STUDENTS' PREFERENCE OF LEARNING MODALITY IN DATA SCIENCE COURSES—A CASE STUDY

Galkande Iresha Premarathna
Iresha.premarathna@metrostate.edu
Department of Mathematics and Statistics
Metro State University
Saint Paul, MN, U.S.A.
ORCID: 0000-0002-4425-5369

Thanaa Ghanem
Thanaa.ghanem@metrostate.edu
Department of Computer Science and Cybersecurity
Metro State University
Saint Paul, MN, U.S.A.
ORCID: 0009-0002-3673-1756

Yue Zhang
Yue.zhang@metrostate.edu
Department of Mathematics and Statistics
Metro State University
Saint Paul, MN, U.S.A.
ORCID: 0000-0003-3199-0302

David Jacobson
David.jacobson@metrostate.edu
Department of Mathematics and Statistics
Metro State University
Saint Paul, MN, U.S.A.
ORCID: 0000-0001-7724-5557

Ismail Bile Hassan
Ismail.bilehassan@metrostate.edu
Department of Computer Science and Cybersecurity
Metro State University
Saint Paul, MN, U.S.A.
ORCID: 0000-0001-8790-240X

Simon Jin
Simon.jin@metrostate.edu
Department of Management Information System
Metro State University
Saint Paul, MN, U.S.A
ORCID: 0000-0001-7499-8908

Wei Wei
Wei.wei@metrostate.edu
Department of Mathematics and Statistics
Metro State University
Saint Paul, MN, U.S.A.
ORCID: 0000-0003-3706-1715

ABSTRACT
Since the pandemic, students have experienced different learning modalities—in-person, online synchronous, online asynchronous, and hybrid. This paper studies students' attitude and preferences towards these learning modes. We collected data over four semesters on students' preferences toward the learning modalities of their previously taken and future courses.
We found that students preferred online synchronous offerings more than the other learning modes throughout the four semesters, based on both their previously taken and future courses. Overall, the order of preferences from the most to the least favorable are online synchronous, online asynchronous, in-person, and hybrid. In addition, we found that the preference towards synchronous courses over asynchronous courses was greater for upper-division than lower-division courses.
Keywords: online, in-person, synchronous, asynchronous, hybrid, learning modes

Introduction

Distance and online learning have been introduced since 2000 and have been growing since then (Clark, 2024; Prinsloo, 2016; Zawacki-Richter & Naidu, 2016). Studies have found that students prefer online classes over other learning options due to their flexibility and ability to accommodate work schedules (Shlomo & Rosenberg-Kima, 2024; Johnson, 2022). During the pandemic, most institutions shifted to online learning mode. Post-pandemic, many institutions switched their course offerings back to in-person for the benefits of direct interaction and hands-on learning experiences, while some retained online section options for their courses. That being said, there are a noticeable number of students who still prefer the online learning mode after the pandemic (Bentrim et al., 2022, Shlomo & Rosenberg-Kima, 2024), illuminating student perceptions of learning modality changes.

Student perceptions of learning modes provide invaluable insights into their experiences and expectations of classes (Dawson et al., 2019). Student perspectives are important to motivating their learning and attendance in a class (Larson et al., 2023). Studies have mentioned that student attitudes toward learning modalities are influenced by non-teaching factors, and understanding student preferences of delivery or learning modes are important fostering their learning experiences. (Artino, 2010; Van Wart et al. 2020; Kartika et al., 2021; Zhang et al., 2022).

Metro State University is a four-year university in Saint Paul, Minnesota, U.S., with diverse student population. Metro State University serves both traditional students and adult learners. Previous studies, mentioned above, investigated student perceptions and preferences in traditional institutions. Yet, few studies have identified student attitudes toward online learnings in non-traditional schools, such as universities and colleges focusing on adult learners and non-traditional students. In this study, we investigated student preferences of online and in-person learning modes at a non-traditional university.

While our research focused on student perceptions about learning modes, this is not suggesting that the effect of learning modality on student performance is unimportant. Preferences may not always align with the methods that yield the best academic outcomes; however, previous studies comparing students' performance between online and in-person offerings for introductory programming courses (Smith and Rixner, 2020; Marriott, 2021; Alzahrani et al., 2023) have shown that there were few or no statistically significant differences in exam scores between the students who completed a course online and those who completed the same course in person. Gulati et al. (2023) found that the learning modality was not statistically significant, as the online and in-person sections had a comparable performance on formative assessments, with a slight advantage for in-person students in exams. In addition, there was a positive correlation between attendance and exam scores, regardless of remote or in-person offering (Smith and Rixner, 2020). Offering students their preferred learning mode can enhance class attendance and participation.

In online learning, two modalities were often offered to the students: synchronous and asynchronous. Most courses in online programs tend to be asynchronous, as this format offers greater flexibility for students who may be balancing education with work, family, or other commitments. However, some online programs also offer synchronous courses. Both synchronous and asynchronous learning modes offer unique benefits that cater to diverse student populations (Hung et al., 2024; Zeng & Luo, 2023). Synchronous learning facilitates real-time interaction, fostering collaboration and immediate feedback from the instructor (Katai & Iclanzan, 2023; Belt & Lowenthal, 2022). Conversely, asynchronous learning provides unparalleled flexibility. This modality especially fits to students' work schedules. Studies have reported that students in synchronous settings received more peer-centered activities and greater support of their psychological needs, as well as overall satisfaction (Fabriz et al., 2021; Presley et al., 2023). Yet, not much research has been done to address student attitudes toward these two learning modes for online programs or institutions serving non-traditional students.

Computer science and data science often requires a blend of theoretical learning and practical applications. Studying student perceptions about synchronous and asynchronous learning can help educators design courses that balance student needs while accommodating diverse learning preferences. For instance, students may prefer asynchronous learning for activities like coding which require uninterrupted focus and flexible pacing (Dela Rosa 2022). On the other hand, synchronous sessions might be effective for peer programming and real-time debugging (Sun & Xu, 2024; Tan et al., 2024). In this study, we explored student perceptions toward synchronous and asynchronous online classes in a non-traditional institution.

At Metro State University, we continued offering courses in various learning modes: in-person, online synchronous, online asynchronous, hybrid, and Hy-flex. The in-person learning mode is in the traditional physical classroom setting, providing face-to-face interactions between the instructor and students. The online synchronous mode is very similar to the in-person learning except that learning occurs in a Zoom environment. The online asynchronous courses do not require scheduled sessions. The hybrid learning mode combines elements of online and in-person instruction. There are two to eight in-person sessions scheduled or more than four proctored exams on assigned days and times for a hybrid course. The Hy-flex learning is offered in-person to the students who choose to be in-person and is broadcast via Zoom to the students who choose to be online. There is no course offered in Hy-flex mode in our Data Science program at Metro State University.

Research Questions

Students have diverse needs and education background that influence their attitudes toward different learning environments. For instance, adult learners balancing work and family may benefit more from asynchronous options, while younger students seeking human-human interactions in in-person settings. In this paper, we study two research questions.

The first research question is: What is student preference toward different learning modalities: in-person, online synchronous, online asynchronous, and hybrid, in a non-traditional institution?

The second research question is: If students prefer online learning, or for the students in online degree programs, do they prefer synchronous delivery or rather asynchronous format?

By identifying student preferences of course modality, especially for institutions with similar student population as Metro State University, schools can make informed decisions about course design, ensuring that students are not only more engaged but also more likely to succeed. This research can be generalized to institutions offering online programs and online classes, or with students who prefer online learning modes.

Methods

We created a survey of eight questions to investigate students' attitude toward learning modalities. The first question targeted students' satisfaction of previous courses in regard to the four learning modes: online synchronous, online asynchronous, hybrid, and in-person learning. Questions two, three, and four asked students to elaborate on the challenges and appealing aspects of remote learning. Question five investigated student preferences of learning modalities for their future courses. Question six and seven were extensions of question five, asking the likelihood of students choosing online synchronous versus asynchronous at different course levels (freshmen, sophomore, junior and senior levels). The last question collected students' comments. The eight survey questions are included in the Appendix of this paper. The survey also included students' demographic information. This survey instrument was approved by the Human Subjects Review Board (HSRB) at Metro State University.

Survey invitations were sent out to all Data Science majors each semester as Google Forms and student responses were recorded anonymously. Each academic year, there are about 40 newly enrolled Data Science majors. Students completed the survey voluntarily. Sixty-seven responses were received from four semesters: Fall 2021, Spring 2022, Spring 2023, and Fall 2023. If a student did not take a course in a certain modality, they rated N/A for the corresponding question on the survey. In Fall 2021 and Spring 2022, most of the courses offered at Metro State University are online synchronous or online asynchronous. Starting from Fall 2022, most of the lower division courses in Data Science were offered with both online sections and in-person sections, and most of the upper division courses were offered online. At Metro State University, the class size was capped at 32 students, with some of the upper division classes capped at 24.

Student responses to the first question, asking their satisfaction with the four learning modes from previous courses, were analyzed using the ordinal logistic mixed effect model. The response variable was the satisfaction type (dissatisfied, neither satisfied nor dissatisfied, and satisfied). The explanatory variables were semester, learning mode (online synchronous, online asynchronous, hybrid, and in-person), students' age, gender, Hispanic status, and racial group, alongside random effects for students to account for the non-independence of observations within the same student.

Student responses to question five, investigating students' preferences of learning modes for their future courses, were analyzed using the one-way Chi-square homogeneity test. We tested if the proportions of preference of the four learning modes were significantly different. The response variable was the proportion of students preferring each type of learning mode. The explanatory variable was the learning modality.

Student responses to question six and seven, asking the likelihood of their choosing the online synchronous or asynchronous modes for their future courses, were analyzed using the ordinal logistic mixed effect model. The responses were indicated by a Likert scale labeled with extremely likely, somewhat likely, somewhat unlikely and extremely unlikely, and were considered as the dependent variable. Course modality (online synchronous and asynchronous), course level (100, 200, 300 and 400 levels), number of years in the Data Science program, racial

identities, gender identities, and age group were considered as predictors. The resulting models were compared using likelihood ratio test (LRT) and Akaike Information Criterion (AIC).

All analysis was done using R with the significance level of 0.05.

Results

The descriptive statistics of the responses from the first question (satisfaction with the four learning modes of their previous courses) showed that more than 70% of the students were satisfied with the online synchronous mode (Figure 1). The percentage of students who were satisfied with the online synchronous courses was the highest, and the online asynchronous satisfaction rate was the second highest. Hybrid classes had the least satisfaction rate and the highest "not applicable" rate, due to the limited availability of such courses.

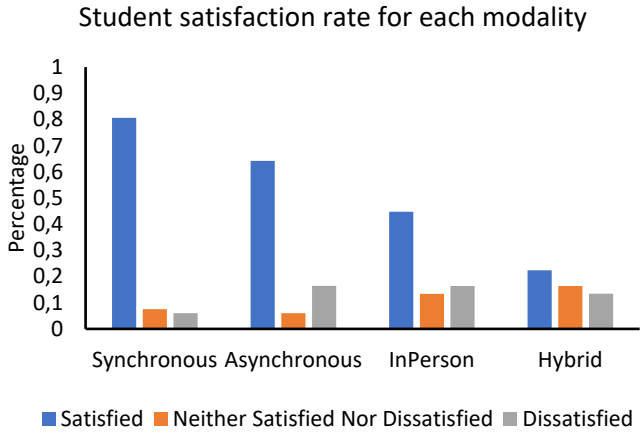

Figure 1. Students' satisfaction of the four learning modes based on their previously taken courses. The heights of the bars represent the percentage of a satisfaction level.

Figure 2 displayed the satisfaction levels of different learning modes by semester. It showed the consistency that the online synchronous classes were the highest preferred and the online asynchronous was the second highest preferred in Fall 2021, Spring 2022, and Fall 2023. At Metro State University, at the beginning of the pandemic, most classes moved online during the 2020-21 academic years and some in-person classes resumed in Fall 2022, and thus we saw a peak of interest toward in-person learning in Spring 2023, but then the interest went back to be much lower than that of synchronous courses in Fall 2023.

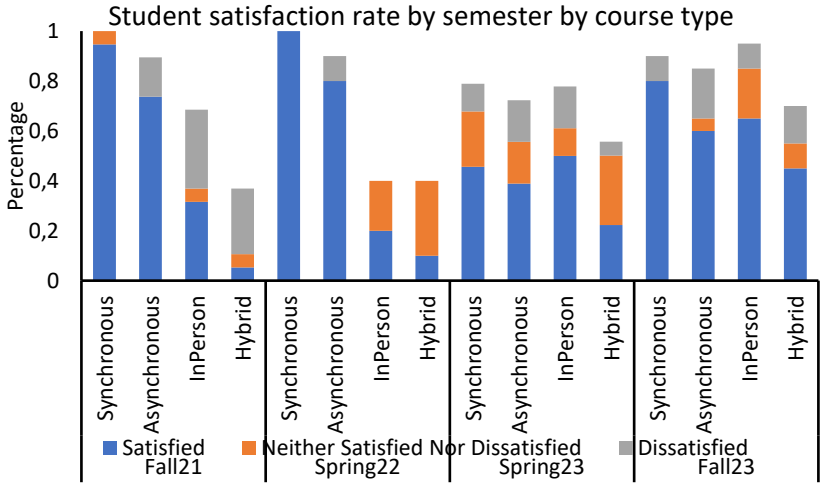

Figure 2. Students' satisfaction of the four learning modes in each semester. The height of the bars is relative frequency of the satisfaction level in each semester.

The ordinal logistic regression model reveals that the learning mode (online synchronous, online asynchronous, in-person, and hybrid) significantly impacts students' satisfaction. The online synchronous classes show the most significantly positive correlation with satisfaction (Z=4.26, p-value<0.001), followed by online asynchronous classes (Z=2.79, p-value=0.005). Traditional in-person classes also show a positive relationship but not statistically significant (Z=1.38, p-value=0.168) with satisfaction. In addition, the ordinal logistic regression model suggests that the factors of semester, age, Hispanic status, gender, and racial group were not significant. The random effects of students show a very small variance (<0.001), indicating minimal variability in satisfaction levels attributable to individual differences between students.

Based on the Chi-square homogeneity analysis of question five responses, we observed that there was significant difference between the proportions of preferences toward the four learning modes ($\chi^2(3)$ =22.02, p-value<0.001). Most of the students preferred the online synchronous mode, followed by the online asynchronous mode (Figure 3).

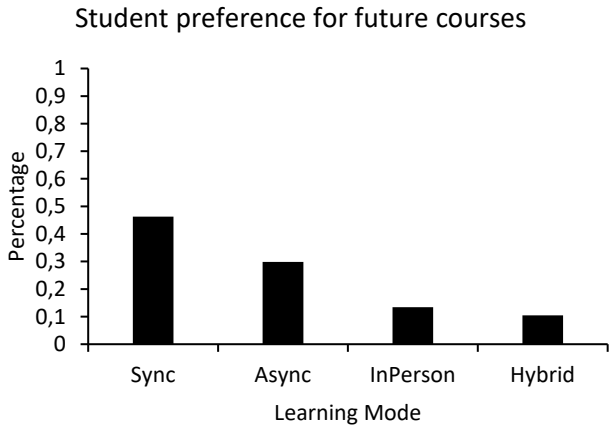

Figure 3. Student's learning mode preference for future classes. The height of the bars represents the percentage of students choosing that learning mode.

Student responses to question six and seven, relating to the likelihood of choosing the synchronous versus asynchronous modes for the four levels of their future courses, showed that 81% of the students were likely (both extremely likely and somewhat likely) to take online courses regardless of synchronous or asynchronous. Looking into the percentage of students who would likely (both extremely likely and somewhat likely) take online courses, synchronous courses were preferred (89.4%) more than asynchronous courses (71.9%) (Figure 4).

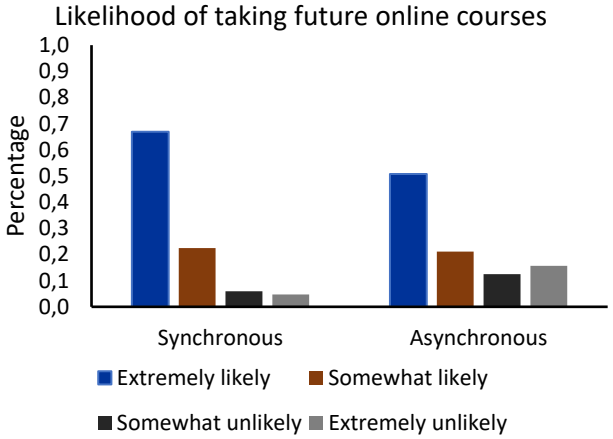

Figure 4. Students' preferences toward online synchronous vs. asynchronous courses. The height of the bars represents the percentages of students indicated the likelihood of choosing that modality for their future classes.

When comparing students' preferences for the online courses for upper versus lower division courses, we found that students were more willing (both extremely likely and somewhat likely) to take online courses for lower (freshman and sophomore) level courses (83.9%), than for higher level courses (77.6%) (Figure 5).

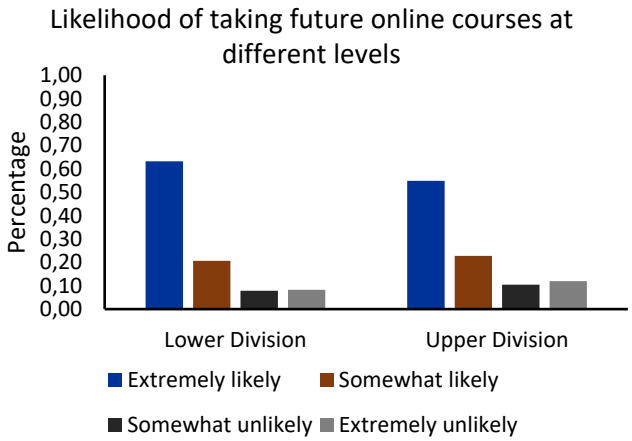

Figure 5. Students' preferences toward online courses by course levels. The height of the bars represents the percentages of students.

The ordinal logistic regression model of the responses from the sixth and seventh questions revealed that the course mode (synchronous vs. asynchronous) is significantly related to the likelihood of choosing the course ($\chi^2(1)=52.25$, p-value<0.001), as well as the course level ($\chi^2(1)=7.08$, p-value=0.0078). There is a significant interaction between the course modality and course level from our model ($\chi^2(1)=4.78$, p-value=0.029).

To further investigate the significant interaction, when it was an upper-division course, the odds ratio of likely taking a synchronous versus asynchronous course was 7.87 (95% CI: 4.23-14.62, p<0.0001, Z=6.53). When it was a lower-division course, the odds ratio of likely taking a synchronous versus asynchronous course was 3.03 (95% CI: 1.56-5.78, p=0.0008, Z=3.36). Students were significantly more likely to take a synchronous course than an asynchronous course for an upper division course.

Looking at the difference between course levels, when it was an asynchronous course, the odds ratio of likely taking it at lower-division versus upper-division was 2.73 (95% CI: 1.53-4.89, p=0.0007, Z=3.39). When it was synchronous, the odds ratio of likely taking it at lower-division versus upper-division is 1.05 (95% CI: 0.55-2.00, p=0.88, Z=0.15). Overall, if the course was offered asynchronously, students preferred it to be a lower-division offering, but when it was synchronous, students were likely to take it at either upper or lower-level.

Discussion

Overall, we found that students showed a consistent interest in taking online courses, and the online synchronous mode was the most preferred delivery mode. Even though this study is only one case study for Data Science students, the results in this study about student perceptions of course modalities can be extended to institutions with similar student populations and institutions with online programs.

In the survey, question two asked students to choose the challenges of taking an online course. Out of the total of sixty-seven students surveyed, thirty-three stated that they did not experience any challenges. The top challenge was that students felt that they could understand the material better in in-person classes (Table 1).

Challenges of online courses	Total number of students who voted this challenge
Did not experience any challenges	33
Understanding materials better in in-person classes	17

The availability of help with the course content	13
Understanding the course expectation	12
Distractions in my surrounding environment	11
Lack of my time management skills	10
Other challenges	9
Frequency of software/hardware issues interfering the course	8
Access to reliable internet connection	6
Concerns about prolonged screen time	6
Access to technology	4
Distractions in the instructor's surrounding environment	2

Table 1. Summary of student choices of challenges when taking online courses. The numbers in the right-hand side column indicate the counts of students who chose that challenge. Note that a student could choose multiple challenges.

Students also indicated the appealing aspects of online courses as well (Table 2). The top appealing aspect was the ability to refer to course recordings.

Appealing aspects of online courses	Total number of students who voted for this aspect
Ability to refer to recorded class materials	57
Time saving (no commute)	57
Convenience	51
Flexibility of learning	46
Others	6

Table 2. Summary of student choice of the appealing aspects of taking online courses. The numbers in the right-hand side column indicate the counts of students who chose that aspect. Note that a student could choose multiple appealing aspects.

Even though we found that age group was not a significant factor, different age groups did show very different preferences. Metro State University has a unique student population where more than half of the students are adult learners. We found that students under 25 preferred the in-person classes more than the online synchronous or asynchronous classes (Figure 6). The age group of 45 or older demonstrated a keen interest in both in-person and online classes. Conversely, the 25-44 age demographic exhibited a pronounced preference for online courses, a choice that may be driven by their needs to juggle other commitments such as work and family obligations.

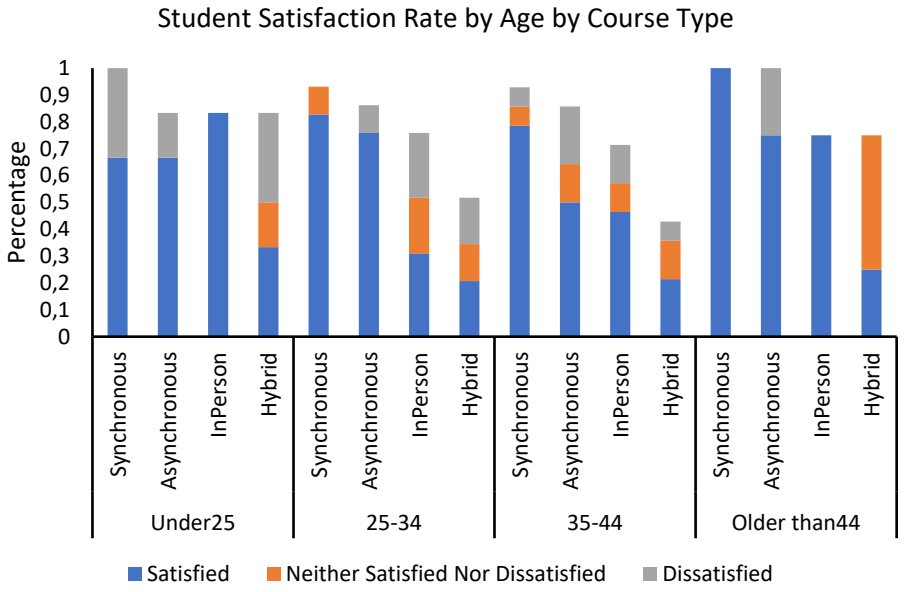

Figure 6. Students' preference of learning modes by age groups. The height of the bars represents the percentage of students.

Students' responses to question six and seven, relating to the online synchronous and online asynchronous preference for the four levels of their future courses, showed a similar pattern; the age group of under 25 indicated that they were more unlikely to choose an online course than the other age groups (Figure 7).

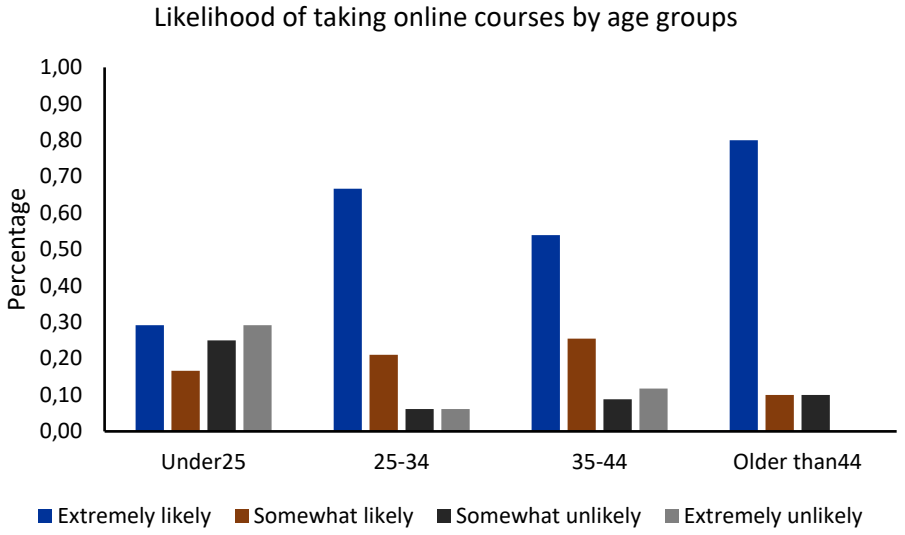

Figure 7. Students' preference toward future courses by age group. The height of the bars represents the percentages of students.

Our research findings suggested that students preferred online synchronous mode over asynchronous. Younger student populations preferred in-person classes more than online classes, while adult learners preferred online learning much more than in-person.

Those recommendations can benefit schools on their course design and course offering and determining the appropriate learning modality for their student populations.

Future work

This paper focuses on students' attitude toward the four online learning modalities: online synchronous, online asynchronous, in-person, and hybrid. However, this study did not investigate student performance with the four modalities. In our future work, we would like to include student performance data to study student learning outcomes with the four learning modalities.

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