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(WIP) Impact of Classroom Icebreaker Activities and Collaborative Assessment on Students' Sense of Belonging, Teamwork, and Academic Competence

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(WIP) Impact of Classroom Icebreaker Activities and Assessment Format on Students' Sense of Belonging, Teamwork, and Academic Competence

Introduction

For decades, researchers have emphasized the critical role of students' sense of belonging and teamwork in shaping their academic competence and self-efficacy. A strong sense of belonging increases students' motivation, persistence, and academic performance [1], [2]. Teamwork activities effectively develop interpersonal skills and promote peer support, aiding in better understanding of complex topics [3], [4]. Together, these elements create a supportive and interactive learning environment that ultimately enhances students' academic competence and performance [5] - [7]. While numerous strategies exist to enhance these dimensions, this study focuses specifically on classroom icebreaker activities and formative, open-book, and collaborative assessments at the University of Hartford. Classroom icebreaker activities were implemented across first-year ES143 - Engineering and Design, first-year CMT110 - Construction Management Tools & Introduction to Engineering, and junior-year CE310 – Elementary Structural Analysis classes in Fall 2024, and different assessment formats were employed in CE310 class during Fall 2023, Fall 2024, and Fall 2025 semesters for comparison.

The classroom icebreaker activities investigated in this study included team-building activities and "Fast Friend" conversations. Team building activities in the classroom have been shown to effectively increase group climate and cohesion, alleviate anxiety, and cultivate a sense of belonging among students [8], [9], though some studies suggest they have no significant effect on students' psychological safety within teams [10]. The "Fast Friends" protocol [11] involves developing closeness via a structured conversation that increase in levels of self-disclosure. This method has been widely recognized for its ability to create meaningful bonds in a short time and is particularly useful in educational settings to establish trust among peers [12], [13].

The assessment formats newly implemented in the CE class in Fall 2025 included weekly open-book, collaborative in-class quiz with timely formative feedback, supplemented by partially graded homework; an open-book, non-collaborative midterm exam; and an open-book, collaborative final exam. The rationale for adopting open-book and collaborative assessments is grounded in professional practice, as industry engineers routinely work in teams and consult design codes, manuals, and prior examples to solve real-world engineering problems, why should engineering education not reflect this professional practice? Open-book assessments pivot the emphasis from memorization to critical thinking and application of knowledge, better preparing students for complex problem-solving [14]. Collaborative testing introduces peer-learning dynamics that deepen understanding, develop teamwork skills, and reduce test anxiety [15], [16]. Frequent quizzes with timely formative feedback serve as an ongoing diagnostic tool, guiding students and instructors to promptly identify "what is going well and what is not" with actions on that information, leading to improved learning outcomes and confidence [17].

Research Significance

While prior research has established that classroom icebreaker activities and formative collaborative assessment enhance student belonging, teamwork, and learning, few studies have

examined how these interventions vary in impact across year levels in civil engineering and construction management education. Moreover, limited empirical attention has been given to the role of collaborative, open-book formative assessment in building self-efficacy and competence, especially for lower-performing students [18]. This study seeks to address these gaps by exploring how integrated instructional interventions influence classroom climate, academic performance, and student confidence across three different classes. Anonymous pre- and post-surveys assessing students' sense of belonging, teamwork spirit, and class engagement were administered at the beginning and end of the Fall 2024 semester for all the three classes. For the CE class specifically, the direct performance data, including midterm and final exam grades, were compared between Fall 2024 and Fall 2025 semesters to evaluate the effectiveness of collaborative formative assessments in enhancing classroom climate and student learning. This project aims to address the following research questions:

- RQ1: How effective are classroom icebreaker activities (such as team-building exercises and the "fast-friend" protocol) in fostering a cohesive classroom climate, and does their impact differ between lower-level (first-year) and upper-level (junior-year) students?
- RQ2: How does the use of frequent open-book, collaborative assessments with formative feedback influence students' self-efficacy and subsequent performance on high-stakes exams, particularly among lower-performing students?

Methodology

Classroom Icebreaker Activities

Four different kinds of team-building activities were incorporated into all three classes periodically or whenever students formed new working groups: the Marshmallow Challenge, Paper Airplane Challenge, Paper Relay Challenge, and Number Hunt. In the Marshmallow Challenge, teams build the tallest freestanding tower using spaghetti, string, and tape, with a marshmallow placed at the top without collapsing. In the Paper Airplane Challenge, each team constructs two paper airplanes from letter-sized paper and competes to see which airplane flies the farthest. In the paper relay challenge, groups of three or more participants stand in a line. The first person holds a letter-size paper vertically in an open palm and swings it to the next teammate without letting it fall; teammates continue passing the paper down the line and then back to the starter without dropping it. For the Number Hunt, 30 paper balls are prepared, each marked with one of the numbers 1 through 6, with five balls for each number. Each team sends a representative, and participants are assigned a number. The first to collect all five paper balls with their assigned number wins. All activities lasted approximately 5 - 15 minutes depending on the type and the size of the class. Sample icebreaker activity pictures are shown in Fig. 1. Students in all three classes also participated in two rounds of "Fast Friends" conversations, one at the beginning and one at the midpoint of the semester, by answering six questions each time. Students were randomly paired, and all the questions are listed in Appendix - Table 1.

Figure 1. Classroom icebreaker activities: (a) marshmallow challenge; (b) paper airplane challenge; (c) number hunt; and (d) fast friend conversation

Formative and Collaborative Assessment

Prior to Fall 2025, assessments in the CE class consisted of regular homework assignments and closed-book midterm and final exams. In Fall 2025, the assessment structure shifted to a combination of partially graded homework, open-book collaborative in-class quizzes, and open-book collaborative/non-collaborative exams. Of the 14-week lectures conducted during the semester, eight open-book collaborative quizzes were administered every one to two weeks. Each quiz consisted of one to two calculation-based problems with an approximate 15-20 minute time limit. The collaborative format allowed students to discuss solution strategies and reasoning with nearby students during the quiz. Each quiz was preceded by a corresponding homework assignment, typically distributed four days in advance, which included multiple example problems aligned with the upcoming quiz content. Students were required to complete only one self-selected problem, after which full solutions to all homework problems were released through the learning management system upon submission. This structure enabled students to practice a representative problem while reviewing complete solutions to prepare for the subsequent quiz. Complete quiz solutions were posted online and reviewed at the beginning of the following class session to provide timely formative feedback. The midterm and final exams, which included both conceptual multiple-choice questions and calculation-based problems, were administered after four quizzes and after all eight quizzes, respectively. Both exams were open-book; however, the students worked independently during the midterm and collaboratively during the final exam. This design aimed to assess the effects of collaboration during high-stakes assessments, as well as whether prior experience with open-book collaborative quizzes supported performance on a non-collaborative exam.

Data Collection

To evaluate the effectiveness of classroom icebreaker activities, all three classes in Fall 2024 administered pre- and post-semester surveys consisting of 37 Likert-scale items to measure changes in students' perception of belonging, engagement, and self-efficacy (IRB Protocol ID 25-02-402). All survey items are listed in Appendix-Table 2, with post-survey question wording shown as reference. For the pre-survey, items were modified to reference students' experiences in prior semesters. For instance, the post-survey question "About how often have you done the following in this class?" was revised to "In previous semesters, about how often have you done the following?". All survey items were drawn from peer-reviewed, validated sources [19] - [23]. Subject recruitment was constrained by class enrollment, with all students in the three courses invited to participate, resulting in sample sizes of 10–18 students per course. For CE310 class, both midterm and final exam grades were compared between the intervention semester (Fall 2025) and prior non-intervention semesters (Fall 2024 & Fall 2023). All exams across semesters covered consistent content and followed the same grading rubric. Exam difficulty in Fall 2025 was appropriately elevated relative to prior semesters to account for the open-book collaborative format. Student survey responses (N=77) and performance data (N=44) were analyzed using statistical t-tests conducted in IBM SPSS Statistics software, supplemented by the first author's observation and reflections to contextualize the findings.

Results and Discussion

Student Survey

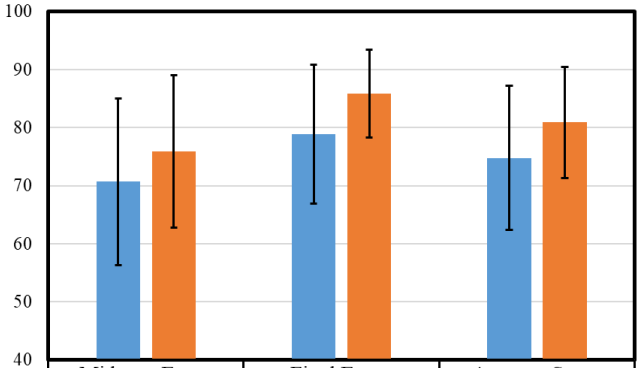
Survey response rates were as follows: in the CE class (N=20), 14 (70%) and 18 (90%) students completed the pre- and post-surveys, respectively; in the CMT class (N=14), 12 (86%) and 11 (79%) students responded; and in the ES class (N=19), 10 (53%) and 12 (63%) students responded. An initial screening of survey items was conducted based on item wording and conceptual intent, followed by analyses for internal consistency to identify questions that might reasonably be grouped as measuring the same underlying construct. Pre- and post-semester composite scores were computed by averaging the respective items and used in subsequent analyses. The final aggregation of the primary survey items was defined as follows: academic interaction (AI) includes Q1, Q2, Q3, Q6, Q7 (Cronbach's alpha = 0.76); instructional quality (IQ) includes Q10 - Q13 (Cronbach's alpha = 0.84); learning and skill development (LS) includes Q20 - Q26 (Cronbach's alpha = 0.86); class confidence (CC) includes Q27 - Q29 (Cronbach's alpha = 0.82); classroom belonging (CB) includes Q30 and Q31 (Cronbach's alpha = 0.81); entrepreneurial mindset (EM) includes Q32 - Q37 (Cronbach's alpha = 0.83).

Independent-samples t-tests (Table 3) were conducted to examine pre–post changes in composite scales (N = 77) for each class individually, for the combined two first-year classes (CMT & ES), and for the pooled sample across all three classes (CE & CMT & ES). When Levene's test for equality of variances was significant ($p < 0.05$), Welch's *t*-test results assuming unequal variances were reported. Descriptive statistics indicated modest to moderate increases in only three outcomes (bold in Table 3), which were evaluated for statistical significance at $\alpha = 0.05$. In these cases, post-semester mean scores were higher than pre-semester mean scores, resulting in negative mean difference (pre minus post) values.

As shown in Table 3, significant pre–post increases were observed for class confidence (CC) in the ES class ($p = 0.046$), and in the combined CMT & ES cohort ($p = 0.010$), likely suggesting that improvements in class confidence were concentrated among first-year students. While multiple factors contribute to growing student confidence over a semester, a cohesive classroom environment fostered by icebreaker activities likely accelerates and amplifies that improvement. In contrast, the CE class showed, though not statistically significant, declines in post semester ratings across nearly all outcomes, with instructional quality (mean difference = −0.296, $p = 0.201$) as the sole exception. These patterns align with instructor observations: first-year CMT & ES students exhibited notably higher engagement and enthusiasm than junior level students, particularly during icebreakers. Junior CE class students appeared more focused on grades and showed limited interest in social interaction, classroom climate, or teamwork. This may suggest that for upper-level students, logistical factors such as timely grade posting may outweigh pedagogical efforts aimed at fostering classroom community. A significant pre–post increase was also observed for instructional quality (IQ) across all three courses ($p = 0.047$), which may indicate that the icebreakers alleviated student anxiety and increased receptiveness to instructional activities across all class levels. Taken together, the survey results and instructor observations address RQ1 by suggesting that classroom icebreaker activities can likely foster a cohesive classroom climate and enhance student engagement, with greater impact among lower-level students than upper-level students. The statistical findings should be interpreted with caution, however, given the relatively small sample sizes, *p*-values close to the significance threshold ($p = 0.05$), and the stability of most outcomes over the semester, which together suggest limited statistical power and the possibility of false-positive findings.

Direct Performance Assessment

The paired-samples t-test results comparing the CE class midterm exam, final exam, the change from midterm to final exam, and average score between intervention (Fall 2025, N=16) and non-intervention (Fall 2024 & Fall 2023, combined N=28) semesters are shown in Appendix - Table 4 (total N=44). Results indicated that the final exam mean for Fall 2025 semester with open-book collaborative discussion (85.887) yielded significantly higher performance relative to closed-book no-discussion exams (78.890) in Fall 2024 and Fall 2023 semesters. The performance differences for the midterm exam, or the change from the midterm to the final exam, or the average score, were only marginally significant, likely because the midterm exam in Fall 2025 did not allow collaborative discussions, diminishing the peer support while amplifying the text anxiety, but still exceeded the midterm performance from non-intervention semesters (75.937 vs. 70.731). The overall mean and standard deviation comparison, as shown in Fig. 2, appears to suggest that the open-book collaborative and formative assessment in the CE class enhanced students' academic competence, particularly for lower-performing students as evidenced by notably smaller standard deviations in the intervention versus non-intervention semesters. This is further supported by instructor observations and consistent with the previous studies [15], [18]. These findings address RQ2, suggesting that open-book collaborative assessments likely improve academic competence, particularly on high-stakes exams and among lower-performing students. However, the contribution of individual intellectual capability remains difficult to isolate within the current study design.



	Midterm Exam	Final Exam	Average Score
Non-Intervention	70.731	78.890	74.811
Intervention	75.937	85.887	80.912

Figure 2. Comparison for midterm exam, final exam, and average score for intervention (Fall 2025) and non-intervention (Fall 2024 & Fall 2023) semesters.

Conclusion

Classroom icebreaker activities and formative, open-book, and collaborative assessments were selectively implemented across Fall 2024 and Fall 2025 semesters in a first-year engineering design class, a first-year construction management class, and a junior-level structural analysis class. The effectiveness of these interventions was evaluated using a mixed-methods approach, including pre- and post-surveys of students, direct assessment grades analysis, and instructor observations and reflections. Key findings include:

- Classroom icebreaker activities can likely foster a cohesive classroom climate, alleviate student anxiety, and enhance student engagement, with greater effectiveness on lower-level students than higher-level students.
- Open-book collaborative assessments foster teamwork, peer learning, and reduce test anxiety, with the most pronounced gains among lower-performing students.

Limitations and Future Work

A primary limitation of this study is the modest sample sizes within individual courses (10–18 students per class), which limited statistical power to detect effects. While aggregating data across courses increased power, individual class analyses may have failed to reach significance due to sampling variability. These small samples also constrain generalizability, and findings should be interpreted cautiously. Future research with larger cohorts is needed to replicate these results and confirm the observed patterns. Future work will also further examine whether frequent collaborative assessments improve student individual intellectual growth and academic performance even on traditional closed-book assessments where discussion is not permitted.

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Appendix – Tables

Table 1. "Fast Friends" Questions

Round 1 Questions
Given the choice of anyone in the world, who would you want as a dinner guest?
Would you like to be famous? In what way?
Before making a phone call, do you ever rehearse what you are going to say? Why?
What would constitute a "perfect" day for you?
Is there something that you've dreamed of doing for a long time?
Where would you go for your dream vacation?
Round 2 Questions
When did you last sing to yourself? To someone else?
What's a personal goal you've set for yourself recently, and what steps are you taking to achieve it?
For what in your life do you feel most grateful?
If you could change anything about the way you were raised, what would it be?
What is one trait that you value?
If you won a million dollars, what would you do with the money?

Table 2. Student survey items

Q#	Question Description with Scales (Post-Survey as Example)
	About how often have you done the following in this class? [Very often = 4, Often = 3, Sometimes = 2, Never = 1]
1	Asked another student to help you understand course material
2	Explained course material to one or more students
3	Prepared for exams by discussing or working through course material with other students
4	Worked with other students on course projects or assignments
5	Connected ideas from your courses to your prior experiences and knowledge
6	Talked about career plans with a faculty member
7	Discussed course topics, ideas, or concepts with a faculty member outside of class
	How much has this class emphasized the following? [Very much = 4, Quite a bit = 3, Some = 2, Very little = 1]
8	Memorizing course material
9	Applying facts, theories, or methods to practical problems or new situations
	To what extent has your instructor of this class done the following? [Very much = 4, Quite a bit = 3, Some = 2, Very little = 1]
10	Clearly explained course goals and requirements
11	Used examples or illustrations to explain difficult points
12	Reviewed and summarized key ideas or concepts
13	Taught in a way that aligns with how you prefer to learn
14	Enabled you to demonstrate your learning through quizzes, assignments, and other activities
	About how often have you done the following in this class? [Very often = 4, Often = 3, Sometimes = 2, Never = 1]
15	Reviewed your notes after class
16	Summarized what you learned in class or from course materials
	Which of the following have you done while in the University or do you plan to do before you graduate? [Done or in progress = 4, Plan to do = 3, Do not plan to do = 2, Have not decided = 1]
17	Participate in an internship, co-op, field experience, student teaching, or clinical placement
18	Hold a formal leadership role in a student organization or group
19	Work with a faculty member on a research project
	How much has your experience contributed to your knowledge, skills, and personal development in the following areas? [Very much = 4, Quite a bit = 3, Some = 2, Very little = 1]
20	Writing clearly and effectively
21	Speaking clearly and effectively
22	Thinking critically and analytically
23	Acquiring job- or work-related knowledge and skills
24	Working effectively with others
25	Understanding people of other backgrounds (economic, racial/ethnic, political, religious, nationality, etc.)
26	Solving complex real-world problems
	Indicate your experience with this class so far [Extremely confident = 5, Quite confident = 4, Somewhat confident = 3, Slightly confident = 2, Not at all confident = 1]
27	How confident are you that you can complete all the work that is assigned in this class?
28	How confident are you that you can learn all of the material presented in this class?
29	How confident are you that you will remember what you learned in this class, next year?
	Indicate your experience with this class so far [Strongly agree = 5, Agree = 4, Neither agree nor disagree = 3, Diagree = 2, Strongly disagree = 1]
30	I feel like I belong to this class
31	I really enjoyed the work done in this class
32	In the future, I could see myself doing well academically for any other courses
33	I am willing to compromise if another idea seems better than my own

34	I appreciate the value that individuals with different strengths bring to a team
35	I recognize that people with different backgrounds from my own might have better ideas than I do
36	I am willing to learn from others who have different areas of expertise
37	I am comfortable asking others for help

Table 3. Independent-samples t-test results comparing pre- and post-semester student survey responses (N = 77)

Class	Outcome	Pre Mean	Post Mean	Mean Difference (Pre - Post)	t	Degree of freedom	two-sided p
CE	AI	2.571	2.333	0.238	0.967	30	0.341
	IQ	2.857	3.153	-0.296	-1.306	30	0.201
	LS	2.765	2.579	0.186	0.748	30	0.461
	CC	3.667	3.574	0.093	0.298	30	0.768
	CB	3.929	3.694	0.234	0.720	30	0.477
	EM	4.286	4.204	0.082	0.435	30	0.667
CMT	AI	2.133	2.109	0.024	0.144	21	0.887
	IQ	2.354	2.515	-0.161	-0.682	21	0.502
	LS	2.619	2.857	-0.238	-1.031	21	0.314
	CC	3.417	3.849	-0.432	-1.561	21	0.133
	CB	3.792	3.864	-0.072	-0.286	14.95	0.779
	EM	4.417	4.318	0.099	0.520	21	0.609
ES	AI	2.220	2.433	-0.213	-0.795	20	0.436
	IQ	3.025	3.354	-0.329	-1.324	20	0.200
	LS	2.943	3.214	-0.271	-1.038	20	0.312
	CC	**3.633**	**4.222**	**-0.589**	**-2.123**	**20**	**0.046**
	CB	3.950	4.250	-0.300	-0.797	20	0.435
	EM	4.633	4.486	0.147	0.992	20	0.333
CMT & ES	AI	2.173	2.278	-0.106	-0.672	43	0.505
	IQ	2.659	2.953	-0.294	-1.447	43	0.155
	LS	2.766	3.044	-0.277	-1.565	43	0.125
	CC	**3.515**	**4.044**	**-0.528**	**-2.688**	**43**	**0.010**
	CB	3.864	4.065	-0.202	-0.910	43	0.368
	EM	4.515	4.406	0.109	0.904	41.51	0.371
CE & CMT & ES	AI	2.328	2.302	0.025	0.183	75	0.855
	IQ	**2.736**	**3.041**	**-0.305**	**-2.017**	**75**	**0.047**
	LS	2.766	2.840	-0.074	-0.505	73.09	0.615
	CC	3.574	3.837	-0.263	-1.506	75	0.136
	CB	3.889	3.902	-0.014	-0.073	75	0.942
	EM	4.426	4.317	0.109	1.047	69.05	0.299

Table 4. Paired-samples t-test results comparing intervention (Fall 2025, N=16) and non-intervention (Fall 2024 & Fall 2023, combined N=28) exams (Total N = 44) for the CE class

Outcome	Exposure 0 Mean (Fall 2024 & Fall 2023)	Exposure 0 Standard Deviation	Exposure 1 Mean (Fall 2025)	Exposure 1 Standard Deviation	Mean Difference (0 - 1)	t	degree of freedom	p-value
Midterm Exam	70.731	14.346	75.937	13.157	-5.206	-1.192	42	0.240
Final Exam	**78.890**	**11.990**	**85.887**	**7.536**	**-6.997**	**-2.374**	**41.52**	**0.022**
Delta	8.159	9.010	9.950	9.663	-1.791	-0.618	42	0.540
Average Score	74.811	12.430	80.912	9.571	-6.102	-1.694	42	0.098