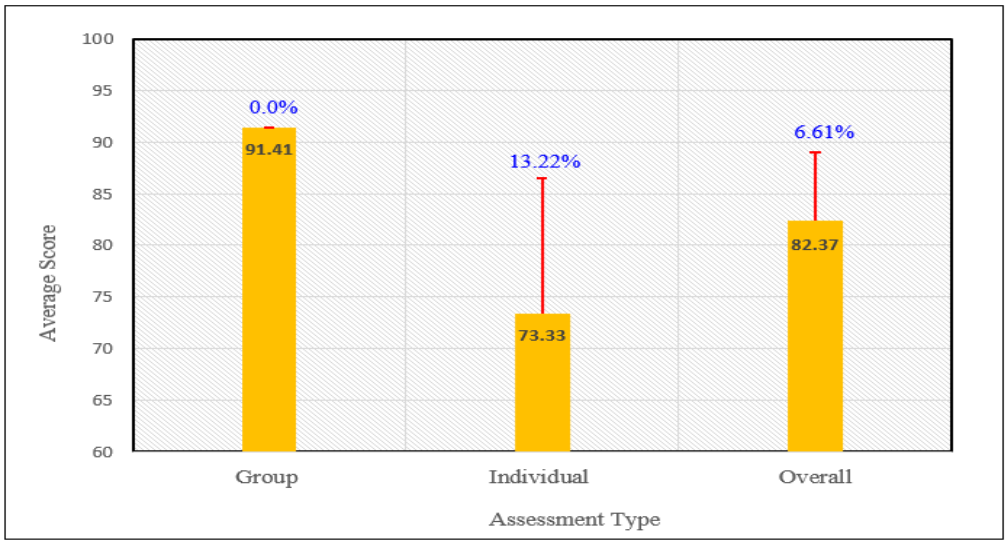

Fig. 2: The Average Score of One Senior Design Team

Figure 3 presents the grade distribution for three different senior design teams. There were 14 students on these three teams. As in Figure 3, based on group assignments, the grade distribution was 4 “As” and 10 “Bs”. For the individual assignments, 6 students had “A” grade, 2 students had “B” grade, and 6 students received “D” grade. However, when the group and individual grades were blended together, the students with A and B grades stayed with no change while the other six students improved their final grade from D to C grade.

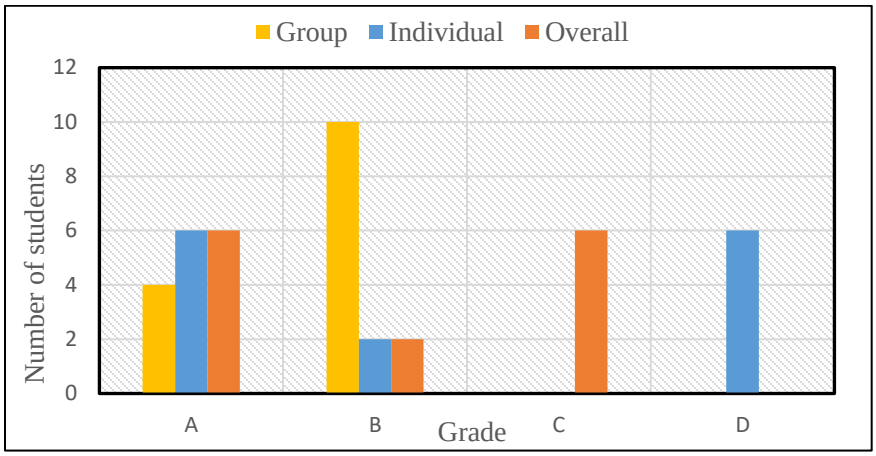

Fig. 3: Grade Distribution of Three Senior Design Teams

Focusing on the data variation, the average score of the three teams is depicted in Figure 4. Based on the group assignments, the average score of the three different teams with 14 students was 89.04% which is very comparable to the one team with 4 students average score (91.41%). On the other hand, the variation was increased from 0% for one team to 1.55% for the three teams. For the individual assignments the average score changed from 73.33% for one team to 81.06% for the three teams. Interestingly, the variation in data of the individual assignments did not show a big difference between the results from one team (13.22%) and three teams (13.52%). The average overall score for the three teams showed slight increase from 82.37% to 85.05% and there was no significance change in the average score variation for one team (6.61%) and three teams (6.50%).

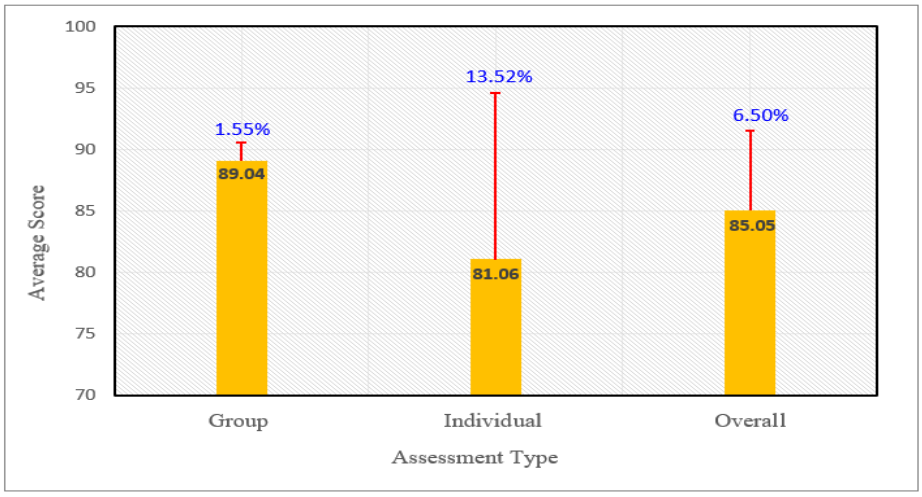

Fig. 4: The Average Score of Three Senior Design Teams

For further validation of the results obtained from this study, the analysis was extended to include six senior design teams from two different academic years. There were 26 students in these six teams. The grade distribution for the six teams based on group and individual assignments is displayed in Figure 5. For group assignments, 8 students had "A" grade while 18 students received "B" grade. The individual assignments showed wide distribution of the grade with 13 As, 5 Bs, 1 C, and 7 Ds. The combination of the group and individual assignments adjusted the final grade to 10 As, 9 Bs, 7 Cs.

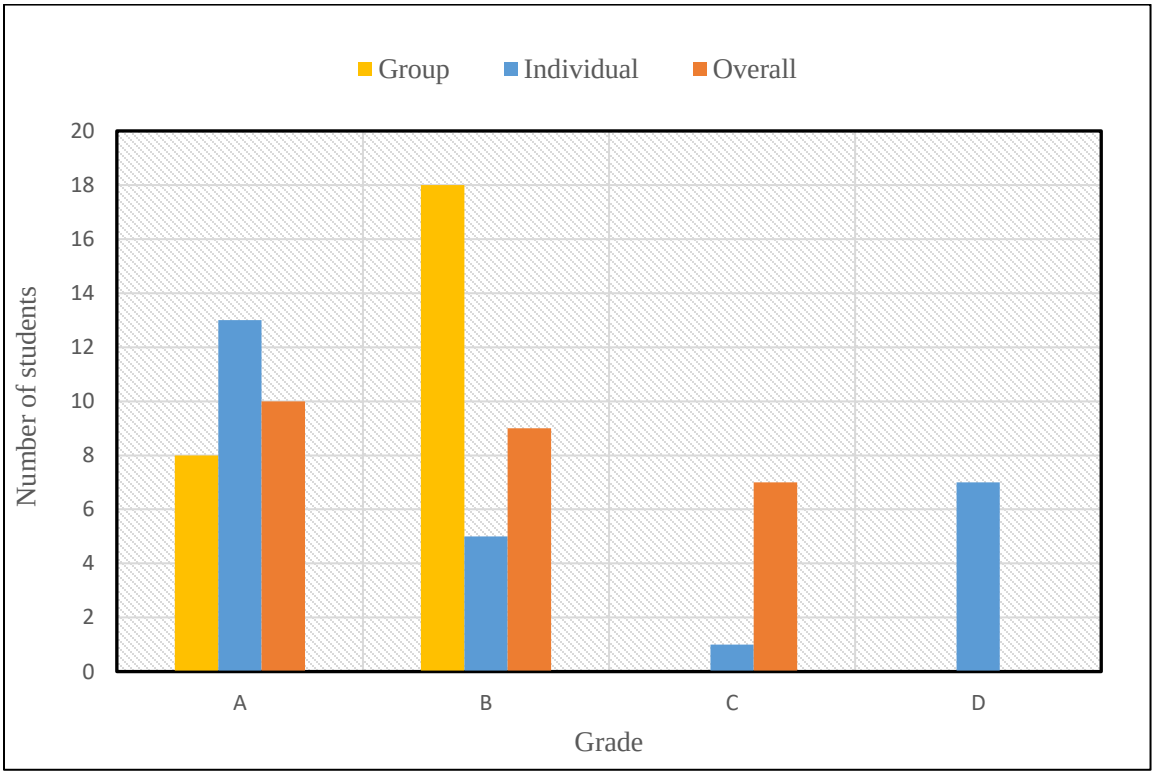

Fig. 5: Grade Distribution of Six Senior Design Teams

The average score for the six teams is presented in Figure 6. For the group assignments, the average score for the three cases was very comparable. The average score was (91.41%) for one team, (89.04%) for three teams, and (88.04%) for six teams. The variation in data in the group assignments showed consistent increase from 0% for one team to 1.55% for the three teams, to 3.06% for six teams. For the individual assignments the average score increased gradually from 73.33% for one team to 81.06% for the three teams, to 84.36% for six teams. The variation in data of the individual assignments for six teams dropped slightly to 12.68% as compared to 13.22% for one team and 13.50% for three teams. Again, the average overall score for the six team show small increase to 86.20% from the three teams average of 85.05%. Also, results indicated insignificant difference between the average score variation for one team (6.61%), three teams (6.50%), and six teams (6.13%).

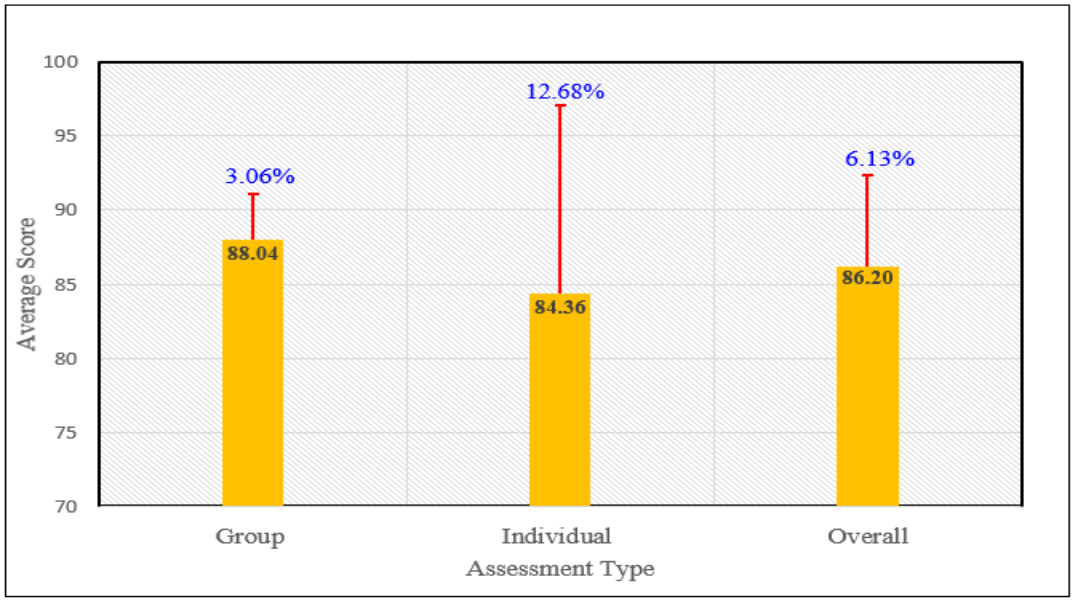

Fig. 6: The Average Score of Six Senior Design Teams

Figure 7 depicts the variation in the data for group, individual, and overall assignments of one, three, and six teams. For group assignments there is a noticeable difference in the data variation (from 0% to 3.06%.) as the number of teams increased form one team to six teams. This result was expected since the group assignments were graded based on each group performance. For individual assignments and the average overall score, the results showed that there is no significant difference in the data variation between one, three, and six teams. The difference in the data variation was about 0.84% (13.52% to 12.68%) for individual assignments and 0.48% (6.61% to 6.13%) for the overall average score. The insignificant difference in the data variation was due to the fact that the sample size was large for individual and the overall assignments as compared to the group assignments.

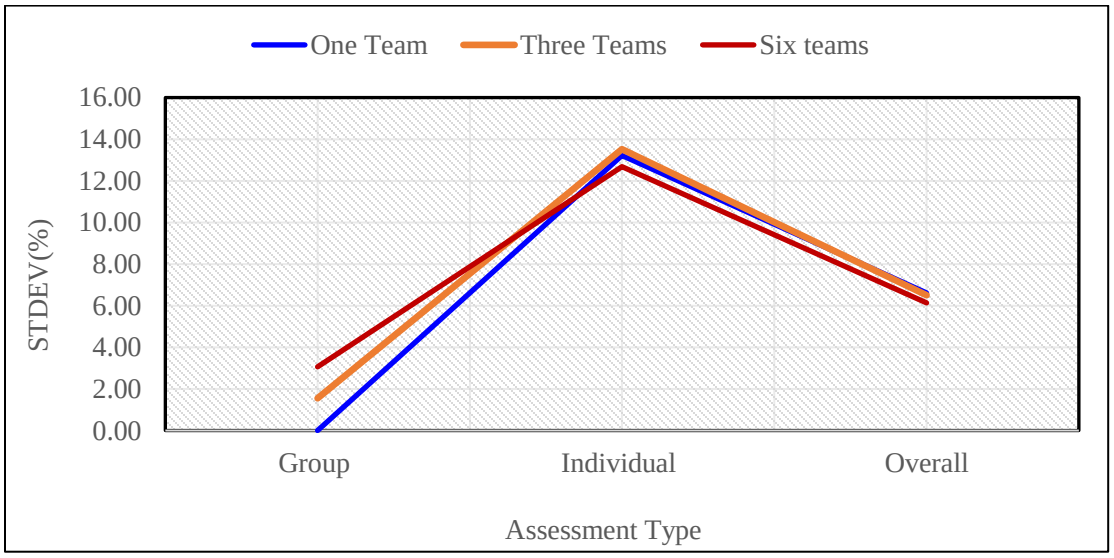

Fig. 7: Difference in Data Variation for one, Three, and Six Teams

Conclusion

This study presented an effective mechanism for awarding a fair grade to each student on a senior design (SD) project team based on his/her contribution to the project success. The student's overall grade was a combination of group assignments and individual assignments. The analysis was performed using the data from one team with 4 students, three teams with 14 students, and six teams with 26 students. The study showed that while the group assignments allocate the same grade for each student on the team, the individual assignments played a major role in adjusting the overall grade of each student on the team based on his/her actual performance on the project. For each team the data variation was found to be 0% on the group assignments but about 13.0% on the individual assignments. The variation in the individual assignments reflected the actual performance of the student and helped in assigning a fair grade for each student on the team. The study indicated that while the unenthusiastic students were benefited from the group assignments and able to enhance their grade, but they will not obtain the same grade as the dedicated students on the team. This study demonstrated the importance of including some individual assessment components not only on the senior design project but on any group project. These individual components could be short knowledge reflection assay about what the student learned from the project or short presentation by each student about the project.

References

[1] J. Estell and J. Hurtig, "Using Rubrics for the Assessment of Senior Design Projects", *American Society for Engineering Education Annual Conference and Exposition,* Chicago, Illinois, June 18-21, 2006

[2] S. Laguette, "Assessment of Project Completion for Capstone Design Projects", *American Society for Engineering Education Annual Conference and Exposition,* San Antonio, Texas, June 10-13, 2012

[3] R. Bringula, "Development of Rubrics for Capstone Project Courses: Perspectives from Teachers and Students", *Computer and Society*, 2011, Available online at https://doi.org/10.48550/arXiv.2011.11035

[4] D. Jones, "Successful Use of Rubrics to Assess Student Performance in Capstone Projects", *American Society for Engineering Education Annual Conference and Exposition*, Louisville, Kentucky, June 20-23, 2010

[5] T. Sasipraba et. al., "Assessment Tools and Rubrics for Evaluating the Capstone Projects in Outcome Based Education", *Procedia Computer Science,* 172, p 296–301, 2020, Available online at www.sciencedirect.com

[6] R. Hannemann, "Senior Design: A Simple Set of Report Outlines and Evaluation Rubrics", *American Society for Engineering Education Annual Conference and Exposition*, Louisville, Kentucky, June 20-23, 2010

[7] F. Abu Salem et. al., "Effective Assessment of Computer Science Capstone Projects and Student Outcomes", *International Journal of Engineering Pedagogy (IJEP),* Vol. 10. No. 2, 2020

[8] R. Melnyk and D. Boettner, "An Integrated Approach to Grading a Mechanical Engineering Capstone Design Course at the United Sates Military Academy", *American Society for Engineering Education Annual Conference and Exposition,* Pittsburgh, Pennsylvania, June 22-25, 2008

[9] R. Ferdiana, "The Triangulation Assessment Model for Capstone Project in Software Engineering", *The 12th International Conference on Information Technology and Electrical Engineering (ICITEE),* Virtual Conference, October 06-08, 2020

[10] D. Gosselin and D. Golick, "Posters as an Effective Assessment Tool for Capstone Course", *Journal of Environmental Studies and sciences,* Vol. 10:426-437, 2020, Available online at https://link.springer.com