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Comparing Student Performance in Individual and Collaborative Problem-Based Learning in The Basic Power System Course

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A B S T R A C T

Collaborative learning is associated with higher achievement, improved social connections, enhanced communication skills, and increased self-esteem. However, challenges such as a lack of collaboration skills, unequal participation, and free riding can hinder its effectiveness. It emphasizes the need for students to develop individual learning skills—such as analysis, synthesis, and reflection—before engaging in collaborative learning to ensure success. The paper aims to analyze and compare students' learning performance in a Basic Power System course over two consecutive years, in which the first year employed collaborative learning strategies and the second year used individual learning strategies, involving fourth-semester students in an Electrical Engineering Bachelor's program. The comparison of student marks between the 2022/2023 and 2023/2024 academic years indicates that individual assignments resulted in better performance, surpassing group assignments by an average of 23.7%. Exam results corroborate these findings: the 2023/2024 cohort surpassed the target scores, while the previous year's results fell significantly short. Despite this improvement, the exam results for both years were unsatisfactory, suggesting a need for more effective learning strategies, particularly those that boost students' self-efficacy in mastering course materials.

INTRODUCTION

Outcome-Based Education (OBE) is an educational framework that focuses on achieving specific, measurable learning outcomes rather than merely covering course content. It emphasizes what learners are expected to know, do, and value after completing a program, ensuring that all educational activities align with clearly defined outcomes. This approach shifts the focus from the traditional teacher-centered model to a learner-centered one, where assessment and curriculum design are driven by intended results. OBE promotes continuous improvement in teaching and learning by linking outcomes with assessment and feedback mechanisms [1], [2], [3]

Outcome-Based Learning has benefits such as developing problem-solving, critical thinking, and adaptability skills [4]. It also prepares students to learn and upskill beyond formal education. One type of Outcome-Based Learning is Problem-Based Learning. In Problem-Based Learning, learners develop knowledge and skills by solving real-world problems collaboratively [5], [6], [7].

Collaborative learning is often seen as an effective learning method for higher education. When compared with individual learning, collaborative learning has the advantage of higher achievement and productivity, better social connections, communication skills, and self-esteem [8], [9]. However, some difficulties may arise in implementing collaborative learning, hindering the learning process. Survey in [10] found that a lack of collaboration skills, unequal contributions among group members, and free riding are obstacles that reduce the benefits of collaborative learning.

Individual learning skills, i.e., analyzing, synthesizing, combining, and comparing to previous knowledge, making generalizations, and reflecting, must be honed before the students apply collaborative learning [11]. Otherwise, the collaborative learning will not be an effective way of studying. Therefore, care must be taken to ensure that the collaborative learning applied becomes an effective way to deliver the courses.

The Basic Power System course is an introductory course in electrical engineering, focusing on how electrical power is generated, transmitted, and distributed [12], [13], [14]. This course is essential because it's the foundation for understanding how electricity is produced and delivered safely and efficiently. From homes and hospitals to industries and data centers, almost everything depends on reliable electrical power. Understanding how that power is generated, transmitted, and distributed is critical for any electrical engineer [15], [16].

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This course serves as a gateway to various advanced subjects, including Power System Analysis, Power System Protection, Power Electronics, Smart Grids & Renewable Integration, Power System Operation and Control, and Power System Stability. The course introduces students to problems in power systems, such as frequency instability, blackouts, overload, under- or overvoltage, faults, and teaches them to analyze, troubleshoot, and prevent these issues [17], [18].

Using data from the two consecutive years, this paper aims to analyze and compare student learning performance in the Basic Power System course, which employs a collaborative learning strategy in the first year and an individual learning strategy in the second year. The course is taken by fourth-semester students of the Electrical Engineering Bachelor's Degree. The course applies the Problem-Based Learning (PBL) strategy.

METHOD

This study employed a comparative research design to examine differences in student performance between individual and collaborative problem-based learning (PBL) approaches in the Basic Power System course. The methodology was structured to provide a systematic comparison of how each learning mode influenced students' understanding and problem-solving skills. Participants were undergraduate electrical engineering students enrolled in the course during the academic semester. The study involved two groups: one engaged in individual PBL tasks, and the other in collaborative PBL activities conducted in small teams. Data were collected through performance assessments and assignments. Statistical analyses were then applied to determine significant differences between the two learning approaches.

The Basic Electrical Engineering course materials cover the introduction to the components and operation of electric power systems. This course is mandatory for all electrical engineering students, as it provides essential knowledge about power systems. As the course employs a problem-based learning approach, students are required to complete assignments that are submitted at the end of each lecture. Through these assignments, students engage with the course material and deepen their understanding. The marks from these assignments are used to evaluate the effectiveness of the learning strategy. In addition to assignment grades, final exam scores are utilized to evaluate the effectiveness of the learning methods. The assessment includes an analysis of the mean, maximum, minimum, and standard deviation of the students' marks.

There were 146 students in the 2022/2023 academic year and 138 students in 2023/2024. In the first year, students worked in groups of three or four to complete their assignments. The groups were created by the lecturers, who aimed to pair high-performing students with those who required additional support. This approach was intended to ensure that each group had roughly equal capabilities and to facilitate knowledge transfer from stronger students to those who were academically weaker.

The collaborative learning was intended to facilitate effective learning, allowing group members to discuss and share knowledge, thereby enhancing their understanding. Moreover, working with peers can be more engaging and motivating than working alone. It also creates a shared sense of responsibility for learning [8]. In collaborative learning, students work together in small groups to achieve shared learning goals, emphasizing interaction, discussion, and mutual support. This method encourages learners to actively construct knowledge through dialogue and cooperation, rather than passively receiving information. By engaging in group problem-solving, peer teaching, and collective reflection, students develop essential skills in critical thinking, communication, and teamwork that are crucial for lifelong learning. Collaborative learning also fosters a sense of community and accountability, enhancing both cognitive and social outcomes within the educational process [8].

In the second year, however, students completed the assignments individually. While they were encouraged to discuss assignment problems with peers, each student was required to submit their work independently. Individual learning often reduces distractions, leading to improved focus and deeper concentration. Solving problems and learning individually builds confidence and a sense of achievement.

Individual learning is the process by which learners acquire knowledge, skills, and attitudes independently, taking responsibility for their own progress and outcomes. This approach allows learners to work at their own pace, follow personalized learning paths, and engage in self-reflection to enhance understanding and performance [19]. Individual learning fosters autonomy, intrinsic motivation, and critical thinking, as students actively construct meaning from their experiences rather than relying solely on group interaction or teacher direction. It also accommodates diverse learning styles and abilities, making it an essential component of learner-centered education [20], [21], [22], [23], [24].

This paper will compare assignment and exam results between the academic years 2022/2023 and 2023/2024 to assess the effect of collaborative learning versus individual learning. There are three assignments and one final exam that will be analyzed and compared. The topic of the first assignment was electricity loads, which included the analysis of electric motors. The second assignment focused on transformer operation and characteristics, while the third covered the design and operation of electric power substations. The final exam evaluated students' overall understanding of the basic power system course content. Statistical analysis and performance trends will be examined to identify improvements or differences in learning outcomes between the two learning approaches. Additional analysis and interpretation will also be presented to support the research findings and provide insights into how collaborative problem-based learning affects student achievement and engagement.

RESULTS AND DISCUSSION

This section presents the results of the comparative analysis between individual and collaborative problem-based learning (PBL) approaches implemented in the Basic Power System course. The analysis focuses on evaluating student performance in terms of conceptual understanding, problem-solving ability, and overall achievement. Descriptive statistics were first used to summarize students' scores from both learning settings, followed by qualitative observations from group interactions and

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individual reflections. The results were analysed to provide deeper insights into the learning dynamics under each instructional approach.

The course is offered annually in four classes of approximately 40 students each. The same lecturers teach all classes to ensure consistency in content and assessments. Assignments are assigned during most lectures, requiring students to prepare beforehand and participate actively. Students must submit assignments at the end of each session, supporting continuous learning and prompt feedback. Explanations for assignment answers are provided in the following week's class, enabling reflection and understanding. This routine sustains a steady learning pace and progressively enhances students' analytical and problem-solving skills, preparing them for the final exam and future engineering challenges.

This paper will focus on assessing a single learning outcome of the course, as it received the lowest marks and failed to meet the established minimum standard. The learning outcome states: students should be able to explain the theory of synchronous generators, transmission, substations, and loads. Three assignments were designed to evaluate this outcome, with similar questions across both years. The average marks for these assignments are presented in Figure 1.

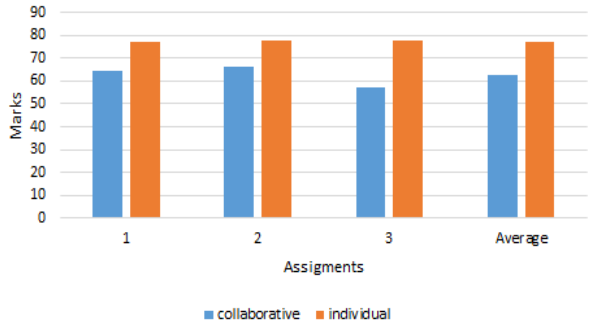

Figure 1. Average assignment marks of two consecutive years

Figure 1 shows the average marks for assignments 1, 2, and 3, and the total average of the three assignments. For all three assignments, students in the individual learning group scored consistently higher than those in the collaborative group. The difference is notable in Assignment 3, where the gap between the two groups is the widest. The average score across all assignments is higher for individual learners (around 75) compared to collaborative learners (around 60). While collaborative scores slightly drop in Assignment 3, individual scores remain consistently high across all assignments, suggesting that individual learners maintained their performance better over time. This indicates that individual assignments yield better results than group assignments, with an average of 23.7%.

These results contradict the belief based on the theory that group learning is more effective and produces better results than individual learning [8], [9]. This condition may occur due to a lack of collaboration skills, unequal contribution among group members and free riding [10]. Free riding is a situation in collaborative learning in which one or more group members do not contribute or contribute very little to the group task. While the active group members fulfill the assignment within the time constraint. Other causes of ineffective collaborative learning are, including: (a) unequal participation, where some students may dominate discussions, while others may be less engaged, leading to imbalanced contributions and potential frustration; (b) varied learning paces, where students learn at different speeds, which can cause frustration for those who grasp concepts quickly and for those who need more time [25].

Individual learning can be highly effective for several reasons, i.e., (a) independent learning fosters a sense of responsibility and ownership over one's education, which can motivate students to take initiative [11], (b) minimizes distractions from peers, enabling students to concentrate fully on the material, (c) learners can choose methods and resources that best suit their unique learning preferences, enhancing engagement and retention.

Exam results further demonstrate that individual learning outperformed collaborative learning in this course. While the exam questions and formats differed, the scores allow for a comparison of learning outcomes. The results corresponding to the learning objectives are presented in Table 1.

Table 1. Average Exam Results of the Two Academic Years with a maximum point is 100

Collaborative	Individual
19.4	57.8

Table 1 shows that the average exam results for collaborative learning are significantly below the target (55), whereas those for individual learning exceed it. The highest and lowest exam marks, along with their standard deviations, are shown in Table 2.

Table 2. Exam Grades of the Two Academic Years

Value	Collaborative	Individual
Highest	95	100
Lowest	0	0
Standard deviation	18.3	25.6

Table 2 shows that the standard deviation of individual learning is higher than that of collaborative learning. This suggests that the variation or dispersion in collaborative learning tends to be close to the mean, whereas a high standard deviation in individual learning indicates a greater spread. This may indicate that students' achievement in individual learning varies more compared to collaborative learning in this course. Figure 2 shows box and whisker chart for the exam results.

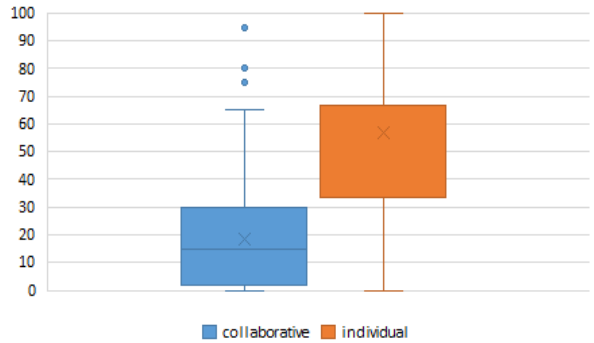

Figure 2. Exam results chart

Figure 2 shows that the median exam score for individual learning is significantly higher than that for collaborative learning. The interquartile range (box size) for individual learning is larger, indicating greater variability in scores than in collaborative learning. The individual learning group shows greater spread, with scores ranging from close to 0 to nearly 100. While the collaborative learning group has a much smaller spread, with most scores concentrated between 0 and about 60.

Collaborative learning reveals multiple outliers with higher scores (above 60), indicating that a few students performed exceptionally well despite the lower overall median. Individual learning also has some outliers, but they are more evenly distributed across the range. Overall, individual learning appears to result in higher exam scores on average, but also with greater variability. Collaborative learning produces more consistent but generally lower scores, with a few exceptions of high-performing students.

However, in both years, the average exam results were unsatisfactory because the percentage of students who passed the minimum mark was below the target. This suggests the need for more effective learning strategies. These strategies should include techniques aimed at enhancing students' self-efficacy to comprehend the course material better [26].

Self-efficacy is a person's belief that he or she has the capability and skill to do a specific task [27]. Student attainments in studying are strongly correlated with self-efficacy [27], [28], besides self-regulation and motivation [29], [30], [31], [21]. Therefore, to improve students' achievement in this course, enhancing student efficacy is considered an appropriate approach.

Self-efficacy of the students can be raised by several strategies. [27] which are relevant to the course delivery style, i.e., (a) recognize each student's misunderstandings and offer chances for them to engage in targeted remedial learning that addresses those specific issues [32], (b) incorporate multimedia, such as videos, to enhance students' learning, but ensure that their use is guided through classroom interactions instead of allowing students to watch resources on their own [33], (c) offer customized resources and activities for students to help them with concepts and skills that past cohorts have struggled to grasp [34], (d) give students positive reinforcement for the correct steps they take in their problem-solving strategies [31], (e) Promote the application of content and emphasize its relevance by linking academic study to professional practice [35].

CONCLUSIONS

The results show that individual assignments consistently yield higher student performance than group assignments, primarily due to common challenges in collaborative work such as unequal participation, free riding, and varied learning paces. Although individual tasks enhance responsibility and allow students to apply personalized learning strategies, the overall achievement level in both academic years remains below expectations. This highlights the importance of strengthening students' self-efficacy, motivation, and self-regulated learning skills to support better academic outcomes.

The relatively short intervention period in this study may have limited students' ability to develop effective collaborative routines. Future research should therefore consider extending the learning duration and refining group formation strategies by incorporating both prior knowledge and students' partner preferences. These improvements may enable more cohesive group dynamics and foster more effective collaborative learning in subsequent implementations.

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REFERENCES

[1] W. G. Spady, *Outcome-Based Education: Critical Issues and Answers.* ERIC, 1994.

[2] S. Amirtharaj, G. Chandrasekaran, K. Thirumoorthy, and K. Muneeswaran, 'A Systematic Approach for Assessment of Attainment in Outcome-based Education', *Higher Education for the Future*, vol. 9, no. 1, pp. 8–29, Jan. 2022, doi: 10.1177/23476311211017744.

[3] M. Yasmin and A. Yasmeen, 'Viability of outcome-based education in teaching English as second language to chemical engineering learners', *Education for Chemical Engineers*, vol. 36, pp. 100–106, Jul. 2021, doi: 10.1016/j.ece.2021.04.005.

[4] F. Bouslama, A. Lansari, A. M. Al-Rawi, and A. A. Abonamah, 'A Novel Outcome-Based Educational Model and its Effect on Student Learning, Curriculum Development, and Assessment', *Journal of Information Technology Education: Research*, vol. 2, no. 1, pp. 203–214, Jan. 2003, [Online]. Available: https://www.learntechlib.org/p/111473

[5] D. E. Allen, R. S. Donham, and S. A. Bernhardt, 'Problem-based learning', *New directions for teaching and learning*, vol. 2011, no. 128, pp. 21–29, 2011, [Online]. Available: https://onlinelibrary.wiley.com/doi/abs/10.1002/tl.465

[6] M. J. Newman, 'Problem based learning: an introduction and overview of the key features of the approach', *Journal of Veterinary Medical Education*, vol. 32, no. 1, pp. 12–20, 2005.

[7] A. Fyrenius, B. Bergdahl, and C. Silén, 'Lectures in problem-based learning—Why, when and how? An example of interactive lecturing that stimulates meaningful learning', *Medical teacher*, vol. 27, no. 1, pp. 61–65, 2005.

[8] M. Laal and S. M. Ghodsi, 'Benefits of collaborative learning', *Procedia - Social and Behavioral Sciences*, vol. 31, pp. 486–490, Jan. 2012, doi: 10.1016/j.sbspro.2011.12.091.

[9] S. Yager, D. W. Johnson, and R. T. Johnson, 'Oral discussion, group-to-individual transfer, and achievement in cooperative learning groups.', *Journal of Educational Psychology*, vol. 77, no. 1, pp. 60–66, 1985, doi: 10.1037/0022-0663.77.1.60.

[10] H. Le, J. Janssen, and T. Wubbels, 'Collaborative learning practices: teacher and student perceived obstacles to effective student collaboration', *Cambridge Journal of Education*, vol. 48, no. 1, pp. 103–122, Jan. 2018, doi: 10.1080/0305764X.2016.1259389.

[11] A. Yadin and R. Or-Bach, 'The importance of emphasizing individual learning in the "collaborative learning era"', *Journal of Information Systems Education*, vol. 21, no. 2, pp. 185–194, 2010, [Online]. Available: https://aisel.aisnet.org/jise/vol21/iss2/5/

[12] A. Von Meier, *Electric power systems: a conceptual introduction*. John Wiley & Sons, 2024.
[13] P. Schavemaker and L. Van der Sluis, *Electrical power system essentials*. John Wiley & Sons, 2025.
[14] C.-W. Ten and Y. Hou, *Modern power system analysis*. CRC Press, 2024.
[15] N. Rosenberg, 'The role of electricity in industrial development', *The Energy Journal*, vol. 19, no. 2, pp. 7–24, 1998.
[16] C. E. Hoicka and J. MacArthur, 'The infrastructure for electricity', in *The Oxford handbook of energy politics*, Oxford University Press, 2021.
[17] A. Chakrabarti and S. Halder, *Power system analysis: operation and control*. PHI Learning Pvt. Ltd., 2022.
[18] H. Golpîra, H. Bevrani, A. R. Messina, and B. Francois, 'A data-driven under frequency load shedding scheme in power systems', *IEEE Transactions on Power Systems*, vol. 38, no. 2, pp. 1138–1150, 2022.
[19] I. Fazey, J. A. Fazey, and D. M. Fazey, 'Learning more effectively from experience', *Ecology and society*, vol. 10, no. 2, 2005.
[20] B. J. Zimmerman, 'Becoming a Self-Regulated Learner: An Overview', *Theory Into Practice*, vol. 41, no. 2, pp. 64–70, May 2002, doi: 10.1207/s15430421tip4102_2.
[21] B. J. Zimmerman and D. H. Schunk, *Self-regulated learning and academic achievement: Theoretical perspectives*. Routledge, 2013.
[22] B. J. Zimmerman and A. Kitsantas, 'Developmental phases in self-regulation: Shifting from process goals to outcome goals.', *Journal of educational psychology*, vol. 89, no. 1, p. 29, 1997.
[23] A. Bandura and D. H. Schunk, 'Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation.', *Journal of personality and social psychology*, vol. 41, no. 3, p. 586, 1981.
[24] B. J. Zimmerman and M. Martinez-Pons, 'Construct validation of a strategy model of student self-regulated learning.', *Journal of educational psychology*, vol. 80, no. 3, p. 284, 1988.
[25] K. Sinitsa, 'Introduction: Learning Individually: a Life-Long Perspective Introduction to the Special Issue', *Journal of Educational Technology & Society*, vol. 3, no. 1, pp. 17–23, 2000.
[26] Z. Shafait, M. A. Khan, U. F. Sahibzada, Z. Dacko-Pikiewicz, and J. Popp, 'An assessment of students' emotional intelligence, learning outcomes, and academic efficacy: A correlational study in higher education', *PLOS ONE*, vol. 16, no. 8, p. e0255428, Aug. 2021, doi: 10.1371/journal.pone.0255428.
[27] K. Bartimote-Aufflick, A. Bridgeman, R. Walker, M. Sharma, and L. Smith, 'The study, evaluation, and improvement of university student self-efficacy', *Studies in Higher Education*, vol. 41, no. 11, pp. 1918–1942, Nov. 2016, doi: 10.1080/03075079.2014.999319.
[28] A. Bandura and S. Wessels, *Self-efficacy*. Cambridge University Press Cambridge, 1997.
[29] D. B. Miele and A. A. Scholer, 'Self-regulation of motivation', in *Handbook of motivation at school*, Routledge, 2016, pp. 363–384.
[30] C. Sansone, T. Fraughton, J. L. Zachary, J. Butner, and C. Heiner, 'Self-regulation of motivation when learning online: The importance of who, why and how', *Educational technology research and development*, vol. 59, no. 2, pp. 199–212, 2011.
[31] B. J. Zimmerman and A. Kitsantas, 'Acquiring writing revision and self-regulatory skill through observation and emulation.', *Journal of Educational Psychology*, vol. 94, no. 4, pp. 660–668, 2002, doi: 10.1037/0022-0663.94.4.660.
[32] L.-H. Chen, 'Enhancement of student learning performance using personalized diagnosis and remedial learning system', *Computers & Education*, vol. 56, no. 1, pp. 289–299, Jan. 2011, doi: 10.1016/j.compedu.2010.07.015.
[33] L. J. Govaere Jan, A. de Kruif, and M. Valcke, 'Differential impact of unguided versus guided use of a multimedia introduction to equine obstetrics in veterinary education', *Computers & Education*, vol. 58, no. 4, pp. 1076–1084, May 2012, doi: 10.1016/j.compedu.2011.11.006.
[34] W. Cheung, E. Y. Li, and L. W. Yee, 'Multimedia learning system and its effect on self-efficacy in database modeling and design: an exploratory study', *Computers & Education*, vol. 41, no. 3, pp. 249–270, Nov. 2003, doi: 10.1016/S0360-1315(03)00048-4.
[35] M. Papastergiou, 'Enhancing Physical Education and Sport Science students' self-efficacy and attitudes regarding Information and Communication Technologies through a computer literacy course', *Computers & Education*, vol. 54, no. 1, pp. 298–308, Jan. 2010, doi: 10.1016/j.compedu.2009.08.015.

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