

Testing Teaching and Learning Delivery Modes for Independence – A Chi-square Analysis through Students' Perceptions of Barriers

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Abstract

This study tests the independence of four Teaching and Learning Delivery Modes (DMs) in Higher Education: Face-to-Face, Blended, Hybrid, and Online. We collected students' perceptions of barriers to these DMs through a survey with 192 respondents and tested for independence using Pearson's Chi-square. The main result is that Hybrid and Online are perceived as one DM. Considering other academic work, we can conclude that hybrid delivery modes are superior to entirely online, as they allow students to adjust the DM based on their individual needs.

Keywords: *Delivery Modes, Chi-square, Digital Teaching, Barriers.*

1. Introduction

During the COVID-19 pandemic, traditional in-person teaching was replaced by online instruction. Emergency Response Teaching (ERT) emerged as a necessity as conventional teaching methods were abruptly substituted (Hodges et al., 2020). Before the pandemic, there had been discussions about digitizing higher education institutions (HEIs), including their teaching and learning (Ananga & Biney, 2021). Still, various obstacles hindered the widespread adoption of digital teaching and learning (Tesar & Sieber, 2010). Institutions often avoided diverse Teaching and Learning Delivery Modes (DMs) or relied on temporary solutions (Hadjimanolis, 2003). The complexities and potential solutions for instructional DMs require more systematic and focused research. It is important to note that ERT and standard online teaching differ significantly in their characteristics (Tesar & Sieber, 2010). The pandemic and its aftermath can provide valuable insights into the large-scale application of various DMs, which should be leveraged to enhance their effectiveness.

Following an explorative pre-study, this paper addresses the following research question (RQ): How are the four Teaching and Learning Delivery Modes associated when measured through their perceived barriers in the post-COVID-19 era?

First, we will summarize the challenges and solutions in the relevant literature. Next, we will outline our survey-based research method, which focuses on barriers to instructional delivery modes. To generate the results, we will employ Pearson's Chi-square test of independence and apply it to six combinations of four delivery modes. We will then present and discuss the results, concluding with a forward-looking perspective.

Our study contributes empirical insights crucial for HEI growth. Incorporating student feedback is essential with the rise of the "student-as-consumer" approach and increasing competition. We examine differences in DMs and their barriers, helping educational managers make informed decisions beyond simple DM substitutions. According to the SAMR model (Hamilton et al., 2016), redefinition may be the best approach when contexts change. Prior pandemic-related research has explored HEI strategies (Popova et al., 2020) and case studies (Marshalsey & Sclater, 2020). As survey development has taken time, post-pandemic quantitative research on barriers remains scarce since the pandemic officially ended in May 2023 (Wise, 2023).

2. Teaching and Learning Delivery Modes

A Teaching and Learning Delivery Mode (DM) is the medium or method through which instructional content is transmitted and interactions are exchanged between learner–content, learner–learner, or learner–teacher, including face-to-face (synchronous), entirely online (asynchronous), or blended/hybrid formats (Bernard et al., 2009; Jamaluddin et al., 2023).

Educators often use the TPACK framework (Technological, Pedagogical, Content Knowledge) to explore technology integration in teaching. The goal is to combine these three elements into a course design seamlessly (Harris et al., 2010). However, ERT disrupted this integration by prioritizing technology over pedagogy. Current literature reflects on pandemic experiences and anticipates future needs, predicting a surge in digital higher education post-COVID-19. However, future developments must prioritize educational quality (Daniel, 2020; Ramola, 2021). Student feedback is crucial in determining the effectiveness of digital course designs. Teachers require training in multiple DMs to deliver high-quality education (Donitsa-Schmidt & Ramot, 2020). Additionally, the pandemic highlighted the need for health-related classes and digital mental health services (Toquero, 2020). A responsive, healing, and reflective approach is recommended for future work (Bhagat & Kim, 2020). Other studies have emphasized the importance of improved internet connectivity and socioeconomic conditions for the success of digital higher education (Pokhrel & Chhetri, 2021). During the pandemic, teachers focused on providing additional instructional resources while students sought more assignments to reinforce their learning (Mishra et al., 2020).

Research has also examined the impact of technology on academic achievement (Janson et al., 2014) and the adoption of digital systems (Irons et al., 2002). Studies advocate for blended learning course designs that consider both drivers and barriers (Scherer et al., 2019). At the

organizational level, resistance to change poses significant challenges, necessitating faculty support (Al-Senaidi et al., 2009). Resource allocation issues further complicate matters, limiting educators' access to time and technology. Curriculum adjustments are seen as essential for the successful digitization of education. External factors, such as political and economic pressures, also hinder the digital transformation of higher education, as HEIs often struggle to adapt to rapidly changing environments (Burch & Mohammed, 2019).

The pandemic and the shift to ERT altered many of the existing barriers. While online teaching became the dominant DM during ERT, other DMs, such as hybrid and blended learning, had already been used (Artino, 2010). Traditional face-to-face teaching remains the standard in-classroom DM, while online teaching represents its digital counterpart. Blended learning combines face-to-face instruction with online or self-study phases, whereas hybrid DMs simultaneously integrate face-to-face and online elements (Hwang, 2018).

3. Method

In a previous qualitative analysis, we identified barriers to digital higher education (HE) instruction (Draxler-Weber et al., 2022). Building upon this study, we developed an online survey to investigate the challenges of different DMs by using the identified overall classifications and their specific barriers. Each barrier within these classes translated into at least one survey item, culminating in 34 items across eight dimensions. The dimensions ranged from barriers concerning technical resources, interaction with peers and teachers, personal skill set, didactics and pedagogy, workload, health, personal readiness, and framework conditions.

Respondents were asked to indicate whether they encountered each barrier item in one or more specified DMs, resulting in categorical data (Agresti, 2013). Additionally, the survey included demographic questions related to age, current semester, study program, the number of different DMs experienced, and the respondent's country of study.

The online survey was completed by 192 German, Swedish, and Turkish university students during the winter term of 2023. Among the respondents, 141 were enrolled in Bachelor's programs, 42 were pursuing Master's degrees, and nine did not specify their degree level. Respondents were drawn from various disciplines and semesters to ensure diverse experiences and perspectives. The largest group of respondents studied Business Administration (78), followed by Media and Management (61) and Information Systems (45). Smaller groups represented Mathematics, Project Management, Law, and Economics. As we employed a convenience sampling method with students we or our colleagues taught, the respondents were primarily from one university in Germany, one in Sweden, and one in Turkey. This gives us background knowledge about their distinct learning management systems (LMS) and conferencing tools. For instance, students at the German university used Stud.IP and

BigBlueButton, while those at the Turkish university relied on Google Classroom. In contrast, the Swedish university adopted Canvas and Zoom for its digital teaching activities.

Based on the collected data, we conducted an exploratory pre-study, identifying the barriers that differentiated face-to-face and online DMs the most. The pre-study revised ten barriers in five dimensions (Packmohr & Draxler-Weber, 2025).

To investigate the relationship between DMs in this study further, we selected one barrier from each dimension of the pre-study that exhibited the smallest difference between the face-to-face and online DMs. Selecting one barrier from each dimension minimizes potential interdependencies between the barriers. Further, we hypothesize that we will obtain more reliable results using this maximum-minimum selection method. If the differences are already substantial, a Chi-square test will naturally indicate the independence of the DMs.

Table 1 summarizes the barriers selected for analysis. The Dimension column indicates the source of the barrier from the pre-study, and the Category abbreviation column specifies the short name of the item used in this study.

Table 1. Relation between dimension – item - categories

Dimension	Item in survey	Category abbreviation
Interaction	I cannot observe teachers' nonverbal reactions	nonverbal
Workload	My overall workload for the lectures is high.	workload
Health	My participation in the lectures leads to bodily discomfort.	discomfort
Personal readiness	I am not flexible enough to participate in the teaching format.	inflexibility
Framework Conditions	I perceive my spatial learning environment as distracting for the lectures (e.g. by noises).	environment

4. Results

The Chi-square test of independence analysis is used to test if there is a significant association between two categorical variables. The Null Hypothesis (H_0) is that no association between the DMs conceptualized through six barrier categories exists.

To prepare for the Chi-square test, the contingency tables for all six possible combinations of DMs were calculated. Table 2 shows an example of the face-to-face / online combination of DMs. The value 38 in Table 1 is the highest in all contingency tables. In 38 cases, respondents indicated bodily discomfort in the face-to-face DM and the impossibility of observing the teachers' nonverbal reactions in the online DM. On average, the observed values were 9.5.

Table 2. Contingency table for the observed DM combination Face-to-Face / Online¹

F2F / Online	nonverbal	workload	discomfort	inflexibility	environment
nonverbal	1	2	1	2	1
workload	36	24	19	7	16
discomfort	38	14	17	8	16
inflexibility	25	11	8	8	8
environment	22	9	11	5	6

After calculating the observed contingencies, we performed Pearson's Chi-square test of independence for all six DM combinations. The results are shown in Table 3. For five combinations, H_0 was not rejected, indicating no significant associations exist. Only the H_0 for the hybrid / online combination was rejected, indicating a significant association.

Table 3. Results of the conducted Chi-square tests.

	F2F	Blended	Hybrid	Online
F2F	-	$\chi^2 (16) = 7.40, p > 0.05$ (H_0 not rejected)	$\chi^2 (16) = 21.00, p > 0.05$ (H_0 not rejected)	$\chi^2 (16) = 10.34, p > 0.05$ (H_0 not rejected)
Blended	-	-	$\chi^2 (16) = 25.48, p > 0.05$ (H_0 not rejected)	$\chi^2 (16) = 16.16, p > 0.05$ (H_0 not rejected)
Hybrid	-	-	-	$\chi^2 (16) = 37.82, p < 0.05$ (H_0 rejected)
Online	-	-	-	-

5. Discussion and Conclusion

Our results indicate that hybrid and online DMs are perceived as similar. Thus, in students' perceptions, there are three independent DMs: Face-to-Face, Blended, and Hybrid-Online.

In our study, we defined hybrid DM for the respondents as synchronously in time, but students can choose to participate in physical or virtual space. In an online DM, the delivery occurs synchronously in time solely in the virtual space. Comparing participation within hybrid DM, there is higher online participation if the class is announced online, even if in-class participation is possible. Also, students tend to join in-class more if only a few participants join online (Beatty, 2007). Still, hybrid models, which incorporate face-to-face interaction, may enhance motivation and engagement more than fully online DMs (Gamage et al., 2022). Thus, a purely online DM might only apply on rare occasions to prevent the spread of diseases or include a

¹ In total, there are six contingency tables for each combination. The other five contingency tables are available upon request.

geographically dispersed audience. Still, technological and personal capability efforts are much higher than those of pure DMs (Alducin-Ochoa & Vázquez-Martínez, 2016).

For our respondents, we defined blended DM as lectures synchronously in time and space, accompanied by timely asynchronous self-study phases, often through online material. Even if blended learning combines face-to-face and online elements, it shows no associations with other DMs. Thus, it is perceived as a stand-alone DM significantly different from the others. It permits self-directed learning in combination with different modes of participation and increases student engagement (Bandara & Jayaweera, 2024).

Our method involved selecting barriers to analyze the relationships between the DMs. Another approach could provide an analysis at a dimensional level, including all the barrier items from the survey. Pearson's Chi-square calculations are critical for contingency values below five (Agresti, 2013). In this case, the tables contain some values under five. Nevertheless, the average is 9.5. Therefore, we consider the data satisfactory for using Pearson's Chi-square.

In conclusion, our results show an overlap between the hybrid and online DMs. Thus, HEIs should reconsider the categorization and deployment of their DMs. Since students perceive hybrid and online modes as closely related, curriculum developers may streamline these into a single flexible category to reduce complexity. At the same time, hybrid models should be prioritized, as they offer students the ability to choose between face-to-face and virtual participation, which can enhance engagement and motivation. Blended learning also emerges as a distinct mode, as it offers flexibility to combine synchronous interaction with asynchronous self-studies. Both DMs can enhance student-centered design in curriculum planning.

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