
Why Online Students Outperform Hybrid Students: The Role of Attendance, Course Structure, and Engagement in a Project-based Mathematics Course

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This study examines the effects of hybrid and online instructional modalities on student achievement, attendance, and attitudes toward mathematics in a project-based college course. Using a quasi-experimental design, 315 students across fourteen course sections were compared on multiple performance measures, including homework assignments, quizzes, projects, exams, participation, and overall course grades. Results consistently showed that online students outperformed hybrid students across all achievement categories. No significant differences were found in students' attitudes toward mathematics, with both groups showing stable attitudes from the beginning to the end of the semester. Attendance emerged as a significant predictor of academic performance, with online students maintaining substantially higher attendance rates than hybrid students. Mediation analysis confirmed that attendance partially explained the superior outcomes achieved by the online group. Survey responses further revealed that students valued the flexibility, pacing, and convenience of online learning, while hybrid students reported greater uncertainty about course expectations. These findings highlight the critical role of attendance, clarity, and course structure in determining instructional effectiveness and suggest that thoughtfully designed online formats can support strong learning outcomes in project-based mathematics courses.

1. Introduction

As a researcher who has taught the Foundations of QR (project-based) course in-person for eight years, we initially believed it was impossible to teach a project-based course online. However, in Spring 2020, due to the COVID-19 outbreak, all courses at the University switched to online formats. Faced with no other option, we had to adapt our course to an online format.

Over time, we modified our projects to fit the online environment and began to notice the benefits of offering classes online. Students with newborns, disabilities, military commitments, or caregiving responsibilities could attend our class online, overcoming challenges related to commuting to campus. This experience led us to question how we could provide the same quality of instruction to online students, allowing them to benefit from the flexibility of the online model while still achieving similar learning outcomes. This research aims to explore and address these questions, ensuring that online students receive the same content and achieve comparable learning achievements as their in-person counterparts.

The students in both formats received the same lecture videos and completed the same homework assignments online weekly. The quizzes and exams were identical and were done online. The hybrid sections completed projects in-class on campus, while the online sections did them on Zoom once a week. The projects were almost identical, with some modifications to better fit the online format. The quiz and exam scores were used to determine any significant differences in learning achievements between the two groups. We also tested students' attitudes towards mathematics at the beginning and end of the semesters to see which model improved students' attitudes more. Additionally, there was a set of survey questions addressing the advantages and disadvantages of both models.

2. Literature Review

Research comparing in-person, online, and hybrid learning formats has expanded considerably in recent years, revealing a multifaceted and often contradictory landscape. Rather than pointing to a single modality as consistently superior, the body of evidence suggests that instructional design, clarity, engagement, and student support play far more influential roles in shaping student performance than the delivery format itself. Still, the literature offers valuable insights into patterns, preferences, and pedagogical features that help explain differences in learning outcomes across modalities.

2.1 Comparative Effectiveness Across Modalities

A substantial portion of the literature finds that online learning can perform as effectively as face-to-face instruction when carefully designed. For example, Elzinga and Harper (2023) reported no significant difference in student performance between in-person and online sections, with students in their study even expressing a preference for the online format. Their findings suggest that when course expectations and instructional components are aligned, online environments can support student success as effectively as traditional classrooms. Similarly, Rojas (2023) found that online classes incorporating active learning strategies can be just as effective as traditional face-to-face instruction. These results align with broader trends showing that the quality of instructional strategies such as feedback cycles, opportunities for practice, and interaction which mediates performance more strongly than the physical environment in which learning occurs.

At the same time, other researchers have reported performance outcomes that vary across assessments and content areas. Little and Jones (2020), who conducted a comprehensive comparison of face-to-face, online, and hybrid classes, observed “mixed” results in which online and hybrid classes outperformed face-to-face classes on some assessments, while face-to-face sections excelled on others. Their study underscores that modality interacts with course content, assessment type, and instructional practices. Similarly, Rahmawati et al. (2022) found that hybrid learning significantly enhanced students’ critical thinking skills in mathematics, while Zein et al. (2019) reported substantial improvements in learning outcomes for students engaged in hybrid mathematics instruction. Together, these findings suggest that hybrid learning when well structured, can offer advantages by combining the strengths of online flexibility with the immediacy of face-to-face interaction.

However, not all comparisons favor online or hybrid formats. Howard (2019) found that students in face-to-face cohorts achieved significantly higher summative course grades compared to their peers in hybrid sections. Moreover, online students in Howard’s study perceived the course as requiring more work than those in the face-to-face format, raising important questions about workload transparency, pacing, and instructional clarity in digital environments. These findings echo earlier work by Henry and Romeo (2017), who observed that although student outcomes in online and hybrid courses were comparable, online students often reported a

perception of increased effort even while appreciating the convenience of the format. Taken together, these studies highlight that differences in student performance across modalities may be shaped as much by learner perception, discipline-specific demands, and course structure as by modality itself.

2.2 Student Preferences and Perceived Advantages

In addition to performance outcomes, student preferences offer another lens for understanding modality effectiveness. Plescau and Drob (2023) reported that students favored hybrid formats over both online and face-to-face options, a finding that points to the value students place on the balance between flexibility and interaction. Jaleel et al. (2024) found that while online courses outperformed hybrid ones on certain performance measures, students nevertheless preferred hybrid courses because they perceived them as more interactive and supportive. These results align with broader evidence that students value flexibility, autonomy, and convenience, but also rely on synchronous interaction, instructor presence, and opportunities for collaboration to feel connected and supported.

2.3 Active, Applied, and Project-Based Learning in Mathematics

Several studies emphasize the importance of course design that fosters active engagement and relevance. Julian (2017) offers a notable example with her investigation of a project-based Foundations of Quantitative Reasoning course at a two-year college. Using pre- and post-surveys of mathematical attitudes and pre- and posttests of achievement, Julian compared the project-based course to a traditional College Algebra section. The project-based course produced significant improvements in both attitudes toward mathematics and mathematics achievement, suggesting that real-world application and hands-on tasks can greatly enhance learning particularly for non-STEM students who may not feel connected to traditional algebra. Julian's findings support the broader consensus that applied, context-based learning strategies can improve motivation, deepen conceptual understanding, and support stronger academic outcomes, regardless of instructional modality.

2.4 Instructional Clarity, Engagement, and Feedback

Beyond modality comparisons, the Scholarship of Teaching and Learning (SoTL) literature consistently emphasizes instructional clarity, engagement, and support as central determinants of student success. Bowers and Kumar (2015) found that student satisfaction and performance in online mathematics courses were closely tied to the presence of timely feedback and structured support systems. In parallel, Bawa (2016) highlighted that student persistence in online learning depends heavily on clarity of expectations, feedback loops, and opportunities for interaction. These findings suggest that online and hybrid formats do not inherently disadvantage students; instead, challenges arise when expectations, structure, or communication are unclear.

Martin and Bolliger (2018) further demonstrated that students value synchronous meetings, collaborative activities, and prompt instructor feedback in online environments which help replicate the engagement and accountability typically associated with face-to-face courses. Together, these studies highlight a critical theme: effective online and hybrid learning depends on thoughtful integration of engagement opportunities that reduce student isolation and promote active participation.

2.5 Connection to the Current Study

The themes identified across this literature directly informed the design of the present study. Both hybrid and online students received identical lecture videos, assignments, and assessments, ensuring that differences in student achievement could not be attributed to content or instructional materials. Weekly synchronous meetings were incorporated into both sections to support interaction, structure, and clarity, reflecting best practices identified in SoTL research (Bawa, 2016; Bowers & Kumar, 2015; Martin & Bolliger, 2018). Additionally, the course design included project-based elements similar to those shown by Julian (2017) to enhance student engagement and learning outcomes, offering relevance and application across modalities.

By standardizing instructional design while varying only the modality, the present study follows recommendations across the literature to isolate the true impact of delivery format. The study design aligns with research indicating that when clarity, engagement, structure, and applied learning are prioritized, online and hybrid modalities can support strong academic outcomes comparable to traditional environments.

3. Objectives of the study

The purpose of this study is to investigate the impact of hybrid and online instructional methods on students' learning achievements, attitudes towards mathematics, and their overall online learning experience.

4. Methodology

4.1 Study Design

The study was conducted using two quasi-experimental two-group designs since the participants were not randomly assigned to hybrid and online groups but selected based on the sections in which the students enrolled. There was some consistency in sample sizes across groups, as student enrollment varied by section. The sample consisted of 315 students (hybrid group: 151 students; online group: 164 students). The study took place during the Fall 2023, Spring 2024, Summer 2024, and Fall 2024 semesters at the University. Participants were enrolled in the Foundations of QR course. The hybrid group consisted of seven sections taught using a hybrid setting, while the online group comprised seven sections taught by the same instructor using an online setting. Both groups were similar since they were enrolled in the same course with the same prerequisite requirements. The hybrid group met once a week on-campus to work on their projects, while the online group met once a week on Zoom to complete their projects. The independent variable was the pedagogy approach. The dependent variables were learning achievement, measured by quizzes and exams, and students' attitudes toward mathematics, measured by pre-attitude-survey and post-attitude-survey using the Attitudes Toward Mathematics Inventory (ATMI) (Tapia, 1996; Tapia & Marsh, 2005). Attitude data were collected at the beginning and end of the semesters. The goal of this research was to determine whether hybrid or online instructions improve students' achievements more effectively.

4.2 Study Setting

The study was conducted in a total of 14 sections of the 3-credit-hour Foundations of QR course at the University (seven sections were hybrid and the other seven were online). Both groups received the same video lectures and completed the same homework assignments, quizzes, and exams online. The hybrid sections completed projects in-class on-

campus, while the online sections did them on Zoom once a week. A couple of projects needed some modifications to fit the online format while maintaining the same concepts. The homework assignments, quizzes, and projects were open-book, while exams were online, closed-book, and proctored by Honorlock. The same instructor taught both hybrid and online sections using the same textbook.

4.3 Participants

The participations in this study were recruited from all students enrolled in Foundations of QR course taught by the researcher. From a total enrollment of approximately 315 students, 151 students in hybrid sections chose to participate, and 164 students in online sections chose to participate.

4.4 Instrumentation

The instruments used to determine students' achievements in this study were homework assignments, quizzes, projects, and exams. The instrument used to measure students' attitudes was the Attitudes Toward Mathematics Inventory (ATMI) developed by Martha Tapia of Berry College (Tapia, 1996; Tapia & Marsh, 2005). The ATMI consists of 40 items rated on a five-point Likert scale (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree) divided into five subscales: Value of Mathematics, Enjoyment of Mathematics, Motivation in Mathematics, and Anxiety toward Mathematics. It has a reliability Cronbach alpha coefficient of 0.97. Tapia and Marsh demonstrated that the ATMI is a reliable instrument for data collection and is appropriate for American college students (Tapia & Marsh, 2005). The sum of the subscales gives the total score of a student's attitudes towards mathematics, with a maximum score of 200 points. The higher the score on the ATMI, the more positive attitudes students exhibit towards mathematics.

4.5 Procedure

Participants for the research study were recruited in class during the first week of the semesters. The research instructions were read aloud by another faculty member as students listened at the beginning of their class period. Students choosing to participate in the study read a consent form and completed a short demographic questionnaire. Participants were informed about all research activities involved in the study. They were

assured that the data would be used for research purposes, that participation was voluntary, and that they could withdraw from the study at any time for any reason or no reason without penalty. Approval for this study was obtained from the Institutional Review Board (IRB) at the University. Participants completed the pre-attitude-survey at the beginning of the semester and the post-attitude-survey and online experience survey toward the end of the semester.

4.6 Data Analysis Strategy

The data was analyzed by using SAS and R with the level of statistical significance was set at 5%. An independent t-test was carried out to determine the effectiveness of hybrid and online instructions on students' achievements. The null hypothesis was "There is no significant difference in total, homework assignments, quizzes, projects, or exams scores among the hybrid and online groups." A Multivariate Analysis of Covariance (MANCOVA) was then used to compare learning outcome measures across the hybrid and online groups. The corresponding null hypothesis was "There is no significant difference in all achievement measures together among the hybrid and online groups." Lastly, a mediation analysis consisting of three sets of regression and a bootstrapping procedure was conducted in this research. The null hypothesis for this analysis was "There is no indirect effect of instructional modality on performance measures through the mediator."

5. Results

The results showed that overall the online group performed better in all parts: homework assignments, quizzes, projects, and exams, with a p-value (two-tailed) less than 0.05 using the Pooled method. Consequently, the total scores were higher with a p-value (two-tailed) less than 0.01 using the Pooled method. However, there is insufficient evidence to show that the students' attitudes towards mathematics in both groups are different or that the attitudes had improved after completing the course.

Table 1: the total scores of the hybrid and online groups

Total Scores	Hybrid	Online
Mean	65.18	73.88
SD	24.3	23.9
N	151	164
DF	131	
t value	-2.94	
p-value (two-tailed)	0.0036	

Table 1A: Equality of Variances of total scores

Method	Num DF	Den DF	F Value	Pr>F
Folded F	150	163	1.03	0.8499

The total scores consisted of 15% homework assignments and 10% quizzes on Pearson MyLabMastering, 15% projects completed either on-campus or online, 5% participation from watching the lecture videos, 15% Exam 1, 15% Exam 2, and 25% Final Exam. Table 1 shows that the total scores of the online students were higher. Since the Folded F-test from Table 1A indicates that the variances of the two groups are equal, we used the Pooled t-test and obtained a two-tailed p-value of 0.0036, which is less than 0.01. This means there is very strong evidence that the means of the total scores of the two groups are not equal. Given that the mean of the total scores of the online group was higher than that of the hybrid group, we can conclude that there is a very strong indication that the mean of the total scores of the online group is higher, with a one-tailed p-value of 0.0018, which is even less than 0.01.

Table 2: the exam scores of the hybrid and online groups

Exams	Hybrid	Online
Mean	62.10	70.83
SD	30.44	29.47
N	151	164
DF	131	
t value	-2.38	
p-value (two-tailed)	0.0181	

Table 2A: Equality of Variances of exam scores

Method	Num DF	Den DF	F Value	Pr>F
Folded F	150	163	1.07	0.7027

The exam scores were composed of 30% Exam 1, 30% Exam 2, and 40% Final Exam. Table 2 illustrates that the online students achieved higher exam scores. Since the Folded F-test from Table 2A confirmed that the variances of the two groups are equal, we employed the Pooled t-test, resulting in a two-tailed p-value of 0.0181, which is less than 0.05. This indicates the means of the exam scores of the two groups differ substantially. Given that the mean of the exam scores of the online group was higher than that of the hybrid group, we can infer very strong evidence that the mean of the exam scores of the online group is higher, with a one-tailed p-value of 0.00905, which is less than 0.01.

Table 3: the project scores of the hybrid and online groups

Projects	Hybrid	Online
Mean	73.68	81.58
SD	26.86	26.52
N	151	164
DF	131	
t value	-2.41	
p-value (two-tailed)	0.0166	

Table 3A: Equality of Variances of project scores

Method	Num DF	Den DF	F Value	Pr>F
Folded F	150	163	1.03	0.8752

Next, we examined how students performed on their projects. Both hybrid and online students completed nearly identical projects, with 1-2 projects modified to better suit the online format. Table 3 reveals that the project scores of the online students were higher. Since the Folded F-test from Table 3A indicated that the variances of the two groups are equal, we employed the Pooled t-test, resulting in a two-tailed p-value of 0.0166, which is less than 0.05. This suggests strong evidence that the means of the project scores of the two groups are not equal. Given that the mean of the project scores of the online group was higher than those of the hybrid group, we can infer a very strong indication that the mean of the project

scores of the online group is higher, with a one-tailed p-value of 0.0083, which is less than 0.01.

Table 4: the homework assignment scores of the hybrid and online groups

Assignments	Hybrid	Online
Mean	78.59	87.10
SD	20.45	17.50
N	151	164
DF	131	
t value	-3.69	
p-value (two-tailed)	0.0003	

Table 4A: Equality of Variances of homework assignment scores

Method	Num DF	Den DF	F Value	Pr>F
Folded F	150	163	1.36	0.0712

Table 5: the quiz scores of the hybrid and online groups

Quizzes	Hybrid	Online
Mean	51.39	58.95
SD	23.55	23.88
N	151	164
DF	131	
t value	-2.59	
p-value (two-tailed)	0.0101	

Table 5A: Equality of Variances of quiz scores

Method	Num DF	Den DF	F Value	Pr>F
Folded F	150	163	1.03	0.8817

Students in both groups completed the same homework assignments and quizzes online using Pearson MyLabMastering. Each week, students were assigned approximately 20-25 questions for their homework assignments, allowing seven attempts per question with no time limit. For quizzes, students were assigned about 1-2 questions, allowing only one attempt with a time limit. All assignments and quizzes were due the night before the class meetings. The results from Table 4, Table 4A, Table 5, and Table 5A indicate very strong evidence that the means of the homework

assignment and quiz scores of the online group are higher, with two-tailed p-values of 0.0003 and 0.0101 respectively, both of which are less than 0.01 for one-tailed.

Table 6: the participation scores of the hybrid and online groups

Participations	Hybrid	Online
Mean	70.55	80.25
SD	27.42	24.89
N	151	164
DF	131	
t value	-3.04	
p-value (two-tailed)	0.0026	

Table 6A: Equality of Variances of participation scores

Method	Num DF	Den DF	F Value	Pr>F
Folded F	150	163	1.21	0.2606

Following the surprising results above, we decided to investigate students’ participation in the class. Participation points were awarded to students who watched the video lectures, with higher points given for watching more videos. As anticipated based on previous results, Table 6 and Table 6A indicate very strong evidence that the mean of the participation scores of the online group is higher, with a two-tailed p-value of 0.0026, which is less than 0.01. This suggests that online students watched more videos.

Table 7: the ALEKS scores of the hybrid and online groups

ALEKS scores	Hybrid	Online
Mean	42.44	44.95
SD	19.28	21.11
N	151	164
DF	131	
t value	-1.21	
p-value (two-tailed)	0.2267	

Table 7A: Equality of Variances of ALEKS scores

Method	Num DF	Den DF	F Value	Pr>F
Folded F	150	163	1.20	0.2154

Evidently, the online group performed better in every component: assignments, quizzes, projects, participation, exams, and overall grades. We then investigated the students’ knowledge background prior to enrolling in the class. At our college, we use ALEKS to assess students’ math levels before starting the course. We recommend students achieve at least a score of 30 on the ALEKS math test to enroll in this course. Students can take the test up to five times, and we used the highest scores they received before the semester’s start date. Our analysis (Table 7 and Table 7A) shows that there was no significant difference in students’ ALEKS scores, indicating that both groups had similar backgrounds in mathematics knowledge, as the p-value is large.

Next, we performed a MANCOVA in R to analyze the differences of all achievement measures (homework assignments, quizzes, projects, exams, participations, and total scores) between hybrid and online groups. This analysis allowed us to determine whether all achievement measures collectively are affected by the difference in modalities. Using MANCOVA also reduced the type I error that could have been inflated by performing separate tests earlier. Because both groups demonstrated similar backgrounds in mathematics knowledge, we used ALEKS scores as covariate.

Before running the analysis, we examined the assumptions of MANCOVA. Given the relatively large sample size, we assumed that multivariate normality was present in the data. Using boxM test in R, we concluded that the variance-covariance matrices of the two groups were equal (with Chi-sq (approx.) = 36.0493, df = 21, p-value = 0.02159). Next, we evaluated the assumption of homogeneity of regression slopes by testing whether there was a significant interaction (modalities*ALEKS).

Table 8: Homogeneity of regression slope results

	Df	Pillai	F	num	den	P(r>F)
ALEKS	1	0.022264	0.79320	6	306	0.57617
Modalities	1	0.062161	2.30879	6	306	0.03522
ALEKS:Modalities	1	0.016153	0.57188	6	306	0.75248

Table 8 shows that there was no significant interaction because p-value of 0.75248 is very large.

Table 9: MANCOVA results

	Df	Pillai	F	num	den	P(r>F)
ALEKS	1	0.022262	0.7969	6	307	0.57329
Modalities	1	0.062088	2.3169	6	307	0.03459

Table 9 shows that the p-value for the covariate (ALEKS scores) is relatively large, meaning that students’ mathematics background did not have a significant relationship with all the dependent variables (performance measures). In contrast, the p-value for modalities is small (less than 0.05), indicating a significant difference between the two groups across all achievement measures.

Additionally, based on the researcher’s observations, online students were more consistent in attending their class meetings. An investigation of attendance records confirmed this: the online group had a higher average attendance rate (62%) compared to the hybrid group (38%). We then performed a mediation analysis to test whether attendance (the mediator) fully explains the superior outcomes of the online classes over the hybrid classes. Specifically, we tested whether the direct effect of modalities on performance becomes statistically insignificant after attendance is included in the model.

We defined the independent variable (X) as the instructional modality (online vs. hybrid), the mediator variable (M) as attendance rate (percentage of classes attended throughout the semester), and the dependent variable (Y) as the performance measures (homework assignments, quizzes, projects, exams, participations, and total scores). The mediation analysis consisted of three sets of regression: X->Y, X->M, and X+M->Y. We first started with the first regression X->Y.

Table 10: X->Y regression

	Estimate Std	Error	t value	Pr(> t)
(Intercept)	65.175	2.286	28.504	<2e-16
Modalities	8.708	2.961	2.941	0.00355

Table 11: X->M regression

	Estimate Std	Error	t value	Pr(> t)
(Intercept)	69.560	2.572	27.046	<2e-16
Modalites	7.019	3.330	2.107	0.036

Table 12: X+M->Y regression

	Estimate Std	Error	t value	Pr(> t)
(Intercept)	20.02459	3.00240	6.670	1.43e-10
Modalites	4.15178	2.04330	2.032	0.0431
Attendance	0.64909	0.03683	17.622	<2e-16

Table 10 indicates that modalities significantly affect achievement measures since p-value is small (<0.01). Table 11 shows that modalities also significantly predict attendance rates because p-value is small (<0.05). Table 12 reveals that the effect of modalities on performance measures still exists after including attendance in the model, but in smaller magnitude. Therefore, attendance partially mediates between instructional modality and achievement. We then conducted a bootstrap analysis in R with at least 5,000 stimulations.

Table 13: Bootstrap Analysis

	Estimate	95% CI lower	95% CI upper	p-value
ACME	4.555766	0.492332	8.760794	0.0272
ADE	4.151782	-0.036322	8.302431	0.0524
Total Effect	8.707548	2.840054	14.272664	0.0040
Prop Mediated	0.523197	0.094430	0.997549	0.0288

Table 13 shows that ACME = 4.555766 with a small p-value (<0.05). We therefore conclude that the mediation (attendance rates) effects are statistically significant.

Table 14: the pre-attitude scores of the hybrid and online groups

Post-attitudes	Hybrid	Online
Mean	118.1	121.6
SD	10.97	10.86
N	151	164
DF	313	
t value	-1.31	
p-value (two-tailed)	0.1960	

Table 14A: Equality of Variances of pre-attitude scores

Method	Num DF	Den DF	F Value	Pr>F
Folded F	150	163	1.02	0.9445

Table 15: the post-attitude scores of the hybrid and online groups

Pre-attitudes	Hybrid	Online
Mean	121	120.9
SD	14.96	15.91
N	151	164
DF	313	
t value	0.04	
p-value (two-tailed)	0.9689	

Table 15A: Equality of Variances of post-attitude scores

Method	Num DF	Den DF	F Value	Pr>F
Folded F	150	163	1.13	0.5375

To assess the effects of the classroom formats on students' attitudes towards mathematics, we asked participants to complete the Attitudes Toward Mathematics Inventory (ATMI) at the beginning (pre-attitude survey) and the end (post-attitude survey) of the semesters. The ATMI consists of 40 questions that address the value of mathematics, enjoyment of mathematics, motivation in mathematics, and anxiety towards mathematics. The highest possible score is 200, with higher scores indicating more positive attitudes towards mathematics. Tables 14, Table 14A, Table 15, and Table 15A show that there is no significant evidence of differences in attitudes towards mathematics both at the beginning and the

end of the semesters between the two groups, as the p-values are large ($p = 0.1960$ for pre-attitude and $p = 0.9689$ for post-attitude).

Table 16: the pre-post survey scores of the hybrid and online groups

Attitudes	Hybrid	Online
Mean	-5.72	4.48
SD	15.47	12.32
N	63	74
DF	62	73
t values	-1.57	1.67
p-values	0.1350	0.1114

We then conducted paired sample tests within the hybrid and online groups. A total of 63 students in the hybrid group and 74 students in the online group completed both the pre- and post-attitude surveys. The results in Table 16 indicated a slight increase in attitude scores for the hybrid group and a slight decrease for the online group. However, the p-values for both paired tests were relatively large, indicating no statistically significant evidence of either an increase or decrease in attitude scores between the pre- and post-surveys.

Lastly, we asked participants to complete a survey regarding their online learning experience. The survey included three sets of questions with responses: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. The first set of questions addressed the reasons for considering taking a math course with online lectures (videos): *I would consider taking a math course that has lectures online (videos) because...*

Table 17: the percentages of responses from hybrid and online groups to the question:

I would consider taking a math course that has lectures online (videos) because ...

<i>I would consider taking a math course that has lectures online (videos) because ...</i>	Strongly Agree or Agree	
	Hybrid	Online
It is easier to schedule.	60.27%	60.43%
It allows me to move at my own pace.	74.03%	64.75%
It saves me the time and money of commuting.	73.97%	59.71%

I can work during a time of day I feel best suits me.	74.70%	80.58%
I don't have to volunteer answers in front of my peers.	52.83%	30.94%

The second set of questions addressed the reasons for considering taking online math courses with class meetings: *I would not consider taking an online math course with no class meetings because...*

Table 18: the percentages of responses from hybrid and online groups to the question:
I would not consider taking an online math course with no class meetings because ...

<i>I would not consider taking an online math course with no class meetings because ...</i>	Strongly Agree or Agree	
	Hybrid	Online
I would not be able to ask questions and get immediate feedback	56.34%	52.17%
I would not be able to interact with my classmates.	43.14%	22.46%
I would not be sure how I rank with the rest of the class.	63.51%	42.75%
I think it would be more difficult to follow the lessons on my own.	57.38%	39.13%
I need more instructions from the professor during the class meetings.	69.44%	47.10%

The last set of questions addressed student’s online learning experience.

Table 19: online learning experience survey responses from hybrid and online groups

Questions	Strongly Agree or Agree	
	Hybrid	Online
I feel I would be likely to cheat on an exam in an online course rather than face-to-face course.	27.27%	7.09%
I don't believe a reliable exam is possible to administer online.	28.85%	17.73%

I feel that an online course should have graded projects/assignments rather than exams.	76.92%	65.96%
I would like to have seen/know the person giving me my grade.	50.00%	38.30%
I don't think exams would be treated differently in an online course versus a face-to-face course.	53.52%	49.65%
I feel like I would do/learn better if my class meetings are in-person.	78.21%	34.04%
I think the online class meetings are just as good as in-person meetings.	52.94%	58.16%
I would save my time and gas by not having to go to the campus to attend the meetings in-person.	76.00%	87.94%
I believe going to the campus to attend my class meetings motivates me to do well in the class.	77.03%	39.72%
I prefer to have class meetings in-person rather than online.	64.94%	24.11%
I can avoid technical issues by attending class on campus in-person.	84.42%	46.10%
It does not matter to me if my class meets in-person or online. No preference to me.	49.30%	46.81%
I like the flexibility of online class meetings so I can attend my class anywhere even when I travel.	81.48%	90.78%
If I don't have transportation to the campus, online meetings would be helpful to me.	84.81%	90.78%
I believe attending online class meetings takes away from my college experience.	50.00%	21.99%
I think online courses are favorable in any subject area.	58.93%	45.77%
I think online courses are favorable in certain subjects, but not math.	55.56%	33.10%
If an online math course is offered, I will sign up.	55.00%	64.08%
An online course would have the same level of difficulty as a face-to-face course.	59.62%	26.06%
I would feel that my grade in an online course would be less significant to me as my grade in a face-to-face course.	67.69%	59.86%

6. Discussion

Based on the data collected, online students performed better in every area: assignments, quizzes, projects, participation, and exams. Attitudes toward mathematics, however, remained constant in both the online and hybrid groups and did not show meaningful improvement or decline over the semesters. The online group also maintained significantly higher attendance rates than the hybrid group, and our findings indicate that attendance had a measurable impact on student learning.

Although the online group demonstrated significantly higher academic performance, this improvement did not coincide with a significant change in attitudes toward mathematics. This pattern is well-documented in mathematics education research, where affective constructs such as attitudes, beliefs, and anxiety are understood to be relatively stable, trait-like characteristics that do not shift easily over a single semester (McLeod, 1992; Hannula et al., 2016). Research has shown that beliefs are the most stable and least malleable affective constructs, with attitudes occupying a middle position between beliefs and emotions, which change more readily (Hannula et al., 2004). Similarly, work by Hannula and colleagues indicates that many affective variables operate along a continuum from rapidly fluctuating “states” to long-term, stable “traits,” with attitudes and beliefs typically falling on the trait end of the scale (Hannula et al., 2016). Longitudinal research also shows that emotional and motivational profiles in mathematics tend to remain consistent across grade levels unless targeted interventions are applied (Zakariya et al., 2024). In our study, online students benefited from clearer course structure, consistent weekly meetings, and higher attendance, all of which directly supported performance. However, these structural advantages do not necessarily alter students’ long-standing feelings about mathematics. Many students enter the course with fixed perceptions shaped by years of prior experiences, and improvements in course performance alone may not be sufficient to shift these attitudes within a single semester. Thus, the online format appears to enhance learning behaviors and outcomes without substantially influencing students’ affective relationship with mathematics.

A related factor that may help explain the performance gap involves attendance differences between groups. One possible explanation for the lower attendance rates in the hybrid group is the convenience of attending class meetings online rather than traveling to campus for in-person sessions.

As a result, even though students may benefit from in-person instruction, those advantages cannot be realized if students do not attend regularly. In contrast, online students attended class meetings more consistently, allowing them to engage with the content more continuously and achieve better outcomes by the end of the semester.

Another contributing factor to the higher achievement outcomes in the online group may be confusion regarding the expectations of the hybrid format. Hybrid students may not have fully understood all of the tasks and requirements that needed to be completed online and may have relied too heavily on their in-person meetings. By the time they recognized the extent of the online responsibilities, they may have already missed important assignments or lost points.

Additionally, differences in student characteristics may have played a role, even if only indirectly. Hybrid students may have selected the hybrid format because they felt less confident in their math skills or believed that in-person meetings would provide the one-on-one support they needed. Conversely, online students may have felt more confident in navigating course materials independently or been better prepared for the demands of the course. They may also have had clearer expectations that the course would involve substantial work, making them more prepared to engage from the start.

This rationale led us to investigate the student demographics further. We found that 20.7% of students in both groups are in Pre-health Professions, 10.8% in Psychology, 10.2% in Pending Veterinary Technology, 9.2% in Applied Media Communications, 8% in Criminal Justice, 29% in Communications, and the rest in other fields. One notable group among the others is College Credit Plus, which comprises only 2.9% of the total student population. The majority of these students are in the online group, making up 85.7%. This could be because these students already have busy schedules in their high schools and prefer attending classes online rather than commuting to campus.

Table 20: Ages of students in online group

Ages	Percentages
Younger than 18	0.73%
18-23	87.96%
24-29	5.84%
30-39	3.28%
40-49	1.82%
50 or older	0.36%

Table 21: Ages of students in hybrid group

Ages	Percentages
Younger than 18	0%
18-23	92%
24-29	6%
30-39	2%
40-49	0%
50 or older	0%

We also examined the ages of the students. The hybrid group had more traditional students, while the online sections served a slightly higher proportion of non-traditional students. However, most of the student population still consists of traditional students. Thus, we do not believe that student demographics significantly contributed to the observed results.

Regarding the students’ online experience, we conducted a survey. Students recognized that the online lectures helped them with scheduling, allowed them to move at their own pace, saved time and money on commuting, and provided flexibility.

Regarding synchronous and asynchronous classrooms, students in both groups preferred meetings to ask questions and receive immediate feedback, but they didn’t particularly care about interactions with their classmates or getting to know their instructor. Hybrid students believed that meetings helped them gauge their performance compared to other students and felt that without meetings, it would be difficult to follow the lessons on their own. They also felt they needed more support from the instructor during class meetings. On the other hand, online students did not share these beliefs.

Regarding online exams, both groups stated that there is no difference between in-person or online exams and that they would be just as honest during online exams as during in-person exams.

Regarding online and in-person meetings, hybrid students valued the in-person meetings and found them helpful, believing that attending meetings in-person would motivate them more. However, online students did not share these beliefs. Both groups agreed that online meetings would save them time and gas by not having to commute and appreciated the flexibility of attending class from anywhere. Hybrid students believed that attending online meetings would detract from their college experience and felt that online courses were not suitable for math, while online students thought otherwise. Moreover, online students recognized that completing an online course would involve more work and be more challenging. Both groups agreed that if an online math course were offered, they would sign up, whether the meetings were in-person or online.

In conclusion, students tend to favor synchronous learning over asynchronous formats due to the immediate feedback provided during live sessions. They also appreciate the flexibility and cost savings associated with online courses, particularly in terms of reduced commuting expenses. Hybrid students value the in-person interactions more, while online students believe that virtual meetings can offer comparable support. Therefore, by offering both synchronous online and in-person meetings, students can select the format that best suits their individual needs.

The findings of this study align with and extend current SoTL research on mathematics instruction in online and hybrid formats. For example, Hoffman and colleagues found that combining instructional platforms with strong human support such as learning assistants and structured communication significantly improved student participation and performance in online asynchronous math courses (Hoffman et al., 2025). Similarly, our study observed that online students, who had consistent access to structured meetings and clear expectations, demonstrated higher attendance and better academic outcomes than their hybrid counterparts.

Bishop and colleagues emphasized that hybrid instruction, when implemented without adequate planning or support, may fail to deliver its intended benefits (Bishop et al., 2024). This resonates with our observation that hybrid students may have misunderstood course expectations or relied too heavily on in-person meetings, leading to missed opportunities and

lower performance. These findings suggest that hybrid models require intentional design and clear communication to be effective.

Moreover, Engelbrecht and Borba highlighted the importance of digital tools in transforming mathematics classrooms, especially during and after the COVID-19 pandemic (Engelbrecht and Borba, 2023). Our study supports this by showing that online students, who engaged more consistently with digital resources such as lecture videos and online meetings, achieved better outcomes. This underscores the potential of well-integrated technology to enhance learning in mathematics, provided students are supported in using it effectively.

In light of these findings, our study contributes to the growing body of evidence that online instruction when thoughtfully designed and supported can lead to strong academic performance in mathematics. However, it also cautions that hybrid formats may not automatically confer advantages unless students are fully engaged and understand the structure of the course. These insights reinforce the need for ongoing research and refinement of instructional strategies to ensure equitable and effective learning experiences across modalities.

7. Conclusion

This study examined the effects of hybrid and online instructional methods on students' learning achievements and attitudes toward mathematics in a project-based college course. The findings revealed that students in the online group consistently outperformed their hybrid counterparts across all measured components, including assignments, quizzes, projects, participation, and exams. Despite these performance differences, there was no statistically significant change in students' attitudes toward mathematics in either group over the course of the semester.

One of the most compelling findings from this research is the role of attendance and engagement. Online students demonstrated higher attendance rates and greater consistency in participating in class activities, which evidently contributed to their superior academic performance. Additionally, survey responses highlighted the value students place on flexibility, convenience, and the ability to learn at their own pace. These factors may enhance motivation and performance in online settings.

While hybrid instruction offers the benefit of face-to-face interaction, its effectiveness in this study appears to have been hindered by

two key factors: lower attendance and potential confusion about course expectations. Because our data showed that attendance significantly impacts student learning, the hybrid group's reduced participation likely prevented students from fully benefiting from in-person instruction. Additionally, if hybrid students were uncertain about when and how to attend class sessions or how the hybrid structure operated, this confusion may have further limited their engagement. These findings suggest that the success of any instructional format depends not only on the delivery method but also on consistent student participation and clear, well-communicated course expectations.

Ultimately, offering both hybrid and online options may best serve the diverse needs of students, allowing them to choose the format that aligns with their learning preferences, schedules, and personal circumstances. Future research could further explore how to optimize hybrid models to improve attendance and engagement, ensuring equitable learning outcomes across instructional formats.

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