Addressing Participation and Feedback Challenges in Large Computer Science Classes*

Abbas Attarwala Ph.D.[1], Ed Lindoo Ph.D.[2] and Paul Viotti Ph.D.[3]
[1]Computer Science Department
California State University
Chico, CA, 95973
aattarwala@csuchico.edu
[2]Computer Information Systems
Anderson School of Business
Regis University
Denver, CO, 80221
elindoo@regis.edu
[3]Political Science Department
California State University
Chico, CA, 95973
pviotti@csuchico.edu

Abstract

Teaching large classes, particularly in computer science (CS), presents notable challenges that can hinder student learning. Common issues include low student participation, often due to students feeling hesitant or uncomfortable speaking up in large groups, and difficulties in providing timely feedback. To address these challenges, this study introduces a straightforward and practical solution: a dual-component quiz system integrated into laboratory sessions. In this approach, students first complete a quiz individually, followed by a collaborative phase where they

retake the same quiz in small groups. This structure promotes peer feedback and reinforces understanding. The grading scheme allocates 60% of the total score to individual performance and 40% to group performance, encouraging both personal accountability and collaborative engagement. To assess the effectiveness of this method, a comparative analysis was performed using course evaluations from five sections of CS 132 at Boston University. Two sections, serving as the baseline, did not include the quiz component, while three sections implemented the new system. The results of the Welch Statistical Test (WST) revealed that the collaborative quiz system significantly improved student participation, promptness of feedback, and quality of feedback to students.

1 Introduction

Teaching large classes, such as those with more than 100 students, presents notable challenges that can hinder student learning. A major issue is the reluctance of many students to participate in such environments, often due to feelings of shyness or intimidation [7]. As a result, only a small fraction of students actively engage, while the majority remain passive. In addition, timely and constructive feedback is crucial for effective learning [14], but delivering it in large classes is difficult, even with the support of teaching assistants. The sheer volume of grading leads to delays, and by the time students receive feedback, they may have already moved on from the material, diminishing its impact on their learning.

Williams [17] emphasized that active participation and timely feedback are critical to effective learning. He found that students who actively participate in class are more likely to retain information, develop critical thinking skills, and achieve stronger academic performance. Timely feedback enables students to identify and correct mistakes, reinforce their understanding of key concepts, and apply improvements while the material remains fresh. In contrast, delayed feedback reduces its effectiveness, potentially creating comprehension gaps that can hinder future learning. Inspired by the findings of Williams [17], we revisited student course evaluation data collected at Boston University. The evaluation data specifically measured instructor performance on eight attributes: (1) Effectiveness in explaining concepts, (2) Ability to stimulate interest in the subject, (3) Encouragement of class participation, (4) Fairness in grading, (5) Promptness in returning assignments, (6) Quality of feedback provided to students, (7) Availability outside of class, and (8) Overall instructor rating. Our analysis specifically focused on the attributes of Encouragement of class participation, Promptness in returning assignments, and Quality of feedback provided to students. Our goal was to determine whether the incorporation of a collaborative quiz component into lab sessions significantly impacted these

targeted attributes based on student teaching course evaluation data.

Based on prior research [7, 13], we hypothesized that a collaborative quiz approach would encourage students to reflect on their individual efforts, promote peer learning, and facilitate immediate feedback from classmates, teaching assistants, and instructors. Our quiz system was thus designed with two parts: an individual component, where students first attempted the quiz on their own, and a collaborative component, where they retook the same quiz in small groups. Subsequent studies have since reinforced the value of quizzes, frequent formative assessments, and immediate feedback in enhancing learning outcomes and student engagement [8, 9, 11, 17], indirectly supporting the effectiveness of our collaborative design choices.

The grading scheme was also adjusted to incentivize participation and collaboration, with 60% of the quiz grade based on individual performance and 40% on group performance. The goal is to ensure that by the end of the lab session, student concerns are addressed through group discussions, enhancing their understanding and retention of the material. More formally, the research question is stated as, *How does the implementation of a collaborative quiz component in large class-size courses impact student engagement, participation, and the effectiveness of feedback compared to without such a component?*

In this study, we compare student course evaluation data from five different sections of CS 132. Two sections of CS 132, taught in Fall 2017 and Fall 2018, did not include any quiz component. Three other sections i.e., Spring 2019 Section A, Spring 2019 Section B, and Fall 2019 incorporated the collaborative quiz component. A WST test was used to determine whether differences in course evaluations between sections without quizzes and sections with the collaborative quiz component were statistically significant.

By assessing the effectiveness of this approach, the goal is to provide insight into how structured peer collaboration and timely feedback can enhance learning experiences in large classroom settings. The findings may have broader implications for educational practices and policies in higher education, particularly within STEM disciplines.

2 Literature Review

Chen and Liu [3] identified flipped learning, and classroom approaches as particularly well-suited for STEM courses, noting their frequent application in these disciplines. They explained that flipped learning shifts direct instruction from the group setting to the individual learning space (or vice versa), transforming the group space into a dynamic, interactive environment.

Samaila and Al-Samarraie [11] pointed out that a major issue in teaching with a flipped classroom model in CS is that many students avoid watching

pre-class videos or watch them right before the lectures, which can negatively impact learning. They suggest adopting a quiz-based flipped classroom, where quizzes within the videos increase student interaction with the pre-class content, thereby promoting greater engagement in the classroom as well. Unlike the approach of embedding quizzes within pre-class videos, our method integrates a collaborative quiz component directly into the classroom setting. This allows students to engage with the material both individually and in groups, facilitating immediate feedback and peer learning, which can enhance understanding and retention of the subject matter.

Group quizzes, where students collaborate, are supported by social interdependence theory [7] and social constructivism [15, 6], both of which highlight the role of student dialogue in improving the learning experience. Research by [10] indicates that students perform significantly better on final exams and projects when quizzes are open-book and allow for collaboration, such as discussing questions in pairs. Similarly, [9] found that students who participated in frequent quiz-based assessments achieved higher final exam grades compared to those who only took the final exam. Furthermore, [13] reported that collaborative learning groups not only improve student learning outcomes but also create positive attitudes toward both subject matter and peers. Their study on collaborative testing in an introductory Sociology course revealed that, compared to a control group, students involved in collaborative testing completed more assigned readings and demonstrated improved attitudes toward learning and the testing process.

Bandura contends that self-efficacy plays a crucial role in learning environments, directly supporting our collaborative quiz approach [1]. As students collaborate on quizzes, they observe peers successfully applying concepts, which enhances their own self-efficacy and willingness to participate in subsequent learning activities. This theoretical perspective is consistent with our finding that students who initially provided incorrect responses demonstrated better comprehension after engaging in peer discussions.

Wenger's communities of practice framework [16] provides additional theoretical grounding for our findings. Collaborative quizzes create temporary micro-communities in which students develop shared understanding through negotiation of meaning. This social learning process facilitates deeper conceptual engagement than individual study alone. Similarly, Boud et al. describe a "multiplier effect" in which students simultaneously give and receive feedback, addressing the delayed feedback limitations that Williams [17] identified as problematic in large classes. The peer learning framework of Boud et al. [2] sheds light on how peer feedback often proves more accessible and actionable than instructor feedback alone.

Simsek [12] found that a five-point Likert scale is the most preferred re-

sponse format for measuring individual characteristics in self-report instruments such as questionnaires and surveys. They further noted that both parametric and non-parametric analyses using this item type have been widely reported in previous research. In their study, [12] analyzed the suitability of the Wilcoxon-Mann-Whitney test, Welch's t-test, and Student's t-test for Likert-type data. The results indicated that the Wilcoxon-Mann-Whitney test is more effective for analyzing smaller datasets, whereas WST performs better with larger datasets, particularly when the variances between the two groups are unequal.

3 Methodology

Williams [17] made a key observation that inspired this study: students struggle to learn effectively when feedback is delayed or when they lack engagement during class. Based on this insight, the hypothesis is that incorporating a collaborative quiz component, which requires small group interactions, will enhance students' understanding of the material through peer discussions. This approach allows students who initially answer quiz questions incorrectly to learn from their peers and address gaps in their understanding during the lab session. In support of this, [12] reported that students who initially provided incorrect responses demonstrated better comprehension after participating in peer discussions. As detailed in Section 6, the results show a statistically significant improvement in both class participation and the quality of feedback provided to students.

This study analyzed end-of-semester course evaluations to compare semesters in which the collaborative quiz component was implemented with those in which it was not. The objective was to determine whether the inclusion of the collaborative quiz led to statistically significant improvements in student engagement, the quality of feedback received, and the promptness of feedback delivery. Although [9] did not specify whether a collaborative quiz component was introduced, the focus of this study is to evaluate whether such a component enhances student participation, improves the quality of feedback, and ensures timely feedback delivery.

For this study a statistical analysis was performed to evaluate the effectiveness of the collaborative group quiz component introduced in CS 132. Two sections of CS 132 from Fall 2017 and Fall 2018, were compared, with no collaborative quiz component, against three sections of CS 132, specifically two sections of Spring 2019 and one section from Fall 2019, where the collaborative quiz component was implemented. The null hypothesis (H_0) and alternative hypothesis (H_1) were established as follows:

- H_0: There are no differences in the mean ratings of each of the eight

evaluation questions between sections with and without the collaborative quiz component.

- H_1: There is a significant difference in the mean ratings for each of the eight evaluation questions between sections with and without the collaborative quiz component, which could be positive or negative.

Although we conducted our statistical tests for completeness across all eight evaluation attributes, the primary focus of this study is specifically on the three attributes identified earlier: Encouragement of class participation, Promptness in returning assignments, and Quality of feedback provided to students. The inclusion of all eight attributes in the hypothesis testing serves to provide a comprehensive perspective, but we emphasize these three attributes due to their particular relevance to assessing the impact of the collaborative quiz component. To evaluate these hypotheses, a two-tailed WST was used for each of the eight evaluation questions. Before performing statistical tests, the alpha level was set at 10%. The analysis was performed in six pairs of sections, comparing each of the two sections without the collaborative quiz component to each of the three sections that incorporated the collaborative quiz component. A two-tailed test is selected because it enables the detection of increases and decreases in teaching effectiveness, irrespective of the direction. The Student t-test presumes equal variances between the compared groups. According to the data presented in Section 5, this assumption does not hold. Therefore, Student's t-test might result in misleading conclusions. In contrast, WST does not require the assumption of equal variances, which makes it more suitable for the course evaluation data [4, 5] in this paper. This test provides a more reliable assessment by adjusting the degrees of freedom according to the sample sizes and variances of each group. The $t\_statistic$ and $Degree\ of\ Freedom$ are calculated for the WST:

$$t\_statistic = \frac{\mu_1 - \mu_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \qquad Deg\ of\ Freedom = \frac{\left(\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}\right)^2}{\frac{(\sigma_1^2/n_1)^2}{n_1 - 1} + \frac{(\sigma_2^2/n_2)^2}{n_2 - 1}}$$

μ_1, μ_2 are the means of the two groups, σ_1^2, σ_2^2 are their variances, and n_1, n_2 are the sample sizes. In our analysis, subscript 1 refers to the "No Quiz" group and subscript 2 refers to the "With Quiz" group. Using WST allows us to more accurately determine whether the observed differences in teaching effectiveness are statistically significant, thus providing a better foundation for potential pedagogical adjustments based on empirical evidence.

4 Quiz Structure

Quizzes were administered every two to three weeks during the 15-week semester during scheduled lab sessions. In the first phase, students completed the quiz individually within 25 minutes, under closed-book conditions, without any aids, and using pen and paper. After collecting individual quizzes, students were organized into groups of three or four, with the teaching assistant or instructor facilitating group formation to ensure balanced teams. The students were then allowed to rearrange the furniture so that they could sit together and engage in collaborative discussions.

After forming the groups, the same quiz printed on a new sheet is distributed to each team. Students are given 20 minutes to complete the quiz collaboratively. The initial individual attempt allows students to identify areas of difficulty which they can address during the group discussion. Throughout this phase, students are encouraged to communicate within their groups and may also seek guidance from the instructor or teaching assistant. In addition, students are encouraged to reference the textbook as needed. This setup transforms the classroom into a dynamic and interactive environment in which students actively engage with one another. A notable dynamic emerges as students who performed well on the individual quiz often take on a teaching role explaining concepts and answers to their peers. This peer teaching is further incentivized by the grading structure which allocates a portion of the overall grade to the collaborative component.

5 Data

The course evaluations from CS 132 were collected at the end of each semester, specifically during the last week, at Boston University. These evaluations were conducted online, allowing students to complete them on their phones or computers. Table 1 presents data from course evaluations for the Fall 2017 and Fall 2018 semesters during which no collaborative quiz component was involved. In contrast, Table 2 includes data from course evaluations for Spring 2019 Section A, Spring 2019 Section B, and Fall 2019 where a collaborative quiz component was integrated into the course.

During the evaluations, students rated the instructor performance on a five-point Likert scale from 1 (poor) to 5 (excellent) in eight questions. For Question #3, "Encouragement of Class Participation," the highest mean rating of 4.25 was achieved in Spring 2019 Section B with the collaborative group component, and the lowest rating of 3.93 in Fall 2018 without the collaborative quiz. In Question #5, "Promptness in returning assignments," the highest mean rating was 4.03 in Spring 2019 Section A, and the lowest was 3.2 in Fall

Table 1: Teaching course evaluations of CS 132 from Fall 2017 and Fall 2018 for classes taught without the collaborative quiz component.

	Fall 2017			Fall 2018		
	N	SD	M	N	SD	M
Effectiveness in explaining concepts	62	1.08	4.03	95	1.18	3.72
Ability to stimulate interest in subject	62	1.02	4.08	95	1.05	4.09
Encouragement of class participation	62	1.03	4.1	95	1.14	3.93
Fairness in grading	62	1	4.35	95	0.95	4.18
Promptness in returning assignments	62	1.06	4	95	1.16	3.2
Quality of feedback to students	62	1.08	4.11	95	1.07	3.84
Availability outside of class	62	1	4.32	95	0.89	4.14
Overall rating of instructor	62	0.98	4.31	95	1.02	4.02

Table 2: Teaching course evaluations of CS 132 from Spring 2019 Section A, Spring 2019 Section B and Fall 2019 for classes taught with the collaborative quiz component.

	Spring 2019 A			Spring 2019 B			Fall 2019		
	N	SD	M	N	SD	M	N	SD	M
Effectiveness in explaining concepts	53	1.12	4.02	60	1.18	3.82	99	1.01	4.14
Ability to stimulate interest in subject	53	1.19	3.85	60	1.09	4.15	99	1.06	4.06
Encouragement of class participation	53	0.91	4.13	60	1.04	4.25	99	1.11	4.1
Fairness in grading	52	0.93	4.15	60	1.12	4.25	98	0.89	4.32
Promptness in returning assignments	53	1.02	3.72	60	1.12	4.03	98	1.13	3.71
Quality of feedback to students	53	1.05	4.04	60	1.13	4.17	99	0.94	4.2
Availability outside of class	53	1	4.17	60	0.92	4.42	99	0.83	4.49
Overall rating of instructor	53	0.92	4.23	60	1.1	4.22	99	0.85	4.42

2018. For Question #6, "Quality of feedback to students," the highest mean rating was 4.2 in Fall 2019 and the lowest was 3.84 in Fall 2018.

An important question arises from this observation: Are the differences in average ratings across these three questions statistically significant when comparing semesters with the collaborative group quiz component to those without it? Understanding whether these differences are statistically significant is crucial. It allows us to determine whether the observed differences are the result of the collaborative quiz component or are simply random occurrences. However, it is important to acknowledge that other factors could have influenced the ratings between semesters, including variations in class size and differences in student cohorts. Aside from these factors, the course material, assignments, and delivery methods remained consistent across all sections.

Student course evaluation data across all eight questions (Tables 1 and 2) were analyzed using a two-tailed WST with hypotheses described in Section 3. While statistical analysis results for all attributes are presented in Section 6 for completeness, this study specifically emphasizes three evaluation questions aligned with the research question in Section 1: (1) Encouragement of class participation, (2) Promptness in returning assignments, and (3) Quality of feedback provided to students.

6 Results and Discussion

The results of this study as seen in Table 3 demonstrate the impact of integrating a collaborative quiz component in CS 132 on 1) Encouragement of Class participation, 2) Promptness in returning assignments, and 3) Quality of feedback to students. In Table 3, row 3, there is one statistically significant result indicating that the collaborative quiz component improved class participation. Even in instances where the results were not statistically significant, the trend in all six pairs consistently showed an improvement in participation. This suggests that the collaborative component positively influences students' willingness to engage during class.

Timely feedback is essential for students to understand their mistakes and improve their learning strategies. The results for promptness in returning assignments, shown in row 5, reveal three statistically significant improvements in sections with the collaborative quiz component. This finding indicates that the immediate feedback provided during collaborative sessions is highly valued by the students. Although the overall assignment feedback, which includes grading outside the lab time, might still experience delays, the instantaneous peer and instructor feedback during the quizzes significantly enhances the students' perception of prompt feedback.

As discussed by [14] and [17] high-quality feedback is vital for students to grasp complex concepts and correct their misunderstandings. In row 6, two statistically significant improvements were observed in the quality of feedback for sections that included the collaborative quiz component. Additionally, although the remaining pairs did not show statistically significant differences, all indicated an improvement in feedback quality for the collaborative sections. This consistent trend underscores the importance of immediate and constructive feedback provided during collaborative activities which plays a crucial role in reinforcing students' learning.

These results are significant for several reasons. Firstly, they demonstrate that incorporating collaborative components in quizzes can enhance student participation, ensure timely feedback, and improve the overall quality of feedback. This approach effectively addresses common challenges in large classroom settings such as student shyness and delays in receiving meaningful feedback. Additionally, the findings indicate that students value and benefit from immediate feedback which collaborative activities can provide efficiently. These findings carry significant implications for educational strategies, indicating that collaborative quizzes can be utilized by educators to create a more dynamic and interactive learning atmosphere.

Table 3: Statistical Analysis of all eight questions. DF is Degree of Freedom, tStat is t statistic, and CI is the 90% confidence interval. Statistical significant results are bolded.

Evaluation Question	Spring 2019 Section A with Quiz		Spring 2019 Section B with Quiz		Fall 2019 with Quiz	
	Fall 2017 with No Quiz	Fall 2018 with No Quiz	Fall 2017 with No Quiz	Fall 2018 with No Quiz	Fall 2017 with No Quiz	Fall 2018 with No Quiz
Effectiveness in explaining concepts	DF = 108.88 tStat = 0.049 pValue = 0.961 CI = [-0.332, 0.352]	DF = 112.48 tStat = -1.532 pValue = 0.128 CI = [-0.625, 0.025]	DF = 118.26 tStat = 1.024 pValue = 0.308 CI = [-0.130, 0.550]	DF = 125.61 tStat = -0.514 pValue = 0.608 CI = [-0.422, 0.222]	DF = 123.13 tStat = -0.645 pValue = 0.520 CI = [-0.393, 0.173]	**DF = 184.95** **tStat = -2.658** **pValue = 0.009** **CI = [-0.681, -0.159]**
Ability to stimulate interest in subject	DF = 103.15 tStat = 1.103 pValue = 0.273 CI = [-0.116, 0.576]	DF = 96.87 tStat = 1.226 pValue = 0.223 CI = [-0.085, 0.565]	DF = 118.83 tStat = -0.366 pValue = 0.715 CI = [-0.387, 0.247]	DF = 122.10 tStat = -0.339 pValue = 0.736 CI = [-0.354, 0.234]	DF = 133.43 tStat = 0.119 pValue = 0.905 CI = [-0.258, 0.298]	DF = 191.80 tStat = 0.198 pValue = 0.843 CI = [-0.220, 0.280]
Encouragement of class participation	DF = 112.87 tStat = -0.166 pValue = 0.869 CI = [-0.330, 0.270]	DF = 128.45 tStat = -1.168 pValue = 0.245 CI = [-0.484, 0.084]	DF = 119.78 tStat = -0.800 pValue = 0.425 CI = [-0.461, 0.161]	**DF = 134.07** **tStat = -1.797** **pValue = 0.075** **CI = [-0.615, -0.025]**	DF = 136.92 tStat = 0.000 pValue = 1.000 CI = [-0.285, 0.285]	DF = 191.11 tStat = -1.052 pValue = 0.294 CI = [-0.437, 0.097]
Fairness in grading	DF = 112.17 tStat = 1.110 pValue = 0.269 CI = [-0.099, 0.499]	DF = 109.62 tStat = 0.187 pValue = 0.852 CI = [-0.237, 0.297]	DF = 117.51 tStat = 0.520 pValue = 0.604 CI = [-0.219, 0.419]	DF = 110.48 tStat = -0.401 pValue = 0.689 CI = [-0.359, 0.219]	DF = 118.71 tStat = 0.193 pValue = 0.847 CI = [-0.228, 0.288]	DF = 189.24 tStat = -1.056 pValue = 0.292 CI = [-0.359, 0.079]
Promptness in returning assignments	DF = 111.40 tStat = 1.441 pValue = 0.152 CI = [-0.042, 0.602]	**DF = 119.65** **tStat = -2.829** **pValue = 0.005** **CI = [-0.825, -0.215]**	DF = 119.08 tStat = -0.152 pValue = 0.880 CI = [-0.358, 0.298]	**DF = 128.89** **tStat = -4.432** **pValue = 0.000** **CI = [-1.140, -0.520]**	DF = 136.03 tStat = 1.643 pValue = 0.103 CI = [-0.002, 0.582]	**DF = 190.37** **tStat = -3.093** **pValue = 0.002** **CI = [-0.783, -0.237]**
Quality of feedback to students	DF = 111.11 tStat = 0.352 pValue = 0.726 CI = [-0.260, 0.400]	DF = 109.39 tStat = -1.103 pValue = 0.272 CI = [-0.501, 0.101]	DF = 119.27 tStat = -0.300 pValue = 0.765 CI = [-0.392, 0.272]	**DF = 120.49** **tStat = -1.807** **pValue = 0.073** **CI = [-0.633, -0.027]**	DF = 116.31 tStat = -0.540 pValue = 0.590 CI = [-0.366, 0.186]	**DF = 186.61** **tStat = -2.486** **pValue = 0.014** **CI = [-0.599, -0.121]**
Availability outside of class	DF = 110.23 tStat = 0.802 pValue = 0.424 CI = [-0.160, 0.460]	DF = 97.57 tStat = -0.182 pValue = 0.856 CI = [-0.304, 0.244]	DF = 119.70 tStat = -0.575 pValue = 0.566 CI = [-0.388, 0.188]	**DF = 122.50** **tStat = -1.869** **pValue = 0.064** **CI = [-0.528, -0.032]**	DF = 112.01 tStat = -1.119 pValue = 0.266 CI = [-0.422, 0.082]	**DF = 189.66** **tStat = -2.830** **pValue = 0.005** **CI = [-0.554, -0.146]**
Overall rating of instructor	DF = 111.99 tStat = 0.451 pValue = 0.653 CI = [-0.214, 0.374]	DF = 117.27 tStat = -1.280 pValue = 0.203 CI = [-0.482, 0.062]	DF = 117.43 tStat = 0.477 pValue = 0.635 CI = [-0.223, 0.403]	DF = 118.54 tStat = -1.134 pValue = 0.259 CI = [-0.492, 0.092]	DF = 115.99 tStat = -0.729 pValue = 0.468 CI = [-0.360, 0.140]	**DF = 183.05** **tStat = -2.961** **pValue = 0.003** **CI = [-0.623, -0.177]**

7 Conclusion

This study highlights the potential of structured peer collaboration to mitigate common instructional challenges in large classroom settings, offering a scalable solution to improve educational experiences in higher education. The study demonstrated that integrating a collaborative quiz component into a large CS course can significantly enhance student engagement as well as the quality and timeliness of feedback. The analysis focused on three key areas: encouraging class participation, ensuring prompt return of assignments, and improving the quality of feedback provided to students. The results revealed that the collaborative quiz component positively influenced class participation with one statistically significant result and consistent improvements observed across all section comparisons. Regarding the promptness of returning assignments, three statistically significant results indicated that students benefited from the immediate feedback facilitated by the collaborative quizzes. Similarly, the quality of feedback showed two statistically significant improvements with all section pairs reflecting a trend toward higher feedback quality in the collaborative sections. These findings emphasize the value of interactive and real-time feedback systems in improving the learning experience, especially in large classroom environments.

The collaborative quiz component attempts to address common challenges such as student shyness and delayed feedback by having students work together in small groups on a collaborative quiz. This study revealed the potential of

collaborative learning techniques to create a more engaging educational environment. Although the results of this study are encouraging, further research is suggested to determine the general applicability of these conclusions. Future investigations should examine the implementation of collaborative quiz elements in diverse courses and educational environments. Through expanding this research, we can further understand the extensive effects of collaborative learning strategies on student performance. Although this study provides strong evidence that the incorporation of collaborative quizzes can significantly enhance various aspects of the learning experience in large CS classrooms, these findings also have the potential to improve teaching methods and educational practices in a variety of disciplines.

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