



# A Study on the Pre- and Post-Pandemic Media of Instruction and Learning Effectiveness in Information Systems Courses

Narasimha S. Paravastu, University of Central Missouri, USA\*

 <https://orcid.org/0000-0001-6511-3872>

Sam Ramanujan, University of Central Missouri, USA

 <https://orcid.org/0009-0003-4529-0806>

## ABSTRACT

The objective of this study is to understand the effectiveness of medium of instruction based on student performance in courses offered face-to-face prior to the pandemic and virtual hybrid mode after the onset of the pandemic from a media richness theoretical perspective. This study analyzed data from 1157 students from 43 Information Systems courses over a 6-year pre- and post-pandemic period. This study analyzed student performance data from face to face and virtual hybrid courses across medium of instruction, type of course, course level, and gender. Overall, students performed better in face-to-face classes prior to the pandemic than the virtual hybrid courses. Across gender, and type of course, and course levels, face-to-face medium of instruction was found to be best for student performance. The post-hoc interviews with students and faculty indicated that face-to-face was the choice of instruction medium for technical courses and virtual hybrid mode was preferred for theory intensive conceptual courses, confirming the results from the data analysis.

## KEYWORDS

ANOVA, Learning Effectiveness, Media Richness Theory, Medium of Instruction, Online Education, Structured Interviews, Student Learning, Virtual Hybrid Learning

## INTRODUCTION

The COVID-19 pandemic caused almost all educational institutions worldwide to adopt a variety of online technology enhanced and hybrid modes to ensure effective course delivery while practicing social distancing and quarantine during the pandemic (Easop, 2021; Viner et al., 2020). The modes of course delivery were as follows: a) completely asynchronous online where the instructor and students may be separated by location as well as time and the instruction happens via the internet using audio, video, and other online tools; b) synchronous online where the instructor and the

DOI: 10.4018/IJISSC.332786

\*Corresponding Author

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students meet at a fixed time, but separated by location, and use technology such as Zoom, Skype, or Google Meet etc. as the medium of communication; and c) modified face to face classes which involved classroom meetings with social distancing, masking, and such safeguards appropriate during the pandemic period dictated by health guidelines. The mode of delivery was determined by various factors such as class size, course level such as introductory, intermediate, or advanced level, or graduate vs. undergraduate level, and the nature of the individual courses—conceptual, hands-on programming, lab, etc.

These technology enhanced online instruction methods have benefits as well as challenges (Bandi, 2021). Flexibility and adaptability have been one of the main advantages that online learning brings both to the faculty as well as the students (Ilgaz & Gulbahar, 2017; Zawacki-Richter & Naidu, 2016). However, past research on student readiness for online education suggests that the students may be ready for using the technology, but may not be completely ready for learning the course content online (Parkes et al., 2015). Other studies found that a blended form of learning combining both online and face to face mode of delivery, also known as virtual hybrid mode (virtual hybrid henceforth) is more effective than mere online education (Ma & Lee, 2021). Further, it is not just the online or face to face mode of delivery but the nature of the course, implementation, and learner characteristics that contribute to student learning (Ryan et al., 2015). The objective of this study is to understand whether the online or virtual hybrid modes of course delivery effectively communicate the course content to the students and help them perform well.

Media richness theory states that the robustness of communication depends on the media used for communicating a given information (Kwak, 2012; Lim & Benbasat, 2000). From a media richness theoretic (Lim & Benbasat, 2000) perspective similar to organizational or day to day communications, the choice of medium and nature of the course makes a difference in communicating the course content to the students for better learning outcomes. Course delivery is also a mode of communication where the faculty pass on their expertise and perspective in their discipline to the students and students interact with the faculty in order to fully understand the nuances of the discipline. Therefore, the choice of media is an important consideration when communicating the content (Lipowski & Bondos, 2018). A key issue in any communication is the choice of medium, and its attributes must align with the communication task characteristics (Koo et al., 2011). In the context of teaching Information Systems courses, the medium of instruction i.e., online (synchronous and asynchronous), virtual hybrid, or face to face is the medium of communication for course content. The nature of the course—i.e., whether an IS course is conceptual, theory-oriented courses (conceptual from here on), or hands-on intensive or technically oriented courses (technical courses from here on) can be considered as task characteristics proposed in media richness theory. Conceptual courses are defined as those courses where the focus is more on the theoretical aspects and may not involve labs or hands-on course work. Technical courses are defined as those courses that require considerable hands-on practice of syntax, for example programming or database courses. For the purposes of this study, all courses offered prior to the onset of the pandemic are considered face to face (pre-pandemic face to face courses from here on), because all courses used in this study were offered face to face. Similarly, all course data used in this study after the onset of the pandemic were offered either as fully online synchronously (where the class meets online using Zoom, Skype or some other form of technology at a pre-scheduled time), fully online asynchronously (where the instructor and the students may not meet at a scheduled time, but the course material is made available online for flexible access), or some form of online and face to face combinations. From here on these courses will be referred to as post-pandemic virtual hybrid courses.

This study addresses an important gap in literature of understanding what type of course delivery helps student learning better, given the type of courses. The previous research has examined the advantages of face to face classes as well as the advantages and flexibility offered by the online or hybrid mode of instruction (de Ocampo, 2023; Estelami, 2012; Harris-Packer & Ségol, 2015; Piccoli et al., 2001; Skylar et al., 2005). However, very few studies analyzed results from successive sections

of the same courses taught by the same instructor over time across several semesters offered in face-to-face and virtual hybrid modes. Very few studies have tried to assess the differences in student performance based on various data characteristics such as gender, course level, or the type of courses (technical vs. conceptual) in information systems discipline.

In an effort to bridge the above gaps in literature, this study attempts to understand the impact of medium of instruction on student learning in conceptual or technical information systems courses. This study addresses the following research questions: What is the impact of medium of instruction (pre-pandemic face to face or post-pandemic virtual hybrid) on: a) student performance; b) student performance based on type of courses (technical or conceptual); c) student performance based on gender; d) student performance based on course level (graduate level classes or undergraduate level classes); e) student performance collectively based on any combinations of gender, type of course, and course level. Understanding what medium of course instruction benefits student learning for different types of courses in Information Systems (IS) discipline is important because IS is a diverse discipline that offers a variety of courses ranging from concept heavy courses such as project management courses, or very technical and hands on oriented courses such as advanced programming courses or database courses.

This study makes the following contributions to literature. This study tested the student performance during the pre-pandemic and post-pandemic courses modes of course delivery using the same classes during face to face as well as virtual hybrid modes, taught by the same instructor, which eliminates the differences in terms of course content or difference in expertise of the faculty members delivering the courses. Secondly, this study tested for different parameters: gender, course level (graduate/undergraduate), and type of course (technical/conceptual). Next, this study corroborated the results of in-class performance of the students with follow-up structured interviews with faculty and students corroborating the results from the statistical analysis. Finally, this study applied the media richness theoretic context to the course delivery and provided a rationale as to why course delivery is similar to organizational communications, and why media richness is very important in technical courses in order to pass on the finer perspectives to the student for better student learning. This study contributes to literature by presenting the results from data collected over six years from face to face, online, as well as hybrid modes of instruction from 2014 through 2021.

The rest of the article is organized as follows. A brief review of media richness theory and its relevance and equivalence to the course delivery context is presented, followed by a brief review of literature on online and face to face modes of course delivery. The data collection, analysis, results, and discussion of the results are presented next.

## LITERATURE REVIEW AND HYPOTHESES

### Media Richness Theory

Media richness theory (MRT) and effectiveness of communication research has its roots in the complexity of information (Daft & Lengel, 1986; Daft et al., 1987) and the ability of a medium to communicate the information and knowledge (Daft & Lengel, 1986; Daft et al., 1987; Koo et al., 2011; Kwak, 2012; Lim & Benbasat, 2000; Rice, 1992). Four important components of MRT are a medium's 1. immediate feedback—a medium's ability to allow bidirectional communications, 2. personal focus or the ability to deliver emotions and contextually and situationally appropriate messages, 3. multiple cues—ability to provide verbal and visual channels of communication, and 4. Language variety—ability to use and express a range of meanings available in a language unambiguously (Daft et al., 1987). Based on ability to carry the information to the intended audience, communication media are classified as either “lean” or “rich” (Kwak, 2012). Generally, face to face communications are classified as rich because of the ability to convey more information due to its visual cues (Daft &

Lengel, 1986), as opposed to other forms of communication such as a telephone conversation, or electronic communication which is considered as lean and not as rich as face to face communication, computer contact, or online communications. This objective assumption about media rich is because of the presence of multiple cues in face to face communications and absence of visual cues, and the ability to provide immediate feedback, to parties in the interaction in other forms of media (Daft et al., 1987; Koo et al., 2011; Suh, 1999). Media richness improves participation in communication and the quality of interaction. A “rich” media has the advantage of conveying information unequivocally, unambiguously, and therefore reducing the possibility of misinterpretation of information (Carlson & Zmud, 1999; Lee et al., 2007). However, an important constraining drawback about MRT is its assumptions that media choices by the users are rational, and that the media richness attribute is objective (Fulk et al., 1987; Markus, 1994). Sometimes, there may not be a choice available for selecting the media. For instance, in the pandemic context, neither the universities nor the students had any choice about the medium of instruction, and virtual hybrid medium of instruction was the only obvious recourse. However, the basic premise of MRT that the medium of communication adds richness to communications (Fan-Chen et al., 2019; George et al., 2013; King & Xia, 1997) is well established in past research in multiple contexts.

### *Relevance of Media Richness Theory to the Context of Medium of Instruction*

Merriam-Webster (Webster, n.d.) dictionary defines teaching as: to cause to know something; to cause to know how; to guide the studies of; to impart the knowledge of; to instruct by precept, example, or experience; In the definitions “to impart the knowledge of” listed above, the word impart (Webster, n.d.) is defined as: to give, convey, or grant from or as if from a store; to communicate the knowledge of. Daft and Lengel (1986) define media as a channel or a vehicle for conveying messages or communications. Teaching is a very important form of communication that conveys to the learner the precept, example, and experiences to impart the knowledge of a discipline in a clear and unequivocal manner. Research in the realm of communication can therefore be extended to the realm of teaching and extrapolate and apply media richness theory to the realm of teaching. Considering that non-traditional modes of teaching such as synchronous and asynchronous online courses, and hybrid media of instruction which employ a combination of synchronous, asynchronous, or face to face courses involve teaching using electronic communication media such as Zoom, Skype, Google Meet, or some form of meeting software. The media richness theoretic research, which has extensively included electronic communications, provides a good basis for applying the theory to the context of teaching and contrasting the communication quality of face to face online, hybrid, or other virtual modes of course delivery in a variety of situations.

## **HYPOTHESES**

If the goal of teaching is to facilitate the transfer of knowledge from the faculty expert to the student learner, then medium of communication is an important factor for instruction effectiveness. Media richness or effectiveness of communication in the context of this study is operationalized as the performance of students in a given course. The communication media effectiveness, or effectiveness of a medium of instruction, is measured based on student performance. If the students perform better in a given medium of instruction than an alternative, then the medium of instruction is considered effective and richer than the alternative medium of instruction. The objective of this paper is to understand, from the perspective of media richness theory, whether there are differences in performance of the students because of changed mode of delivery due to the pandemic. In the context of this study, pre-pandemic medium of instruction was completely face to face and the post-pandemic medium of instruction involved very little face to face instruction. The courses offered in the post-pandemic phase used alternative methods such as online or virtual synchronous methods to impart the course content and could have had an impact on student learning and performance. Teaching technical

courses that have intensive hands-on or practice-oriented components such as advanced database courses or advanced programming courses involve a lot of faculty-student interaction passing on the perspective to the student. The face to face medium of instruction enables the students to not only learn the programming syntax but a lot of other aspects such as good programming practices, techniques of debugging, and finer aspects of advanced technical course content. Imparting such subtler perspectives are often complicated by the lack of media richness. On the other hand, more theoretical oriented courses are more student friendly for online instruction and relatively easier to pass on a given perspective to students.

Because of such variations in course delivery, there could potentially be differences in unequivocally communicating the course content to the students, which in turn could impact their performance. This study hypothesizes that there are differences in student learning for different modes of course delivery—face to face, which involves media rich communications between the instructor and the students, and either fully synchronous online medium of instruction or a virtual hybrid mode, which involves a combination synchronous and/or online as well as some face to face meetings. Such methods of course delivery invariably involve considerable technology for communications between the instructor and the students. This study attempts to understand the differences in student learning because of these different modes of course delivery, and therefore expects that there will be a significant difference in mean performances of students in the face to face and virtual hybrid modes of course delivery.

Past research confirms that, depending upon the course content, student attributes such as gender, course level (graduate or undergraduate or other levels), course content and nature of the course, maturity, and intelligence, among other factors, warrant approaching course delivery differently (Leidner & Jarvenpaa, 1995). Therefore, it is important to understand the impact of face to face and virtual hybrid media on the student performance in terms of gender, course level (graduate level or undergraduate), and technical and conceptual courses.

Differences also exist in the face to face and virtual hybrid medium of instruction based on gender and based on the type of courses (technical vs. conceptual). For example, research indicates that male students performed better than female students in STEM (science, technology, engineering, and mathematics) courses (Gold et al., 2018; Master et al., 2016; Park & Dong-gook, 2020; Stieff et al., 2014; Zhang et al., 2022). Results from past research indicate that female students learn better than males in online formats of course delivery (Hong Thi Thu, 2022). Gender effects were found to be significant in face to face classes (Wehrwein et al., 2007) and in virtual hybrid online classes (McSporry & Young, 2001). There are also conflicting results from other studies that indicate that there were no significant differences based on gender (Astleitner & Steinberg, 2005). Similarly, different interactions on student learning in virtual hybrid courses because of nature of content and technology were studied in the past research (Eom & Ashill, 2016; Swan, 2001). Extending those results, this study hypothesizes differences in student performance for face to face and virtual hybrid medium based on gender, course level, and type of course (hands on vs. conceptual), as follows:

- H1:** Course delivery medium: pre-pandemic face to face medium of course delivery vs. post-pandemic hybrid course delivery mediums. There will be a significant difference in student performance for pre-pandemic face to face courses and post-pandemic virtual hybrid courses.
- H2:** Course delivery medium by the type of course (technical, conceptual): H2a) There will be a significant difference in student performance for technical courses in pre-pandemic face to face courses and post-pandemic virtual hybrid courses. H2b) There will be a significant difference in student performance for conceptual courses in pre-pandemic face to face courses and post-pandemic virtual hybrid courses.
- H3:** Course delivery medium by gender (male, female): H3a) There will be a significant difference in male student performance for pre-pandemic face to face courses and post-pandemic virtual

hybrid courses. H3b) There will be a significant difference in female student performance for pre-pandemic face to face courses and post-pandemic virtual hybrid courses.

**H4:** Course delivery medium by course levels (graduate/undergraduate): H4a) There will be a significant difference in graduate student performance for pre-pandemic face to face courses and post-pandemic virtual hybrid courses. H4b) There will be a significant difference in undergraduate student performance for pre-pandemic face to face courses and post-pandemic virtual hybrid courses.

**H5:** Course delivery medium by type of course and gender: H5a) There will be a difference in male students' performance for pre-pandemic face to face technical courses and post-pandemic virtual hybrid technical courses. H5b) There will be a difference in female students' performance for pre-pandemic face to face technical courses and post-pandemic virtual hybrid technical courses. H5c) There will be a difference in male students' performance for pre-pandemic face to face conceptual courses and post-pandemic virtual hybrid conceptual courses. H5d) There will be a difference in female students' performance for pre-pandemic face to face conceptual courses and post-pandemic virtual hybrid conceptual courses.

**H6:** Course delivery medium by gender and course level: H6a) There will be a difference in graduate male students' performance for pre-pandemic face to face courses and post-pandemic technical virtual hybrid courses. H6b) There will be a difference in graduate female students' performance for pre-pandemic face to face courses and post-pandemic virtual hybrid courses. H6c) There will be a difference in undergraduate male students' performance for pre-pandemic face to face courses and post-pandemic technical virtual hybrid courses. H6d) There will be a difference in undergraduate female students' performance for pre-pandemic face to face courses and post-pandemic virtual hybrid courses.

**H7:** Course delivery medium by type of course and course level: H7a) There will be a difference in graduate students' performance for pre-pandemic technical face to face courses and post-pandemic technical virtual hybrid courses. H7b) There will be a difference in graduate students' performance for post-pandemic conceptual virtual hybrid courses. H7c) There will be a difference in undergraduate students' performance for pre-pandemic technical face to face courses and post-pandemic technical virtual hybrid courses.

**H8:** Course delivery medium by type of the course, gender, and course level: H8a) There will be a difference in graduate male students' performance for pre-pandemic technical face to face courses and post-pandemic technical virtual hybrid courses. H8b) There will be a difference in graduate female students' performance for pre-pandemic technical face to face courses and post-pandemic technical virtual hybrid courses. H8c) There will be a difference in graduate female students' performance for pre-pandemic conceptual face to face courses and post-pandemic conceptual virtual hybrid courses. H8d) There will be a difference in graduate female students' performance for pre-pandemic conceptual face to face courses and post-pandemic conceptual virtual hybrid courses. H8e) There will be a difference in undergraduate male students' performance for pre-pandemic technical face to face courses and post-pandemic technical virtual hybrid courses. H8f) There will be a difference in undergraduate female students' performance for pre-pandemic technical face to face courses and post-pandemic technical virtual hybrid courses.

A summary of the hypotheses is presented in Table 1.

## DATA COLLECTION

Data used in this study were a convenience sample of students enrolled in graduate and undergraduate Information Systems courses from Fall 2016 through Summer 2022 in a midsized university in the Midwest United States. The courses included in the analysis were both technical and conceptual courses. A total of 43 courses were included in the analysis. These courses were taught by a single

Table 1. Table of hypotheses

Table of Hypotheses		
Hypothesis #	Hypothesis Details	
H1	H1	<b>Overall Medium of Instruction</b>
H2	H2a	Medium of Instruction and Type of Course: <i>Technical</i>
	H2b	Medium of Instruction and Type of Course: <i>Conceptual</i>
H3	H3a	Medium of Instruction and Gender: <i>Male</i>
	H3b	Medium of Instruction and Gender: <i>Female</i>
H4	H4a	Medium of Instruction and Course Level: <i>Graduate</i>
	H4b	Medium of Instruction and Course Level: <i>Undergraduate</i>
H5	H5a	Medium of instruction, Type of Course, and Gender: <i>Technical - Male</i>
	H5b	Medium of instruction, Type of Course, and Gender: <i>Technical - Female</i>
	H5c	Medium of instruction, Type of Course, and Gender: <i>Conceptual - Male</i>
	H5d	Medium of instruction, Type of Course, and Gender: <i>Conceptual - Female</i>
H6	H6a	Medium of instruction, Course Level, and Gender: <i>Graduate - Male</i>
	H6b	Medium of instruction, Course Level, and Gender: <i>Graduate - Female</i>
	H6c	Medium of instruction, Course Level, and Gender: <i>Undergraduate - Male</i>
	H6d	Medium of instruction, Course Level, and Gender: <i>Undergraduate - Female</i>
H7	H7a	Medium of instruction, Course Level, and Type of Course: <i>Graduate - Technical</i>
	H7b	Medium of instruction, Course Level, and Type of Course: <i>Graduate-Conceptual</i>
	H7c	Medium of instruction, Course Level, and Type of Course: <i>Undergraduate-Technical</i>
H8	H8a	Medium of instruction, Type, Course Level, and Gender: <i>Technical, Male, Graduate</i>
	H8b	Medium of instruction, Type, Course Level, and Gender: <i>Technical, Female, Graduate</i>
	H8c	Medium of instruction, Type, Course Level, and Gender: <i>Conceptual, Male, Graduate</i>
	H8d	Medium of instruction, Type, Course Level, and Gender: <i>Conceptual, Female, Graduate</i>
	H8e	Medium of instruction, Type, Course Level, and Gender: <i>Technical, Male, Undergraduate</i>
	H8f	Medium of instruction, Type, Course Level, and Gender: <i>Technical, Female, Undergraduate</i>

instructor from Fall of 2016 through Summer 2022. All courses taught by this instructor were included in the analysis. Data for all students enrolled in these classes were included in the analysis and no data were excluded. This facilitated uniform and consistent grading and reporting across all data. 24 of those 43 courses were offered during the period prior to the onset of COVID19 from Fall 2016 to Fall 2019, and were all delivered in a face to face format which involved all the students and instructor meeting in a classroom. 19 courses were taught from Spring 2020 after the official onset of pandemic declared by NIH/Universities during spring of 2020. These courses spanned Spring 2020 through Summer 2022, and all of these courses were offered in a synchronous fully online mode due to the onset of pandemic. There were a total of 1157 students in all courses from Fall 2014 through summer 2022. There were 524 students (45.3%) in the pre-pandemic fully face to face courses and 664 students (54.7%) in the post-pandemic courses. Of the total number of students from pre-pandemic and post-pandemic periods, 493 were female, constituting 42.6% of total, and 664 were male, constituting 57.4% of the total.

The undergraduate level courses were: undergraduate Database Management and Programming with C# courses, and graduate level courses were: Management of Information Systems Security, Project Management, Advanced Applications Development using C#, Web Development using PHP and JavaScript, Client-side programming technologies and frameworks for web development, and Mobile/android application development. Two of these graduate level courses were classified as theory intensive or conceptual courses. The remaining six courses were all technical or hands-on oriented courses. Two of the six courses were at the undergraduate level and four were graduate level courses. All six courses involved considerable amounts of upper level programming/scripting requiring the students to learn some form of syntax and labs involving application development. All the courses had several grade components such as quizzes, homework, in-class labs, projects, and exams. Individual aggregate scores from all components, as well as overall aggregate scores for each individual student for all classes listed above were collected for all students enrolled in those classes for all the semesters starting from Fall 2016 through Summer 2022. A table showing the details of the courses and number of students is shown in table 2.

## DATA ANALYSIS AND RESULTS

This study hypothesized the following: There will be a significant difference in means between pre-pandemic and post-pandemic student performance based on: a) type of courses: conceptual courses vs. technical or hands-on oriented courses for pre- and post-pandemic student performance; b) Gender: male vs. female students' pre- and post-pandemic performance; c) Course level and gender:

Table 2. Data characteristics

Data Characteristics										
		Courses			Students			Gender		
		Conceptual	Technical	Total	Conceptual	Technical	Total	Male	Female	Total
Pre-Pandemic	Undergraduate	0	6	6	0	127	127	83	44	127
	Graduate	5	13	18	124	273	397	238	159	397
	<b>Total</b>	<b>5</b>	<b>19</b>	<b>24</b>	<b>124</b>	<b>400</b>	<b>524</b>	<b>321</b>	<b>203</b>	<b>524</b>
		<b>Conceptual</b>	<b>Technical</b>	<b>Total</b>	<b>Conceptual</b>	<b>Technical</b>	<b>Total</b>	<b>Male</b>	<b>Female</b>	<b>Total</b>
Post-Pandemic	Undergraduate	0	4	4	0	78	78	54	24	78
	Graduate	5	10	15	143	412	555	289	266	555
	<b>Total</b>	<b>5</b>	<b>14</b>	<b>19</b>	<b>143</b>	<b>490</b>	<b>633</b>	<b>343</b>	<b>290</b>	<b>633</b>
		<b>Conceptual</b>	<b>Technical</b>	<b>Total</b>	<b>Conceptual</b>	<b>Technical</b>	<b>Total</b>	<b>Male</b>	<b>Female</b>	<b>Total</b>
ALL	Undergraduate	0	10	10	0	205	205	137	68	205
	Graduate	10	23	33	267	685	952	527	425	952
	<b>Total</b>	<b>10</b>	<b>33</b>	<b>43</b>	<b>267</b>	<b>890</b>	<b>1157</b>	<b>664</b>	<b>493</b>	<b>1157</b>
<b>Courses Included</b>		<b>Conceptual</b>			<b>Technical</b>					
<b>Undergraduate</b>		None (No hypotheses about Undergraduate conceptual courses are proposed in this study).			1. Database Management Systems 2. Advanced Applications Development using C#					
<b>Graduate</b>		1. Management of Information Systems Security 2. Project Management			1. Advanced Applications Development using C# 2. Internet for the Enterprise (Web Development using PHP and JavaScript) 3. Client-Side Internet Resources (Client-side technologies and frameworks for Web Development) 4. Mobile Applications Development using Android and Kotlin.					



graduate-male students vs. graduate-female students' pre- and post-pandemic performance, and undergraduate-male students vs. undergraduate-female students' pre- and post-pandemic performance.

The data was split into two groups: pre-pandemic group for all classes from Fall 2016 through Fall 2019. Data from courses during Spring 2020 through Summer 2022 were classified as post-pandemic group. The data was entered into SPSS and ANOVA conducted on the two groups to find out if the differences in the data from the pre-pandemic group and post-pandemic group. The null hypothesis was that there was no difference in means between pre-pandemic and post-pandemic student performance, and the alternate was that the means were significantly different across the groups. The results from the analysis were as follows:

- H1:** Supported with an F score (F) of 15.654 with 1 degree of freedom (df) and  $p = <0.001$ . There was a significant difference in student performance based on course delivery medium of pre-pandemic face to face medium of course delivery and post-pandemic hybrid medium of course delivery. The students ( $n = 524$ ) performed better in the pre-pandemic face to face classes (mean = 81.8994, std = 12.9227) than the post-pandemic virtual hybrid mode ( $n = 633$ , mean = 78.5365, std = 15.5021).
- H2:** H2a was supported. There was a significant difference in student performance ( $p < 0.001$ ) in pre-pandemic face to face technical courses and post-pandemic virtual hybrid courses ( $F = 17.27$  with 1 df). The students in hands-on intensive classes in pre-pandemic face to face courses ( $n = 400$ , mean = 81.7038, std = 13.4143) performed better than students in technical classes in post-pandemic virtual hybrid courses ( $n = 490$ , mean = 77.5208, std = 16.02). However, the difference in student performance was not significant for conceptual courses for the pre-pandemic face to face conceptual classes ( $n = 124$ , mean = 82.5305, std = 11.2175) and post-pandemic virtual hybrid courses ( $n = 143$ , mean = 81.9921, std = 12.1895). H2b was not supported.
- H3:** Course delivery medium by gender: H3a was supported at the  $<0.001$  level of significance ( $F = 13.42$  with 1 df). H3b was also supported at the 0.009 level of significance ( $F = 6.895$  with 1 df). Both males ( $n = 321$ ) and females ( $n = 203$ ) performed better in the pre-pandemic face to face classes (mean = 80.0342, std = 13.8718) than the post-pandemic virtual hybrid mode (mean = 75.5755, s = 17.1882). Males had a pre-pandemic mean of 80.0342 and std = 13.8718, and post-pandemic mean of 75.5755 and std = 17.1882, while females had a pre-pandemic mean of 84.8489 and std = 10.6429, and post-pandemic mean of 82.0386 and std = 12.3777.
- H4:** Course delivery medium by course levels (Graduate/Undergraduate): H4a was supported at the  $<0.001$  level of significance ( $F = 22.859$ , df = 1). Graduates in face to face classes ( $n = 397$ , mean = 83.1903, std = 12.2756) performed better than graduates in post-pandemic virtual hybrid classes ( $n = 555$ , mean = 78.8286, std = 14.9197). H4b was not supported. There was no significant difference in the performance of undergraduates in face to face and post-pandemic virtual hybrid classes. This could be because the number of students and the number of classes tested is relatively small. A larger sample of undergraduates from more number of classes could yield different results.
- H5:** Course delivery medium by type of course and gender: H5a was supported at the  $<0.001$  level of significance ( $F = 14.2696$ , df = 1). Males in technical pre-pandemic face to face classes ( $n = 250$ , mean = 79.8437, std = 14.2695) performed better than males in post-pandemic virtual hybrid classes ( $n = 279$ , mean = 74.3306, std = 17.7393). H5b was supported at the  $<0.001$  level of significance ( $F = 11.2295$ , df = 1). Females in technical pre-pandemic face to face classes ( $n = 150$ , mean = 84.8040, std = 11.2295) performed better than females in post-pandemic virtual hybrid classes ( $n = 211$ , mean = 81.7500, std = 12.2591). H5c and H5d were not supported. For conceptual classes, there was no significant difference in performance for both male and female students.
- H6:** Course delivery medium by gender and course level: H6a was supported at the  $<0.001$  level of significance ( $F = 16.362$ , df = 1). Male students in graduate level pre-pandemic face to face

classes performed better than male students in graduate level post-pandemic virtual hybrid classes ( $n = 238$ , mean = 81.4156, std = 13.5492) performed better than male students in graduate level post-pandemic virtual hybrid classes ( $n = 289$ , mean = 76.0612, std = 16.3033). H6b was also supported at the  $<0.001$  level of significance ( $F = 12.002$ ,  $df = 1$ ). Female students in graduate level pre-pandemic face to face classes performed better than female students in graduate level post-pandemic virtual hybrid classes ( $n = 159$ , mean = 85.8469,  $td = 9.5110$ ), who performed better than male students in graduate level post-pandemic virtual hybrid classes ( $n = 266$ , mean = 81.8353, std = 12.6120). In case of undergrad level classes, surprisingly, the mode of delivery did not make a significant difference for both male and female students. Both hypotheses H6c and H6d were not supported.

**H7:** Course delivery medium by type of course and course level: H7a was supported at the  $<0.001$  level of significance ( $F = 26.29$ ,  $df = 1$ ). Students in technical pre-pandemic graduate level face to face classes ( $n = 273$ , mean = 83.4900, std = 12.7356) performed better than students in technical graduate level post-pandemic virtual hybrid classes ( $n = 279$ , mean = 74.3306, std = 17.7393). H7b was not supported. There was no significant difference in the graduate level conceptual classes for pre- and post-pandemic student performance. However, at the undergraduate level, the medium of instruction did not make a significant difference in technical classes, which was surprising, interesting, and counter-intuitive. H7c was supported at the  $<0.001$  level of significance ( $F = 26.29$ ,  $df = 1$ ). Students in technical pre-pandemic graduate level face to face classes ( $n = 273$ , mean = 83.4900, std = 12.7356) performed better than students in technical graduate level post-pandemic virtual hybrid classes ( $n = 279$ , mean = 74.3306, std = 17.7393).

**H8:** Course delivery medium by type of course, gender, and course level: H8a was supported at the  $<0.001$  level of significance ( $F = 19.41$ ,  $df = 1$ ). Male students in graduate level technical courses in pre-pandemic face to face classes ( $N = 167$ , mean = 81.7176, std = 14.0189) performed better than male students in graduate level hands on intensive courses in post-pandemic virtual hybrid classes ( $N = 225$ , mean = 74.6613, std = 16.8107). H8b was supported at the  $<0.001$  level of significance ( $F = 11.76$ ,  $df = 1$ ). Female students in graduate level technical courses in pre-pandemic face to face classes ( $N = 106$ , mean = 86.2824, std = 9.8281) performed better than female students in graduate level hands on intensive courses in post-pandemic virtual hybrid classes ( $N = 187$ , mean = 81.4237, std = 12.5707). H8c was not supported. There was no significant difference between pre- and post-pandemic male students' performance in graduate level conceptual classes. H8d was not supported. There was no significant difference between pre- and post-pandemic female students' performance in graduate level conceptual classes. H7e was not supported. There was no significant difference between pre- and post-pandemic male students' performance in undergraduate level technical classes. H7f was not supported. There was no significant difference between pre- and post-pandemic female students' performance in undergraduate level technical classes. A summary of the results is presented in table 3.

## Post-Hoc Analysis

As a follow-up to the above results, structured interviews were conducted with students who took the classes either in virtual-hybrid or face to face, as well as faculty who taught those courses in order to ascertain if the students' as well as the faculty impressions of hybrid and the face to face classes align with the results. Structured interviews asking the impressions of seven faculty members who taught both face to face as well as online virtual hybrid classes, conceptual and technical courses, and have taught both at the graduate and the undergraduate levels were conducted. Similarly, structured interviews asking the impressions of 11 graduate students and five undergraduate students who have taken both technical and conceptual IS courses and have had classes in both formats were conducted.

The interviews were coded and each interview of both faculty and students was analyzed for keywords indicating their preference for and satisfaction with both modes of instruction for all types

Table 3. Summary of hypotheses and results

Summary of Hypotheses and Results									
Hypothesis Details		Result	Course Mode	n	Mean	St.Dev	df	F	PValue
H1	Overall	Supported	F2F	524	81.8995	12.9227	1	15.654	<.001
			Virt.Hybr	633	78.5365	15.5021			
	<b>Type of Course</b>								
H2a	Technical	Supported	F2F	400	81.7038	13.4143	1	17.271	<.001
			Virt.Hybr	490	77.528	16.0296			
H2b	Conceptual	Not Supported	F2F	124	82.5305	11.2175	1	0.129	0.72
			Virt.Hybr	143	81.9921	13.0077			
	<b>Gender</b>								
H3a	Male	Supported	F2F	321	80.0342	13.8717	1	13.42	<.001
			Virt.Hybr	343	75.5755	17.1882			
H3b	Female	Supported	F2F	203	84.8489	10.6428	1	6.895	<b>0.009</b>
			Virt.Hybr	290	82.0386	12.3777			
	<b>Course Level</b>								
H4a	Graduate	Supported	F2F	397	83.19034	12.27556	1	22.859	<.001
			Virt.Hybr	555	78.82864	14.91971			
H4b	Undergraduate	Supported	F2F	127	77.86417	14.0681	1	0.365	0.546
			Virt.Hybr	78	76.45774	19.1291			
	<b>Type of Course &amp; Gender</b>								
H5a	Technical - Male	Supported	F2F	250	79.8437	14.2696	1	15.259	<.001
			Virt.Hybr	279	74.3351	17.7393			
H5b	Technical - Female	Supported	F2F	150	84.804	11.2295	1	5.831	<b>0.016</b>
			Virt.Hybr	211	81.75	12.2591			
H5c	Conceptual - Male	Not Supported	F2F	71	80.7051	12.4404	1	0.016	0.901
			Virt.Hybr	64	80.983	13.3668			
H5d	Conceptual - Female	Not Supported	F2F	53	84.976	8.86903	1	1.156	0.284
			Virt.Hybr	79	82.8096	12.7361			
	<b>Course Level and Gender</b>								
H6a	Graduate - Male	Supported	F2F	238	81.4156	13.5492	1	16.362	<.001
			Virt.Hybr	289	76.0612	16.3033			
H6b	Graduate – Female	Supported	F2F	159	85.8469	9.51103	1	12.002	<.001
			Virt.Hybr	266	81.8353	12.612			
H6c	Undergraduate – Male	Not Supported	F2F	83	76.0733	14.1038	1	1.05	0.307
			Virt.Hybr	54	72.976	21.3046			
H6d	Undergraduate – Female	Not Supported	F2F	44	81.2424	13.5177	1	0.968	0.329
			Virt.Hybr	24	84.2917	9.3074			

continued on following page

Table 3. Continued

Summary of Hypotheses and Results									
Hypothesis Details		Result	Course Mode	n	Mean	St.Dev	df	F	PValue
	<b>Course Level &amp; Type of Course</b>								
H7a	Graduate – Technical	Supported	F2F	273	83.49	12.7356	1	26.293	<.001
			Virt.Hybr	412	77.7306	15.3915			
H7b	Graduate-Conceptual	Not Supported	F2F	124	82.5305	11.2175	1	0.129	0.72
			Virt.Hybr	143	81.9921	13.0077			
H7c	Undergraduate-Technical	Not Supported	F2F	127	77.8642	14.0681	1	0.365	0.546
			Virt.Hybr	78	76.4577	19.1291			
	<b>Type, Course Level, and Gender</b>								
H8a	Technical, Male, Graduate	Supported	F2F	167	81.7176	14.0189	1	19.405	<.001
			Virt.Hybr	225	74.6613	16.8107			
H8b	Technical, Female, Graduate	Supported	F2F	106	86.2824	9.82806	1	11.755	<.001
			Virt.Hybr	187	81.4237	12.5707			
H8c	Conceptual, Male, Graduate	Not Supported	F2F	71	80.7051	12.4404	1	0.016	0.901
			Virt.Hybr	64	80.983	13.3668			
H8d	Conceptual, Female, Graduate	Not Supported	F2F	53	84.976	8.86903	1	1.156	0.284
			Virt.Hybr	79	82.8096	12.7361			
H8e	Technical, Male, Undergraduate	Not Supported	F2F	83	76.0733	14.1038	1	1.05	0.307
			Virt.Hybr	54	72.976	21.3046			
H8f	Technical, Female, Undergraduate	Not Supported	F2F	44	81.2424	13.5177	1	0.968	0.329
			Virt.Hybr	24	84.2917	9.3074			

of classes. All the faculty interviewed indicated that the face to face classes had a better student learning outcome for both technical and conceptual courses at both graduate and undergraduate levels. Interviews with students reveal that the students prefer the face to face mode of instruction for technical courses because of the media richness, personal interaction, immediate help available for any questions, or conceptual clarity in the technical courses.

However, when it came to conceptual courses the students were indifferent between face to face and virtual hybrid modes, and most of the student interviews indicated that they prefer virtual hybrid classes for the conceptual courses. This aligns with the results obtained from the ANOVA data analyses above. A few excerpts from the interviews from both faculty and students are presented below followed by the discussion of the results.

*Excerpts from Faculty Interviews*

**Faculty 1:** “For students who are not self-motivated, online courses are not effective because the instructor cannot see what they are doing and how well they understand the course content during

the class time. There is no difference for students who want to learn and actively participated in the class.”

**Faculty 2:** “I find the technical courses difficult to teach in virtual hybrid mode because it is difficult to see what the student is doing. It is better than asynchronous online classes, so students can ask questions/resolve gaps in their understanding right away. It is difficult in virtual hybrid courses to follow many students on what they are doing. Many students like to keep the video off for privacy reasons and then communication becomes difficult.”

**Faculty 3:** “I did not like teaching conceptual courses over virtual hybrid format as the class interaction was limited and I was not sure if all are paying attention to class. Student learning was not significantly impacted while teaching conceptual classes. Without feedback and ability to quickly fix errors in student understanding was a significant impediment in technical classes in virtual format. In addition, the students seem to have more attention to detail while attending in person classes. It is difficult to teach technical classes without immediate feedback and having the ability to change delivery material based on such feedback. Virtual hybrid mode is not very conducive for such changes in teaching material on the fly. Performance in those virtual hybrid technical courses was significantly poor compared to in person delivery.”

### Excerpts From Student Interviews

**Student 1:** “I prefer taking technical courses in-person only. As soon as we have questions or get stuck while doing in class labs, we can get quick assistance from the professor. This helps in gaining good technical knowledge. One of the key benefits of hands-on learning was the immediate application of theoretical knowledge. Successfully completing hands-on projects or tasks provided a strong sense of accomplishment.”

**Student 2:** “When a class is online where teacher and student working hands-on, most of the time both of them are might not be in sync. There are high chances for a student to lose track and fall behind which leads to losing interest in the course and teacher would not be able to observe and guide their students effectively during the class through a virtual classroom comparing to the face-to-face classroom.”

**Student 3:** “I would opt for conceptual courses over virtual hybrid as it saves lots of time. As it saves time and also it is easy to involve more people to discuss the topic in online classes. I personally prefer online conceptual courses. For technical courses I prefer in-person. There might be some technical issues which need to be addressed directly on your PC. So, this can be handled easy if students are in an in-person class.”

### DISCUSSION

This study analyzed data on 44 programming and non-programming classes and performance of 1157 students in those courses, using both face to face and virtual hybrid modes of instruction over six years to find out if there were any differences in student performance, followed up by structured interviews from faculty and students. The study employed multiple analyses to look for differences across several different criteria: technical and conceptual courses, gender, and at the graduate and undergraduate levels of courses for differences in student performance for face to face versus virtual hybrid modes of instruction. Across all genders, type of courses, and course levels, mode of instruction (H1) significantly impacted the student performance. Students in pre-pandemic face to face classes performed better than the students in the post-pandemic virtual hybrid classes. These results held steady in terms of gender as well (H2). Both male students and female students performed better in face to face classes than in the virtual hybrid classes, generally confirming the results in H1. The

study found that the students across all levels underperformed in the virtual hybrid mode than the face to face mode of instruction.

In case of technical and conceptual courses (H3), students in face to face technical courses performed better than the students in virtual hybrid technical courses. This result is intuitive and also confirms the results from H1 and H3. The technical nature of the course and the complexity involved in those courses require the perspectives of the instructor in addition to just the course content. Students immensely benefit from the personal interaction and additional help that will be available in those face to face classes. However, in the case of conceptual courses, even though the mean student performance was lower in the conceptual virtual hybrid courses, the difference in performance was not significant. This is to be expected because the flexibility and convenience the conceptual courses afford to the students in terms saving the commute time to the classes, and it gives the students extra time to study.

When more granular sub-analyses were included by course type and gender (H4), or course level and gender (H5), and course level and course type (H6), and course level and gender (H7), the results about technical courses were stable and confirmed across all of those hypotheses. For all the hypotheses, including technical courses at the graduate level, the students in the face to face classes performed better, supporting all of those hypotheses (H4a, H4b, H5a, H5b, H6a, H7a, and H7b). This could be a possible confirmation that students, at least at the advanced technical course levels, learn better with face to face classes than the virtual hybrid or online modes of learning. Similar findings have been confirmed in other studies in other disciplines in the past research (Eom & Ashill, 2016; Gold et al., 2018; Master et al., 2016; Park & Dong-gook, 2020; Swan, 2001; Zhang et al., 2022).

None of the hypotheses (h2b, H4c and d, H5c and d, H6b and c, H7c, d, e, and f) about virtual hybrid classes were supported either at the graduate level or undergraduate levels when it came to advanced level conceptual courses. Students in all those courses performed poorer in the virtual hybrid modes than the face to face mode, although this difference was not statistically significant. Even with the unsupported hypotheses, there is an interesting counter-intuitive finding in the results. With conceptual classes, the poorer performance in those classes could be because of the lack of media richness. It is possible that the insights present in the face to face conceptual classes were not present, and that factor could have contributed to the poorer performance. However, the effect was not emphatic enough to be statistically significant. When it came to undergraduate classes, this study did not analyze or hypothesize about the conceptual undergraduate level courses because not enough data was available to analyze the conceptual undergraduate courses. However, the surprising result was that even with the undergraduate technical courses, the difference in face to face and virtual hybrid courses was not statistically significant. A possibility is that the data was not large enough to yield statistically significant results in case of the undergraduate classes.

Some important implications of the results of this study are as follows. Firstly, the results indicate that students perform better in face to face classes across genders, types of classes, and course levels. However, the face to face classes involve some lack of flexibility compared to other online modes of course offerings. Therefore, the course delivery mode is a trade off with the media richness in the mode of delivery. The fact that both faculty teaching the technical courses, as well as the students taking those technical courses, preferring face to face courses indicates that media richness, that is clarity of communicating the content to the student, was important in those technical courses for student learning. When the course content involves technical content and requires media richness, such as passing on deeper insights and perspectives, face to face courses serve the purposes of student learning better. Almost all the students interviewed preferred the face to face mode of courses for technical courses. The flexibility was probably not as important in technical courses when it comes to student learning. This is an important contribution of this study from a media richness theoretic perspective. When the course does not involve technical content, the online or other modes of offerings can reasonably serve the purposes of student learning.

Due to the sample size limitations, the results of the undergraduate courses yield mixed results and require further testing with a larger sample size and a wider variety of classes both technical and conceptual. It is worth noting that even though the hypotheses for the undergraduate courses were not supported in all cases, the mean student performance in face to face classes was higher than the mean student performance in virtual hybrid courses, though not statistically significant.

## **LIMITATIONS**

The sample selected was from a single university in the Midwest United States. The courses were taught by one instructor. However, the sample size is large enough. The generalizations of findings may be problematic unless tested across multiple universities and across courses taught by multiple instructors. This study is a correlational study and therefore does not claim causality. While there was no data available to conclude that one medium of instruction was better than the other definitively because of the shortcomings of the study, such as factors external to the class performance and other non-class related factors, care was taken to make sure that the sample sizes for both pre-pandemic and post-pandemic data were large enough allow for reasonable conclusions from the data. External factors were present, such as organizational infrastructure, students having to adapt suddenly to the new reality of the changed mode of instruction during the pandemic, and stress factors caused by the pandemic itself that inevitably exist given the pandemic context. However, all of those factors cannot be accurately accounted for in a single study. In order to mitigate the extenuating circumstances during the pandemic, extra help and reasonable accommodations were given to students for factors such as pandemic or health related issues when students were affected by it, as directed by the university in every class included in this study. As with any study, generalization of results is problematic across all types of classes, levels, and across all student populations. More replications of this study are needed across several more diverse samples across multiple instructors and multiple type of classes and levels in order to generalize the results. Results pertaining to the undergraduates needs to be investigated deeper in order to gain a fuller understanding about what medium of instruction works well for the undergraduate courses.

## **CONCLUSION**

This study, based on a media presence theoretic perspective, tested for differences in student performance of students in pre-pandemic face to face classes and post-pandemic virtual hybrid courses. The results indicate that indeed the medium of instruction makes a difference in student performance, at least for the technical courses, but not in respect of conceptual courses. The differences in student performance found were deep and significant even when the data were analyzed for gender and course levels. These results from the data analysis were corroborated by the interviews from both faculty and students: that the technical courses, at least in the information systems discipline, are more effective for student learning with face to face medium of instruction rather than virtual hybrid medium of instruction. No statistically significant differences were found in student performance between face to face and virtual hybrid medium of instruction in case of conceptual information systems courses.

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*Narasimha Paravastu, Ph.D., is an Assistant Professor of CIS at the University of Central Missouri, Warrensburg, MO. He received his Ph.D. from Drexel University, Philadelphia. He has published in several peer-reviewed MIS journals such as DATABASE for Advances in Information Systems, CyberPsychology & Behavior, International Journal of Information Systems and Social Change (IJISSC) etc. His research interests are in the areas of IT Outsourcing, Technology Trust, Trust in Information Systems and IT Strategy, IS Security, and Bystander Theory as applicable to Information Systems.*

*Sam Ramanujan is a Professor of Computer Information Systems and Analytics at University of Central Missouri, Warrensburg, MO. His current research interests include software engineering, Internet/Intranet technologies, global information systems, and distributed systems architecture. He has published papers in several journals including the Journal of Global Information Systems and OMEGA.*