Article

Embracing the hybrid experience: Uncovering the emotional effects of synchronous hybrid education on undergraduate university students

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Abstract: This research presents an in-depth examination of the emotional effects of synchronous hybrid education on undergraduate university students at a pioneering private institution in educational innovation. The study had encompassed all courses that were delivered in a synchronous hybrid format, covering 16 courses and involving 241 students. Each student had been observed and recorded on two separate class sessions, with each recording lasting approximately 30 min. This comprehensive data collection had resulted in 409 recordings, each approximately 30 min in duration, translating to nearly an hour of observation per student across the classes, totaling close to 205 h of recordings. These recordings were subsequently processed using neuroscience software tools for advanced statistical analysis, effectively serving as a comprehensive survey of courses within this modality. The primary focus of the research was on the emotions experienced during both face-to-face and online classes and their subsequent influence on student behavior and well-being. The findings reveal higher emotional time ratios for positive emotions such as joy and surprise in face-to-face students. Notably, both groups exhibited comparable ratios for negative emotions like anger and sadness. The research underscores the emotional advantages of face-to-face interactions, which elicit stronger emotions, in contrast to online students who often feel detached and isolated.

Keywords: synchronous hybrid education; emotions; face-to-face students; online students; eye tracker

1. Introduction

The academic landscape, interwoven with the teaching-learning process, is intrinsically emotional, influencing behaviors associated with performance (D'Mello and Graesser, 2012). The global health crisis triggered by COVID-19 has necessitated a deeper exploration of teaching modalities, with a pivot from merely assessing academic outcomes to gauging emotional responses.

López (2015) indicated that the efficacy of teaching, whether synchronous, asynchronous, online, or in-person, hinges on subject and knowledge areas. Moro et al. (2021) echoed that both modalities could be equally effective, contingent upon instructional quality. Conversely, Bailey (2020) discerned no significant disparity between online and blended models. From a sociocultural lens, Soffer and Nachmias

(2018) ascertained that online learner demonstrated higher engagement and comprehension. However, Ruiz et al. (2022) underscored challenges like reduced personal interaction.

The pandemic catalyzed the shift to virtual learning, revealing multifaceted challenges. Lovón and Cisneros (2020) identified increased academic pressures and mental health concerns. Jiménez et al. (2021) observed that while virtual platforms offer flexibility, many students grapple with the nuances of self-directed learning. Irawan et al. (2020) highlighted the pandemic's emotional toll on Indonesian students. According to Córdova et al. (2023), the pandemic significantly impacted students' emotional well-being, understood as individuals' perception and subjective evaluation of their lives (Keyes et al., 2008), which negatively affected their learning ability. Carol Ryff (2008), whose work we echo in this research, mentions that well-being lies within the psychological realm where the individual exhibits indicators of positive functioning in all areas of their life, meaning it includes cognitive and affective aspects that point to self-acceptance, personal growth, and adaptation and integration into the social environment, as well as a sense of purpose and meaning in life.

During the pandemic, studies like Zhang et al. (2020) highlighted significant challenges in online learning, such as technological barriers, environmental distractions, and physical discomfort, which contributed to students' disillusionment and emphasized the need for better teacher-student interaction. Despite a lack of definitive conclusions, research by Biocca and Harms (2002) and psychological insights from Zayas and Shoda (2005) suggest that teaching modalities significantly affect student performance and mental states, with emotional responses influenced by both cognitive processes and the socio-relational environment. Marques et al. (2020) also noted that these responses are crucial within educational settings, impacting the learning experience.

Recognizing the difference in the quality of interpersonal interactions between in-person and virtual modalities, this study explored the emotional experiences of students across various class formats at a private Bolivian university, particularly focusing on synchronous hybrid education. Employing "iMotions Eye Tracking" software, the research analyzed non-verbal emotional cues to understand the emotions of students in hybrid settings compared to those in purely in-person or online environments.

The study encompassed all courses offered in a synchronous hybrid format, involving 241 students and resulting in 409 recordings of approximately 30 min each—totaling nearly 205 h of observation. This extensive data collection, processed using advanced neuroscience software tools, provided a comprehensive survey of emotional experiences in this educational modality.

By delving into these emotional dynamics, the research aims to offer insights that can enhance educational practices and methodologies, helping to develop more effective and student-centered approaches in higher education. The findings contribute to a better understanding of how hybrid education impacts students' emotions, which is essential for adapting teaching strategies to improve both student engagement and academic outcomes.

2. Background

Emotions are an essential part of the human experience and have a significant impact on our behavior and well-being. According to Urzúa and Caqueo-Urízar (2012), well-being is related to quality of life, meaning it has an objective element that refers to living conditions, social and economic development, but also includes subjective elements such as personal experiences and the self-perception of feeling well. However, the WHO (2018) defines well-being as a person's ability to cope with the stresses of normal life, making them functional for work and productivity, as well as contributing to their society. For Ryff and Singer (2008), well-being is not singular but varies according to context, culture, age, and even gender, but can generally be evidenced through six specific dimensions: positive self-regard, ability to manage environmental circumstances, significant social-personal bonds, purpose in life, personal development and growth, and sense of autonomy.

In that sense, emotions are subjective responses we experience in relation to our perception of specific stimuli, which include how we experience ourselves in relation to the situations we live through. Emotions influence human behavior significantly, ranging from physical sensations like increased heart rate and sweating to mood changes, which directly affect decision-making and social interactions (Cantero et al., 2012). Primary emotions—fear, anger, sadness, joy, surprise, and disgust—are universally acknowledged and form the basis for more complex emotions (Meyer and Turner, 2002; Weiner, 1985). The production of emotions involves complex biological, psychological, and social factors, impacting multiple neural regions and networks and is influenced by cognitive and social aspects such as stimulus perception, interpretation, emotional memory, interpersonal relationships, and cultural norms (Choliz, 2005; Matsumoto, 1990; Zayas and Shoda, 2005).

Emotions are expressed through various physiological and behavioral ways, including facial expressions, body language, and vocal tones, which are universally recognizable. These expressions play a crucial role in social communication and how individuals are perceived by others (Choliz, 2005; Schutte et al., 2002). Modern techniques for measuring emotions include self-evaluation, physiological monitoring tools like EEG and SCR, and advanced recognition technologies that analyze facial and vocal expressions to identify emotional states (Krumhuber et al., 2013; Meyer and Turner, 2002; Weiner, 1985).

Technological advancements such as eye trackers and facial recognition software analyze nonverbal signals associated with emotions, detecting specific muscle movements like smiles or frowns. However, their effectiveness can vary based on external factors such as lighting, as well as the subject's cultural background, gender, and age (Krumhuber et al., 2013). Emotions can both positively and negatively impact a person's behavior. Positive emotions typically enhance motivation and performance, while negative emotions can lead to poor performance and demotivation (Cantero et al., 2012; Schutte et al., 2002). Furthermore, emotions like anxiety or stress can impede effective decision-making, whereas emotions such as calmness can improve it (Meyer and Turner, 2002; Weiner, 1985).

Emotions play a critical role in the learning process, influencing attention, motivation, and information processing. They affect how information is perceived

and remembered, especially when emotionally charged, making learning more effective when the learner is emotionally engaged (D'Mello and Graesser, 2012; Goetz et al., 2006; Meyer and Turner, 2002; Weiner, 1985). The "theory of academic emotions" examines the relationship between emotions and academic performance, highlighting the impact of emotions on student learning (Pekrun et al., 2002; Wu et al., 2021).

Emotions can also be contagious, spreading through social interactions and affecting the emotional climate of environments such as classrooms. This contagion underscores the importance of managing emotions in educational settings to optimize learning outcomes (Goetz et al., 2006; Marques et al., 2020). Emotional empathy, where individuals empathize and mirror the emotions of others, plays a significant role in this process. In academic settings, emotions are triggered by various stimuli—both academic, like assignments and presentations, and social, like classroom dynamics—which significantly influence students' performance and the overall learning experience (Goetz et al., 2006).

Recognizing and addressing the wide range of emotions in both online and face-to-face learning environments is crucial for developing effective educational strategies that enhance student engagement and academic performance. The study of emotions in education continues to gain importance, offering insights into optimizing learning environments and improving educational outcomes in both traditional and mediated settings.

Due to the COVID-19 pandemic, the need to develop virtual learning environments has been further emphasized, primarily to prevent the spread of contagion. As a result, schools and universities worldwide have virtualized their learning environments, conducting synchronous online classes through platforms such as Zoom or Meet. Consequently, technology-mediated learning, especially online learning, has become commonplace. Rashid et al. (2022) conducted a study on the perceived emotions of online students during the COVID-19 pandemic, examining emotions such as satisfaction, pride, anxiety, anger, hopelessness, and boredom. In this study, the evaluation did not include the possibility that the pandemic itself could influence the students' emotions. Instead, it focused on the fact that being able to continue studying elicited positive emotions.

Similar emotions were studied by Curelaru and Diac (2022), demonstrating that motivation and satisfaction were positive predictors among online students, while anger and hopelessness were negative predictors. However, they did not evaluate whether these negative emotions were solely due to the learning environment or the entire pandemic context. On the other hand, the studies by Moga et al. (2013) and Córdova et al. (2023) focused on negative emotions linked to online education, virtual learning environments, and the pandemic environment. They found emotions such as boredom, frustration, and hopelessness, aiming to help teachers identify these emotions and improve the emotional state of the classroom.

Research in educational methodologies by authors such as Dávila-Acedo et al. (2022) and Kohoulat et al. (2017) has highlighted the positive impact of active learning and supportive environments on students' emotions, reducing negative emotions and enhancing positive ones. Understanding these dynamics is crucial, especially in virtual settings. The theory of social presence indicates that perceived

connections and satisfaction in technology-mediated interactions hinge on factors such as attention, emotional connection, interaction, and immersion, achievable through both verbal and non-verbal communication. However, virtual interactions often lack the non-verbal cues and physical proximity that enhance emotional connections in face-to-face interactions, potentially leading to weaker emotional bonds and less intense emotions in online students (Biocca and Harms, 2002).

Recent studies have utilized advanced software to measure emotional responses in educational settings, although such studies are still limited. For example, D'Errico et al. (2018) processed recordings of classroom activities to detect emotions in students, while Hirt et al. (2019) and Ahn and Harley (2020) analyzed specific emotions like interest, boredom, and anxiety across different student groups. Butz et al. (2016) extended this research to hybrid environments where they examined emotions like satisfaction, anxiety, and boredom in classes attended both face-to-face and online.

Table 1. Classification of relevant and key studies reviewed.

	Emotions in learning environments	Learning methodologies	Classroom dynamics
Hybrid/analysis of both modalities	Ruiz et al. (2022). Anzelin and Marín (2020). Ahn and Harley (2020). Bailey (2020). Kresse and Watland (2016). Butz et al. (2016).	Knoetze and du Toit (2022). Moro et al. (2021). Pakdaman et al. (2021). Mestan (2019). Soffer and Nachmias. (2018). Neguț et al. (2016). Zhao et al. (2015).	Bravo (2021). Biocca and Harms (2002).
Face-to-face	Wu et al. (2021). Marques et al. (2020). Hirt et al. (2019). Radoff et al. (2019). Rowe and Fitness (2018). Nash et al. (2015). Sánchez (2013). D'Mello and Graesser (2012). Pekrun et al. (2009). Goetz et al. (2006). Pekrun et al. (2002). Meyer and Turner (2002).	Buckley and Doyle (2014). Dávila et al. (2022).	Curelaru and Diac (2022). Lindqvist et al. (2017). Kohoulat et al. (2017). Hu and Choo (2015). Urhahne (2015). Morcom (2014). Biocca and Harms (2002).
Online	Irawan et al. (2020). Lovón and Cisneros (2020). D'Errico et al. (2018). D'Errico et al. (2016). Cleveland and Campbell (2012). Timoštšuk and Ugaste (2012).	Caprara and Caprara (2021). Jiménez et al. (2021). Morales et al. (2020). Lopez (2015).	Peña et al. (2016). Tu and McIsaac. (2002).

This body of research underscores that emotions in learning are influenced by

the learning environment and are not always experienced with the same intensity. According to Frijda's theory of diffuse emotions (Frijda, 1986), emotions in ambiguous situations where the emotional trigger is unclear are less intense and more diffuse. This theory is particularly relevant in complex or hybrid learning environments where multiple stimuli may dilute the clarity of emotional triggers.

The attached **Table 1** organizes these studies by year and further categorizes them into domains such as emotions in learning environments, learning methodologies, and classroom dynamics. This classification not only sheds light on the evolution of research in these fields but also contrasts studies in traditional in-person settings against those in purely virtual environments, providing a comprehensive view of the shifting landscape of educational research.

The study of emotions within learning environments, especially hybrid ones, has been limited. Caprara and Caprara (2022) mention that emotion in online learning is a poorly investigated topic, despite emotions playing a crucial role in people's lives and, consequently, influencing learning processes in general. This study sought to quantify emotions within a synchronous hybrid teaching and learning environment, encompassing 16 courses, engaging 241 students, yielding 409 recordings, and totaling 205 h of footage processed using the iMotions Eye Tracking software for statistical analysis. It's important to highlight that the hybrid nature of these classes wasn't related to a personal choice of the student regarding whether they prefer to attend classes online or not. Instead, the hybrid system was due to classes being simultaneous for two or more campuses (in different cities), which meant that some students were attending in person while others from different campuses had to take the class virtually. These efforts culminated in the findings articulated in this research article.

3. Materials and methods

This study adopted an inherently observational design to explore the emotional differences between university students attending face-to-face versus online courses within a synchronous hybrid educational setting. Utilizing advanced neuroscience tools such as Eye Tracker and Facial Expressions Analysis, the study delved deeply into the emotional variances exhibited by students, who participated voluntarily, ensuring their genuine and unbiased involvement. Each participant was fully informed about the study's objectives and procedures, and informed consent was obtained prior to their participation, ensuring transparency and ethical compliance.

The research encompassed a census of all synchronous hybrid courses offered at the university, rather than employing a randomized experimental setup. This methodology was particularly apt given the impracticality of randomized assignments in such educational settings. By covering all courses in this modality, the study was able to comprehensively capture variations in student experiences across different teaching scenarios. Students self-selected into either online or face-to-face groups, providing naturalistic insights into the emotional impacts of each learning environment. This self-selection is pivotal as it reflects real preferences and behaviors, crucial for understanding the real-world effects of different teaching modalities on student outcomes.

The methodological framework of this study, bolstered by literature that recognizes the strengths of non-randomized designs in educational research, allows for a holistic view of student experiences. For instance, Sanderson-Cook et al. (2005) highlight how quasi-experimental and observational studies can provide valuable insights into the effects of educational interventions. By integrating these approaches, the study not only adheres to realistic educational settings but also rigorously assesses the emotional and educational impacts of hybrid education.

In summary, the design of this study effectively captures the comprehensive dynamics of student well-being and academic outcomes in hybrid learning environments. This approach enhances the credibility of the findings and offers a robust foundation for potential educational innovations and interventions tailored to the diverse needs and preferences of students in these settings.

3.1. Sampling and procedures

A cross-sectional, descriptive, relational, and analytical study was conducted during the second semester of 2022, with undergraduate students from all programs of a private university in Bolivia.

In September 2022, a multidisciplinary team from a private Bolivian university initiated a research project involving the collection of students' emotional responses during lectures. This endeavor, which required ethical clearance due to its nature, utilized the Eye Tracker and Facial Expressions Analysis system to capture students' emotions in both face-to-face and online learning modes.

To test the system's efficiency, a pilot study was conducted in October 2022 on two subjects from the Faculty of Business and Law. The insights from this pilot test informed the creation of tutorial videos for students and professors. While students received guidance on calibrating their devices for the software, professors were equipped with steps to ensure accurate data collection and troubleshooting assistance.

Post the pilot, the research team expanded the scope to sixteen different academic subjects. Professors of these subjects were trained in early November 2022, ensuring they understood the research and could facilitate smooth data collection during their sessions. Additionally, student fellows were trained to offer on-ground support, and communication channels, like email lists and WhatsApp groups, were established with the professors.

For the main study, professors, in coordination with the research team, selected specific sessions for data collection. They shared unique links with their students, enabling them to access the Eye Tracker system. Before every session, informed consent was secured from each participating student, and participation was entirely voluntary. The actual recording process was straightforward: after about 30 min into the lecture, students would close the Eye Tracker software, ensuring data was uploaded correctly.

It's noteworthy that professors maintained their standard teaching methods, with students accessing lectures from their personal computers. The research zoomed in on student behavior and their emotional responses to lectures, excluding recording of the teachers themselves.

Data collection spanned November to December 2022. After each session, the research team verified the quality of the captured data. The study's significance lies in its potential to enhance understanding of student engagement and interaction with academic content. Utilizing advanced technology like the Eye Tracker and Facial Expressions Analysis system, the research promises valuable insights that could revolutionize pedagogical methods and elevate education quality.

The study had comprehensively covered all courses that were delivered in a synchronous hybrid format, spanning 16 courses with the involvement of 241 students, who had constituted the primary units of observation for this research. Each student had been observed and recorded across two distinct class sessions, with each session's recording lasting approximately 30 min. This meticulous data collection had yielded a total of 409 recordings, each about 30 min in duration, translating to nearly an hour of observation per student or approximately 205 recorded h in aggregate. Of the entire student cohort, 60% had been undergraduate students attending face-to-face sessions, while the remaining 40% had participated online. In terms of gender distribution, 51% of the students were male and 49% were female. A significant majority, 88%, of these students had hailed from the School of Business and Law, while the residual 12% had been affiliated with the School of Engineering and Architecture.

The breakdown of students attending in-person versus online classes varied significantly across the sixteen courses analyzed in the study, reflecting a complex interplay of course content, teaching strategies, and student preferences that influenced the mode of delivery. For instance, courses such as Introduction to Economics predominantly had face-to-face attendance at 90.6%, showcasing a strong preference for in-person engagement possibly due to the interactive nature of the course content. On the other hand, International Economics II saw a major shift towards online participation, with 83.3% of students opting for this mode, perhaps due to the course's structure which might facilitate remote learning or the preferences of the student demographic enrolled in this course.

This variability is further exemplified by other courses. Macroeconomic Theory II, taught by a female instructor, had 68.4% students attending online, slightly higher than her male counterpart's course at 69.2%, suggesting that factors beyond just the course content, such as instructor teaching style or student-instructor dynamics, might also influence attendance mode. Similarly, more technical courses like Econometrics II and Integrated Logistics had a higher percentage of face-to-face attendance, at 77.5% and 85% respectively, indicating that courses requiring hands-on activities or complex problem-solving might benefit from in-person interactions.

Moreover, some courses displayed almost equal preference for both modalities. Financial Law had an even split with 50% of students attending in person and 50% online, illustrating how certain subjects might equally support both teaching modes without compromising educational outcomes.

This diversity in attendance not only underscores the varying nature of course delivery preferences but also reflects the institution's flexibility in accommodating different learning styles and needs. It highlights the importance of adaptive teaching strategies that cater to a wide range of student preferences and learning outcomes. The unique breakdown in each course offers valuable insights into how hybrid

educational models can be optimized for different academic disciplines, enhancing both student engagement and academic performance. This nuanced understanding of modality preferences across various courses enriches the institution's approach to pedagogical design, ensuring that educational delivery is both student-centered and responsive to the demands of different subject matters.

3.2. Data analysis

The Eye Tracker, a prominent tool in neuromarketing, measures gaze direction and duration to evaluate visual engagement with stimuli such as advertisements, websites, and university lectures, revealing 'fixation points' and 'visual paths' to identify where attention is concentrated (Bear et al., 2020; Holmqvist et al., 2011; Purves et al., 2019). When combined with facial expression analysis, it offers a deeper understanding of emotional responses by interpreting facial movements, indicating emotions ranging from anger to joy (Goldberg and Wichansky, 2003).

Affectiva's Affdex technology, utilized in the university's neuromarketing lab, exemplifies the advanced software used to quantify emotions from facial expressions. This integration of computational analysis allows for real-time detection of emotional states, essential for evaluating responses to multimedia content. The consistency of facial expressions linked to emotions like disgust or joy transcends gender, age, and cultural differences, providing a reliable basis for emotional analysis (Holmqvist et al., 2011).

Deep learning has propelled significant advancements in automatic facial emotion recognition. Researchers are developing sophisticated algorithms to improve the accuracy of facial expression interpretation and encoding (Du et al., 2014; Mellouk and Handouzi, 2020; Xu et al., 2021). This review focuses on current methodologies and achievements in this field, aiming to guide future research and application of these technologies.

In an academic setting, the emotional effects of synchronous hybrid education on undergraduate students were analyzed using Pearson correlation, Student's *t*-test, and Kruskal-Wallis test. These statistical techniques assessed the relationship between emotions and the proportion of time students experienced various emotional states during class. The concept of an "emotional time ratio" quantifies the duration students feel emotions relative to total class time, offering insights into emotional dynamics in both face-to-face and online environments (Gross and Levenson, 1997).

Box plots were used to visually compare emotional experiences across different lecture attendance modes, excluding outliers to clarify potential differences. Additionally, the Student's *t*-test compared mean emotional time ratios between face-to-face and online settings to identify significant emotional differences. Where normal distribution assumptions were not met, the Kruskal-Wallis test provided a non-parametric alternative for evaluating emotional data.

This comprehensive approach not only enhances understanding of how emotional engagement varies in hybrid learning environments but also underscores the broader applications of facial emotion recognition technology in educational research. By combining advanced tools like the Eye Tracker and deep learning methodologies, this research contributes to refining pedagogical strategies and

improving educational outcomes.

4. Results

The data collection had encompassed 16 courses, engaging 241 undergraduate university students. These students had the flexibility to attend their synchronous hybrid lectures either face-to-face or online. This process had yielded 409 recordings, each approximately 30 min long, amounting to an average of one hour of observation for each student, or a total of roughly 205 recorded hours.

Establishing differences in the emotional response of students in each of the different modes of attendance to their respective classes represents one of the main objectives of this research. To achieve this, various techniques were applied to determine the existence of statistically significant differences in the response of the two groups (students who attended their classes face-to-face versus those who did so on-line) with respect to seven specific emotions determined by the software: positive emotions (joy and surprise) and negative emotions (anger, sadness, disgust, fear and contempt).

4.1. Descriptive statistics and correlations

Table 2 presents the matrix of correlation coefficients for the seven identified emotions, based on the mentioned emotional time ratio. Despite correlation coefficients are not high, it is evident that there are statistically significant correlations for the positive and negative emotions. Among the positive emotions, Surprise is positively correlated with joy at 95% confidence, and it is relevant that none of the positive emotions have significant correlations with the negative emotions.

On the other hand, among the negative emotions there are several positive significant (practically, all of them at 99% confidence) correlations between emotions, but none of them with positive emotions. In this sense, sadness and anger shows significant correlations, disgust is correlated with anger and sadness, as well as contempt and disgust, and fear and sadness are correlated (but roughly at 90% confidence).

Table 2. Matrix of correlation coefficients (r) between emotions.

Emotions	1	2	3	4	5	6	7
1. Joy	-						
2. Surprise	0.12**	-					
3. Anger	−0.02	0.02	-				
4. Sadness	−0.02	0.07	0.36***	-			
5. Disgust	0.04	0.00	0.30***	0.21***	-		
6. Fear	0.04	0.03	0.02	−0.11*	−0.03	-	
7. Contempt	−0.09	0.10	0.03	0.04	0.16***	−0.01	-

Notes: ***$p < 0.01$ (significant at 99% confidence); ** $p < 0.05$ (significant at 95% confidence); * $p < 0.1$ (significant at 90% confidence).

The descriptive statistics, considering the emotional time ratio, are presented in

Table 3. The results show, either at an aggregate or at disaggregate levels, there is a clear advantage of the emotional response favoring students that attended lectures face-to-face compared to those attending the same lecture online.

That advantage is evident when the positive and negative emotions were aggregated, showing that the median, mean, and maximum and minimum levels of the emotional time ratio was higher for students that were present at the classroom. However, the difference is more evident in the case of the positive emotions than for the negative ones.

When the emotions are disaggregated, only in the case of anger and sadness (both negative emotions) there is a slightly higher emotional time ratio according to some of the central tendency measures for the online students compared to those attending face-to-face.

These statistics are presented in **Figure 1**, where the emotional time ratio for each one of the seven emotions is shown. Graphically, it is evident the advantage in the emotional response for students attending their synchronic lectures by a face-to-face modality. Besides, **Figure 1** indicates that the higher scores, according to the attendance modality, are more evident for some of the emotions such as joy, fear or surprise.

Table 3. Descriptive statistics of emotional time ratio (%).

Emotions	Median		Mean		Standard deviation		Max.		Min.	
Aggregate	Face-to-face	Online	Face-to-face	Online	Face-to-face	Online	Face-to-face	Online	Face-to-face	Online
Emotional time ratio %	10.34	4.87	10.80	6.14	5.74	3.22	26.94	15.48	1.91	1.90
Positive emotional time ratio %	4.02	1.33	4.92	1.63	3.56	1.16	14.61	4.69	0.27	0.07
Negative emotional time ratio %	3.85	3.49	4.48	4.00	2.51	2.66	10.89	11.29	0.35	0.25
Disaggregate										
Joy emotional time ratio %	2.02	0.27	3.32	0.66	3.44	1.02	17.83	6.39	0.00	0.00
Surprise emotional time ratio %	1.19	0.79	2.25	1.48	2.66	1.70	17.05	8.50	0.00	0.00
Anger emotional time ratio %	0.12	0.13	0.33	0.36	0.57	0.59	5.30	3.35	0.00	0.00
Sadness emotional time ratio %	0.16	0.19	0.48	0.39	0.90	0.70	8.44	4.33	0.00	0.00
Disgust emotional time ratio %	0.35	0.20	0.56	0.36	0.74	0.43	4.99	2.12	0.00	0.00
Fear emotional time ratio %	0.70	0.14	1.68	0.59	2.54	1.01	13.80	4.40	0.00	0.00
Contempt emotional time ratio %	1.50	1.43	2.17	2.30	2.01	2.30	12.76	9.76	0.08	0.02

Figure 1. Descriptive statistics of emotional time ratio (%) between face-to-face and online students.

4.2. Comparison of emotional in face-to-face and online modalities

To confirm the differences in the emotional time ratio for the evaluated emotions at an aggregate or disaggregate level, in terms of the students' attendance mode, statistical significance tests were applied which results are presented in **Table 4**. The *t*-test showed that at 95% confidence, the means of the positive emotions of the two different groups (face-to-face and online students) are statistically different unlike what is observed with the negative emotions.

The results of the *t*-test for each of the seven emotions showed that only four of them have statistically significant differences in the emotional time ratio between the groups of students with different attendance modes. These emotions are joy, surprise (both positive emotions) and disgust and fear (both negative emotions). The graphical results presented by **Figure 1** were confirmed by this test.

However, in order to avoid making assumptions about the normal distribution of the data, a non-parametric test, specifically the Kruskal-Wallis test, was employed. The results of these tests revealed a statistically significant difference (at a 95% confidence level) in the positive emotional time ratio between the face-to-face and online student groups, while no significant difference was found in the negative emotional time ratio. This finding is of considerable importance and sheds light on the study's outcomes. Taking each emotion separately, the Kruskal-Wallis test

confirmed that only for Joy, Surprise, Disgust and Fear there were statistically significant differences in the medians of the two group of students at 95% confidence.

Table 4. Statistical significance tests of emotions between face-to-face and online students.

Emotions	Mean		*t*-test		Kwallis test		Diff.
Aggregate	Face-to-face	Online	*t*	*p*-value	Chi-squared	*p*-value	
Emotional time ratio %	10.80	6.14	7.05***	0.00	45.63***	0.00	Yes
Positive emotional time ratio %	4.92	1.63	7.96***	0.00	63.66***	0.00	Yes
Negative emotional time ratio %	4.48	4.00	1.41	0.16	2.37	0.15	No
Disaggregate							
Joy emotional time ratio %	3.32	0.66	7.04***	0.00	82.60***	0.00	Yes
Surprise emotional time ratio %	2.25	1.48	2.50**	0.01	6.36**	0.01	Yes
Anger emotional time ratio %	0.33	0.36	-0.39	0.69	0.15	0.70	No
Sadness emotional time ratio %	0.48	0.39	0.82	0.41	0.09	0.77	No
Disgust emotional time ratio %	0.56	0.36	2.44**	0.02	8.03***	0.00	Yes
Fear emotional time ratio %	1.68	0.59	3.82***	0.00	30.95***	0.00	Yes
Contempt emotional time ratio %	2.17	2.30	-0.47	0.64	0.19	0.67	No

Notes: *** $p < 0.01$ (significant at 99% confidence); ** $p < 0.05$ (significant at 95% confidence); * $p < 0.1$ (significant at 90% confidence).

The statistical difference between student groups according to their attendance mode at synchronic lectures is evident in **Figures 2** and **3** where their boxplots are shown. The emotional time ratio is favorable to the face-to-face modality in comparison to an online attendance mode, not only for the emotions taken as a total but also for the positive and negative ones specifically.

In general terms, it is very interesting that positive emotions seemed to be more experienced for the students present at the classrooms than for those connected through the internet while the negative emotions are experienced for both groups without a significant difference.
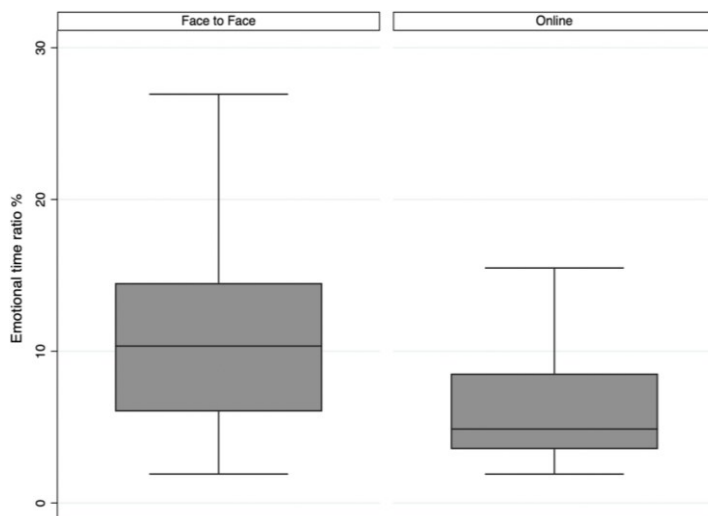

Figure 2. Box plot emotional time ratio (%) between face-to-face and online students.

In conclusion, the study focused on seven distinct emotions and found statistically significant differences in four of them. Specifically, face-to-face students showed a tendency to experience more positive emotions, particularly joy and surprise, while online students experienced negative emotions to a similar degree as their face-to-face counterparts.
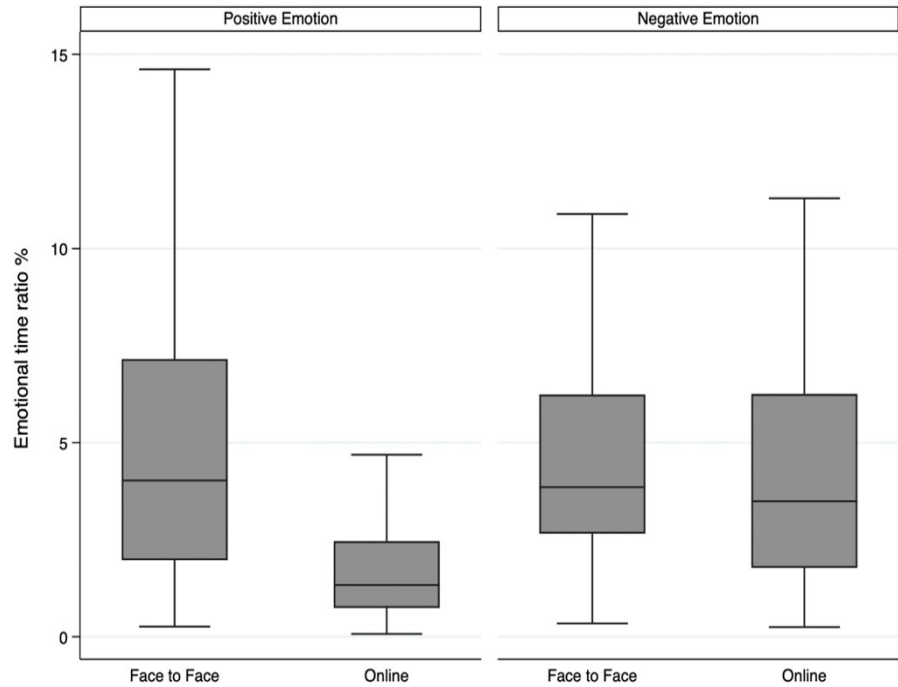

Figure 3. Box plot positive emotional time ratio (%) and negative emotional time ratio (%) between face-to-face and online students.

5. Discussion

Given that in this study the hybrid condition arises from one teacher simultaneously teaching classes across two or more campuses located in different cities, and that the virtual setting is not a student's choice, the overall results of the study suggest that a statistically significant difference in emotional response between face-to-face students and those who attended classes remotely. An emotional time ratio has been established as an analytical measure, identifying the time during which students experience emotions within the total recording time. Taking this indicator into account, it is observed that four out of the seven identified and quantified emotions are significantly higher for students attending face-to-face classes compared to those connected online. Therefore, students attending face-to-face classes experience a longer emotional duration compared to those taking classes online.

In **Figure 4**, we present a visualization of how various educational factors can influence the learning experience. These factors include physical interactions among participants, non-verbal communication, the application of active teaching methodologies, the implementation of pedagogical strategies, and the social presence of peers. The nature of the learning experience can differ significantly between synchronous, in-person, and virtual teaching models, resulting in diverse emotional responses from students. One key finding from this research is the pronounced

elevation of positive emotions experienced in the face-to-face mode. Intriguingly, both online and face-to-face modes demonstrated a similar intensity of negative emotions. This indicates a parallel emotional footprint regardless of the learning environment.
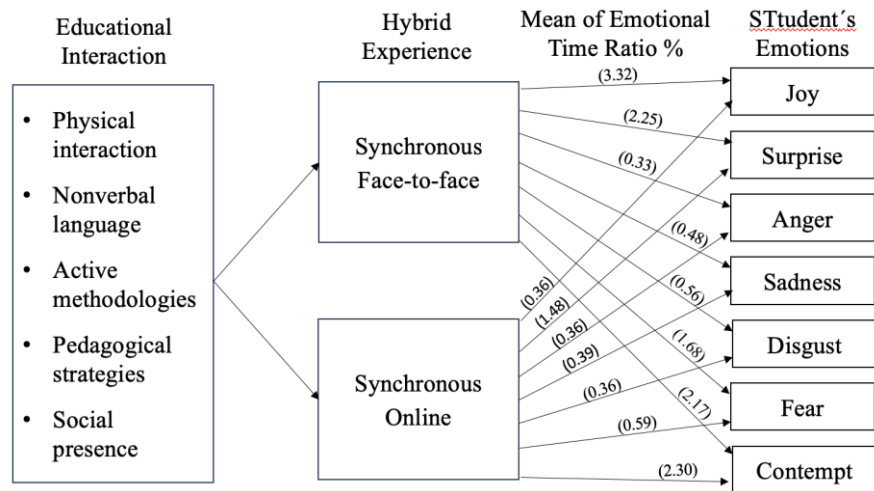

Figure 4. Comparative emotional responses in synchronous hybrid learning: Influence of educational factors and mode of delivery.

In this context, it is important to mention that ICT (Information and Communication Technology) plays a crucial role in the teaching and learning process, becoming a tool for students to enhance their learning. It is undeniable that due to the COVID-19 pandemic, many educational institutions had to mandatory transition to a fully virtual educational model. Subsequently, in the post-pandemic era, a hybrid education environment emerged, where subjects can be taught with both face-to-face and remote students. This result is generated in the context of hybrid education (Cantero et al., 2012; Morales et al., 2020; Weiner, 1985). In the case of our study, this was marked by the need to conduct simultaneous classes for individuals on one campus in a face-to-face setting and for other students who belonged to campuses in other cities and therefore had to attend virtual classes as a result.

Ecclestone and Hayes (2009) assert that student well-being is synonymous with successful practices and outcomes in academic achievements, and behaviors such as self-control and planning are more readily developed when students experience learning with positive emotions (Villavicencio and Bernardo, 2013).

The Covid-19 pandemic and its subsequent effects have led to an increase in anxiety and other mental health risks among university students, including depression, alcohol and drug use, self-harm, and suicidal ideation (Russell et al., 2019). In this context, as Plakhotnik et al. (2021) state, the support provided by faculty and university administration played a mediating role in student well-being. In this vein, it is pertinent to note the importance of positive emotions post-pandemic, even among teachers who experience changes in teaching methods, as mentioned by García-Álvarez et al. (2021). Thus, well-being interventions for teachers using positive psychology enhanced their effectiveness, which in turn facilitates interventions for student well-being and improves learning.

Durlak et al. (2015), after evaluating over 500 Social and Emotional Learning (SEL) programs, stated that the classroom climate and the relationships established among peers, as well as with the teacher, can activate emotions, both positive and negative, more intensely than what occurs in virtual spaces. While virtual classes do not imply that students do not socially interact, as the characteristics of the classes allow them to be in contact with their classmates and the teacher, the type of interaction online students establish with face-to-face students and among themselves is mediated by virtuality, limiting physical and close contact with others.

There is a diversity of studies comparing face-to-face vs. virtual education from different perspectives. For example, Pakdaman et al. (2019) conducted a systematic review of articles published over a 10-year period, focusing on cost and effectiveness, and concluded that online education reduces operational costs while compensating for the lack of human resources, and it can accommodate a larger number of students who are satisfied with quick access to information. On the other hand, Knoetze and du Toit (2022) studied academic achievement through self-regulated learning in both face-to-face and online learning environments, concluding that students in virtual environments are more likely to fall behind in subjects and show less self-regulated learning compared to traditional face-to-face teaching. Likewise, several studies have shown that the use of augmented reality and virtual education tools significantly improved student learning in most cases (Moro et al., 2021; Walgrün et al., 2022; Zhao et al., 2021).

Additionally, the theory of social presence suggests that computer-mediated communication (CMC) can affect people's social experience as it lacks non-verbal signals and other social indicators present in face-to-face interaction (Tu and McIsaac, 2002). The theory proposes that social presence is not only achieved through verbal and non-verbal communication but can be influenced by factors such as physical proximity, interaction, similarity, familiarity, and co-presence, factors that are diminished in the virtual modality. This indicates a reduction in social connection for online students within the hybrid model, who may feel affected by a lack of social interaction while their face-to-face peers are interacting, which can generate a sense of isolation and not feeling part of the group. Consequently, online students may feel less connected to their peers and teachers who are physically present in the classroom, which can affect their ability to experience emotions with the same intensity as their face-to-face peers (Tu and McIsaac, 2002).

This finding seems consistent with the theory of emotional contagion, which suggests that emotions are contagious, especially in proximity to others through non-verbal language (Marques et al., 2020). This suggests that the physical presence of others can have a regulatory effect on emotions. This is supported by the study of Cleveland and Campbell (2012), who argued that the low emotional intensity in online students may be due to the lack of face-to-face social interaction and physical presence of the teacher, limiting the students' ability to emotionally connect with the content and teaching process. This study is corroborated by Kresse and Watland (2016), who found that students in online classes are more likely to feel "disconnected" and miss having a shared experience with other students, which explains the higher emotional ratio in face-to-face students.

Therefore, the mode of instruction has a significant impact on students'

emotional response. These findings are consistent with the theory of emotional regulation and cognitive load theory, emphasizing the importance of considering the emotional dimension in education and teaching. Considering that emotions have a significant impact on motivation, learning, and information retention (Anzelin and Marín, 2020; Pekrun and Maier, 2009), it is important to understand the trends in these differences, as they could condition students' engagement and learning during class. Additionally, these results may have practical implications for the implementation of pedagogical strategies that promote emotional regulation and attention in both face-to-face and online education settings.

However, it is important to note that the results of the study show that while these mean differences appear in four out of seven emotions, they are particularly relevant in positive emotions, not so much in all negative emotions. This indicates that face-to-face students tend to feel and experience more positive emotions during a class, while online students do experience negative emotions, but not positive ones. The average duration of positive emotions experienced by face-to-face students was greater than that of online students within the hybrid model.

Moga et al. (2013) suggests studying negative emotions such as boredom, frustration, and hopelessness in order for teachers to identify them. This study considers emotions such as anger, contempt, disgust, fear, and sadness, which can provide insights to teachers to improve the teaching methodology they employ and achieve an adaptation of an individualized teaching strategy considering the emotional state of the student.

It is important to mention that many studies suggest that these emotions can negatively impact learning, affecting both face-to-face and online students in the same way. However, it is worth highlighting the study by Rowe and Fitness (2018), which focuses on the study of negative emotions, specifically anger, sadness, fear, and boredom, which can be highlighted in learning because they could lead to different behavior. For example, anger and frustration can motivate students to develop deep learning and complete their tasks. The same study mentions that participants reported a variety of emotions that positively or negatively affect their learning.

According to Pekrun (2014), emotions are very important in the learning process since learning is not only conditioned by cognitive aspects but also affective ones. The experiences students have while learning will influence their motivation towards the content, the subject, and the learning process itself, which will have an impact on effective teaching. The emotional experiences students have in the classroom play an important role in their learning, as it will depend on their motivation to learn and the degree of involvement in their own process.

According to Schutte et al. (2002), positive emotions correlate with motivated behavior, as those who experience them tend to have a positive attitude towards the task they are performing. Therefore, they are more likely to concentrate more on what they are doing, focus their attention, pay more attention to detail, and consequently achieve better results. When a student experiences positive emotions during the learning process, these emotions will influence their attention, motivation, and the way they process that information. The student will tend to selectively direct their attention towards stimuli that are satisfying to them, more likely than those they

dislike (Meyer and Turner, 2002; Weiner, 1985). In this sense, if a student experiences positive emotions in the classroom, they will remember the content more and better, as according to D'Errico et al. (2016), information presented in an emotional context can be more easily remembered. Moreover, positive emotions predispose students to be more interested in the content being taught in that class, igniting their desire to read and learn more about that topic.

Positive emotions significantly impact the learning experience. From a practical standpoint, Williams et al. (2013) contend that positive emotions invigorate and enhance learning behaviors, highlighting the pivotal role of motivation, which Butz et al. (2016) consider essential for academic success. Furthermore, contemporary neuroscience research by Li et al. (2020) reveals that central cognitive processes crucial for learning, such as memory, motivation, and attention, are intertwined with positive emotions. This evidence supports the assertion that fostering positive emotions is crucial for improving learning outcomes.

In summary, whether face-to-face or virtual, the care of students' emotions that influence their learning must be considered, in addition to the tools that are used. For example, D'Errico et al. (2016), affirm that when students experience positive emotions through synchronous learning activities (interactions with teachers and among students), the dimensions of affective relevance and engagement significantly increase. On the contrary, negative emotions play a central role during interactive activities with the teacher, as performing these learning tasks can be an initial warning of insufficient preparation. Therefore, teachers must be aware of the negative emotions generated and the intrinsic relationship in the teaching methodology, as well as the didactic tools used, and how this environment affects both face-to-face and online students.

The results show that emotions of Joy and Surprise occur more frequently and with longer duration in face-to-face students, highlighting the difference in emotional intensity and, above all, a clear difference in the recurrence of these emotions in face-to-face settings.

Maya and Rivero (2012), suggest that emotions and motivations are the true driving forces behind any human learning, as they modulate the received information, creating a positive or negative disposition towards learning. However, it is important to note that not all emotions will have the same impact on individuals, and therefore, the relationship in the learning process will also vary depending on the type of emotion experienced.

As proposed by Ramirez (2021), the scientific basis of working with positive emotions has been developed by Neuroeducation, which has demonstrated that emotions enhance learning outcomes and, in conjunction with that, academic self-efficacy is strengthened, and social skills are improved. Additionally, Pekrun (2014) mentions that positive emotions are experienced as pleasurable and can vary in their cognitive and physiological manifestations, influencing attention, motivation, the use of learning strategies, and self-regulation of learning.

While the relationship between emotions and learning, as discussed above, has been demonstrated through a series of studies, it is important to focus on the difference generated among students based on their class modality. In this case, the fact that face-to-face students experience positive emotions with greater intensity

indicates that despite both groups being exposed to the same classroom stimulus, there are a series of factors that condition their experiences, thereby generating different emotional responses and, in this case, greater intensity and duration of emotions such as joy and surprise. Morcom (2014), emphasizes that schools are recognized as places for academic learning but also as contexts for social and emotional development, which may not be replicated in virtual settings where social interaction is limited to the specific demands of the class mediated by the teacher.

In this sense, the difference in experienced positive emotions and their intensity may indicate that online students have a weaker emotional connection with their environment, resulting in lower emotional intensity. According to Bravo (2021), virtual education hinders the formation of strong emotional bonds due to the lack of physical contact and limited communication.

According to the results, negative emotions are generally experienced equally by both face-to-face and online students, except for Fear and Disgust, which are slightly higher (but statistically significant) among face-to-face students.

It is not surprising to experience negative emotions in a learning context. Nash et al. (2015), highlight that learning is not just a cognitive process but predominantly an affective one. Therefore, both positive and negative emotions are important, as the learning process itself is an affective experience. From this perspective, some authors like Yavuz et al. (2016) identify that, similar to positive emotions, negative emotions have a significant impact on learning. These emotions, classified as boredom, shame, helplessness, hopelessness, inadequacy, fear, anger, dislike, anxiety, among others, activate students physiologically and cognitively.

Regarding this, Urhahne (2015) mentions that the connection between emotion and motivation is close, as students are activated, motivated, and oriented, positively or negatively, toward a task based on the affective response it elicits. In other words, if a negative emotion affects students, it can create difficulties in abstraction, thinking, and performance, which will also impact their motivation to study, as referred by Buckley and Doyle (2014). Not only do positive emotions have a positive impact on performance and learning, but negative emotions can also activate students positively, as is the case with anxiety, which in subjects such as mathematics, physics, or chemistry, has been found to have a positive impact because it can induce students to solve a problem or difficulty.

Timoštšuk and Ugaste (2012), state that emotions are part of the learning experience, both positive and negative. Thus, experiencing negative emotions in the classroom is not necessarily bad; it is part of the process. Lindqvist et al. (2017), suggest that it is inevitable for students to experience emotions, both positive and negative. Therefore, beyond trying to prevent it, teachers should be aware, recognize, identify, and manage these emotions. These authors also note that emotions in the classroom fluctuate, and the learning experience does not have a single prevailing emotion; they change during the same class and throughout the process due to many factors, including tests and assessments (Pekrun, 2014), teaching strategies (Nash et al., 2015), teacher credibility (Hu and Choo, 2015), which will condition student receptivity, feedback, and the teacher's beliefs about student achievement.

However, according to Pekrun (2014), the affective burden of the classroom experience should not be limited solely to the teacher and their teaching strategies.

The classroom climate is influenced by various factors, such as students' beliefs about the educational context, the subject matter, the content, the teacher, and their own performance capabilities, which positively or negatively impact their emotions.

Additionally, as seen earlier, Durlak et al. (2015), have shown that socialization, the presence of others, particularly peers, also has an affective impact on the classroom climate (Sánchez, 2013). The interpersonal relationships formed within learning experiences have a significant influence on positive or negative emotional states. Students who do not feel accepted, included, or integrated in the classroom may experience low emotional engagement in an educational environment, regardless of the teacher's pedagogical strategies. This seems to be evident in hybrid environments, as Peña et al. (2016) assert that in e-learning educational processes, the absence of physical interaction between students and between peer students in the class increases the likelihood of experiencing negative emotions. Limited access to nonverbal language, signals, expressions, and nonverbal interactions makes online students feel less connected to the teaching/learning process in the hybrid classroom. Consequently, there is a higher tendency for negative emotions such as confusion, insecurity, or frustration to arise.

On the other hand, the study found that some students did not display any emotions detected by the software during classes. This finding can be concerning as emotions play a fundamental role in student learning and motivation (D'Mello and Graesser, 2012). Generating emotions in students is crucial for their learning and performance improvement (Pekrun, 2014). The lack of emotional response may indicate disinterest or emotional disconnection with the course content. The absence of emotions detected by the software in some students can be attributed to various factors, including lack of interest in the topic, emotional fatigue (D'Mello and Graesser, 2012), or even insufficient skills in facial expression, which the software fails to detect.

An effective alternative to counteract the lack of emotions could be the use of active methodologies in the classroom, which have shown positive results in activating students' emotions and thereby leading to improved learning, as argued by Dávila et al. (2022). The use of active methodologies had a statistically significant effect in promoting positive emotions, self-efficacy, and a reduction in negative emotions.

Furthermore, the so-called "affective learning" focuses on the teaching-learning process through emotional experiences, where emotions play a predominant role in the learning experience, creating a positive emotional climate that leads to better academic performance, increased motivation, commitment, and a better attitude towards learning for students (Rubin et al., 2020; Radoff et al., 2019).

Therefore, utilizing active learning and effective teaching methodologies is a task that teachers should undertake in the classroom. This way, they can generate positive emotions in students to facilitate the teaching-learning process, while creating a conducive environment for learning that is comfortable for both the student and the teacher.

It is important to note that the detection of emotions through facial expression reading software is not a perfect measure of emotional response (Krumhuber et al., 2013), and it is necessary to consider multiple sources of information to fully

understand the students' emotional experience. It is essential to acknowledge that the absence of emotions detected by the software does not imply the absence of emotions in students. It is possible that students may be experiencing emotions internally that are not reflected in their facial expressions.

In this study, it was found that both students attending face-to-face classes and those taking online classes used applications and electronic devices during class, which affected their emotional experience in the classroom. Voluntary and involuntary distractions were identified, such as the use of applications, video games, and social media, as factors contributing to the emotions experienced during class and detected by the software. However, these distractions are not generated by the class itself but are considered distracting factors for students that affect their emotional experience during class. Therefore, it is important to analyze these distractions and their effect on learning and emotional well-being.

Distractions during a class session can have a negative impact on learning as they can decrease attention, information retention, and learning quality. They could also generate emotions related to performance such as frustration, anxiety, and stress (Hobart, 2008). However, not all distractions are the same. There are involuntary distractions such as external noise or interruptions from other students, or even the arrival of an important message that, although they can affect the quality of the emotional experience in the classroom, are unexpected and unplanned. On the other hand, there are voluntary distractions, meaning that the student chooses to get distracted. This could be due to various reasons. One possibility is that the subject matter may be boring or uninteresting to the student (Hobart, 2008), leading them to seek distractions to avoid boredom. It can also be due to the difficulty of the class content, which generates frustration and stress in the student, prompting them to seek distractions to alleviate those uncomfortable feelings. Therefore, it is necessary to analyze the events before the student decides to get distracted.

Furthermore, students may have different stimulation needs, and some individuals require a higher level of brain activity to engage in a task. If the class content does not meet these stimulation needs, the student may seek distractions to obtain the level of stimulation they require (Hobart, 2008).

6. Limitation

The study compared emotions in face-to-face and online learning in a hybrid model, but limitations should be considered. Its narrow scope may limit generalization, and unique post-pandemic circumstances could affect emotions. Limited social interaction may lead to disconnection for online students. Academic performance wasn't directly measured, and individual differences were not considered. Lack of a control group and other variables were not addressed. Nonetheless, the study offers valuable insights into hybrid education emotions, calling for further research to deepen understanding.

7. Conclusion and implications

This study explored emotional effects of synchronous hybrid education on Latin American undergraduates. Face-to-face classes elicited stronger and longer positive

emotions than online classes. Technology's role was crucial yet limited in fostering social connections. Emotions influenced motivation, attention, and retention, advocating for emotional integration in education. Lack of physical interaction and weaker bonds contributed to emotional differences. Some students showed limited expression, signaling disinterest. Active methodologies were recommended to boost emotional engagement. Teachers must create positive emotional climates, fostering self-efficacy and social skills. The study's implications for educators' stress adapting strategies to enhance emotional regulation and strengthen emotional connections with learning.

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Availability of data and materials: The datasets generated and analyzed during the current study are not publicly available due to privacy restrictions but are available from the corresponding author on reasonable request. The data that can be provided will be provided in a de-identified manner.

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References

Anderson-Cook, C. M. (2005). Experimental and Quasi-Experimental Designs for Generalized Causal Inference. Journal of the American Statistical Association, 100(470), 708–708. https://doi.org/10.1198/jasa.2005.s22

Abdul Rashid, N. F. W., Abdul Karim, B., & Othman, A. S. (2022). Students' Emotions towards Online Learning During The Covid-19 Pandemic: A Preliminary Study. International Journal of Academic Research in Business and Social Sciences, 12(8). https://doi.org/10.6007/ijarbss/v12-i8/14536

Ahn, B. T., & Harley, J. M. (2020). Facial expressions when learning with a Queer History App: Application of the Control Value Theory of Achievement Emotions. British Journal of Educational Technology, 51(5), 1563–1576. https://doi.org/10.1111/bjet.12989

Anzelin, I., & Marín, A. (2020). Relación entre la emoción y los procesos de enseñanza aprendizaje. Sophia, 16(1), 48–64. https://doi.org/10.18634/sophiaj.16v.1i.1007

Bailey, L. M. (2020). Comparing students' learning outcomes and satisfaction in online, hybrid and face-to-face education courses. Temple University.

Bear, M., Connors, B., & Paradiso, M. A. (2020). Neuroscience: exploring the brain, enhanced edition: exploring the brain. Jones & Bartlett Learning.

Biocca, F., & Harms, C. (2002). Defining and measuring social presence: Contribution to the networked minds theory and measure. Proceedings of presence, 2002, 7-36.

Bravo, R. N. (2021). Comunicación efectiva a través de la Virtualidad en la Formación Universitaria. Dilemas Contemporáneos: Educación, Política Y Valores. https://doi.org/10.46377/dilemas.v8i.2684

Buckley, P., & Doyle, E. (2014). Gamification and student motivation. Interactive Learning Environments, 24(6), 1162–1175. https://doi.org/10.1080/10494820.2014.964263

Butz, N. T., Stupnisky, R. H., Pekrun, R., Jensen, J. L., & Harsell, D. M. (2016). The Impact of Emotions on Student Achievement in Synchronous Hybrid Business and Public Administration Programs: A Longitudinal Test of Control-Value Theory*. Decision Sciences Journal of Innovative Education, 14(4), 441–474. https://doi.org/10.1111/dsji.12110

Cantero, F. P., Rodríguez, C. G., Gómez, C. G., Ballester, A. C., & Goyareb, R. (2012). Manual de teorías emocionales y

motivacionales. Manual de teorías emocionales y motivacionales. https://mdx.pre.csuc.cat/handle/10503/18359

Caprara, L., & Caprara, C. (2022). Effects of virtual learning environments: A scoping review of literature. Education and Information Technologies, 27(3), 3683–3722. https://doi.org/10.1007/s10639-021-10768-w

Choliz, M. (2005). Psicología de la emoción: El proceso emocional. Valencia, España: Universidad de Valencia.

Cleveland, M., & Campbell, P. (2012). Emotional presence, learning, and the online learning environment. The International Review of Research in Open and Distributed Learning, 13(4), 269–292. https://doi.org/10.19173/irrodl.v13i4.1234

Córdova Olivera, P., Gasser Gordillo, P., Naranjo Mejía, H., La Fuente Taborga, I., Grajeda Chacón, A., & Sanjinés Unzueta, A. (2023, July 6). Academic stress as a predictor of mental health in university students. Cogent Education, 10(2). https://doi.org/10.1080/2331186x.2023.2232686

Curelaru, V., & Diac, G. (2022). Perceived Classroom Assessment Environment and Autonomous Motivation as Predictors of Students' Achievement Emotions in Relation to Learning for Baccalaureate Exam. Educatia 21, 22, 50–64. https://doi.org/10.24193/ed21.2022.22.06

Dávila, M. A., Sánchez, J., Airado, D., & Cañada, F. (2022). Impact of an Active Learning Methodology on Students' Emotions and Self-Efficacy Beliefs towards the Learning of Chemical Reactions—The Case of Secondary Education Students. Education Sciences, 12(5), 347. https://doi.org/10.3390/educsci12050347

Du, S., Tao, Y., & Martinez, A. M. (2014). Compound facial expressions of emotion. Proceedings of the National Academy of Sciences, 111(15). https://doi.org/10.1073/pnas.1322355111

Durlak, J. A. (Ed.). (2015). Handbook of social and emotional learning: Research and practice. Guilford Publications.

D'Errico, F., Paciello, M., Carolis, B. D., Vattanid, A., Palestra, G., & Anzivino, G. (2018). Cognitive emotions in e-learning processes and their potential relationship with students' academic adjustment. The International Journal of Emotional Education, 10(1), 89–111. https://www.um.edu.mt/library/oar/handle/123456789/29670

D'Errico, F., Paciello, M., & Cerniglia, L. (2016). When emotions enhance students' engagement in e-learning processes. When Emotions Enhance Students' Engagement in E-learning Processes - Learning & Technology Library (LearnTechLib). https://www.learntechlib.org/p/173676/

D'Mello, S., & Graesser, A. (2012). Dynamics of affective states during complex learning. Learning and Instruction, 22(2), 145–157. https://doi.org/10.1016/j.learninstruc.2011.10.001

Frijda N. H. (1986). Emotions and action. In: ASR Manstead, N Frijda, A Fischer, eds. Feelings and Emotions: The Amsterdam Symposium. Cambridge: Cambridge University Press.

García-Álvarez, D., Soler, M. J., & Achard-Braga, L. (2021). Psychological Well-Being in Teachers During and Post-Covid-19: Positive Psychology Interventions. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.769363

Goetz, T., Pekrun, R., Hall, N., & Haag, L. (2006). Academic emotions from a social-cognitive perspective: Antecedents and domain specificity of students' affect in the context of Latin instruction. British Journal of Educational Psychology, 76(2), 289–308. https://doi.org/10.1348/000709905x42860

Goldberg, J. H., & Wichansky, A. M. (2003). Eye Tracking in Usability Evaluation. The Mind's Eye, 493–516. https://doi.org/10.1016/b978-044451020-4/50027-x

Gross, J. J., & Levenson, R. W. (1997). Hiding feelings: The acute effects of inhibiting negative and positive emotion. Journal of Abnormal Psychology, 106(1), 95–103. https://doi.org/10.1037/0021-843x.106.1.95

Hobart, M. (2008). Spark: The Revolutionary New Science of Exercise and the Brainby John Ratey with Eric Hagerman; New York, Little, Brown, and Company 2008, 294 pages, $24.99. Psychiatric Services, 59(8), 939–939. https://doi.org/10.1176/ps.2008.59.8.939

Hirt, F., Werlen, E., Moser, I., & Bergamin, P. (2019). Measuring emotions during learning: lack of coherence between automated facial emotion recognition and emotional experience. Open Computer Science, 9(1), 308–317. https://doi.org/10.1515/comp-2019-0020

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H., & Van de Weijer, J. (2011). Eye tracking: A comprehensive guide to methods and measures. OUP Oxford.

Hu, G., & Choo, L. (2015). The impact of disciplinary background and teaching experience on the use of evaluative language in teacher feedback. Teachers and Teaching, 22(3), 329–349. https://doi.org/10.1080/13540602.2015.1058591

Irawan, A. W., Dwisona, D., & Lestari, M. (2020). Psychological Impacts of Students on Online Learning During the Pandemic COVID-19. KONSELI : Jurnal Bimbingan Dan Konseling (E-Journal), 7(1), 53–60. https://doi.org/10.24042/kons.v7i1.6389

Jiménez, Y. I., Hernández, J., & Rodríguez, E. (2021). Educación en línea y evaluación del aprendizaje: de lo presencial a lo

virtual. RIDE Revista Iberoamericana Para La Investigación Y El Desarrollo Educativo, 12(23). https://doi.org/10.23913/ride.v12i23.1005

Knoetze, A., & du Toit, Y. (2022). Emergency remote teaching and learning vs face-to-face: When are students more likely to fall behind? South African Journal of Higher Education, 36(5). https://doi.org/10.20853/36-5-4666

Kohoulat, N., Hayat, A. A., Dehghani, M. R., Kojuri, J., & Amini, M. (2017). Medical students' academic emotions: the role of perceived learning environment. PubMed Central (PMC). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5346172/

Kresse, W., & Watland, K. H. (2016). Thinking outside the Box Office: Using Movies to Build Shared Experiences and Student Engagement in Online or Hybrid Learning. Journal of Learning in Higher Education, 12(1), 59-64.

Krumhuber, E. G., Kappas, A., & Manstead, A. S. R. (2013). Effects of Dynamic Aspects of Facial Expressions: A Review. Emotion Review, 5(1), 41–46. https://doi.org/10.1177/1754073912451349

Keyes, C. L. M., Wissing, M., Potgieter, J. P., Temane, M., Kruger, A., & van Rooy, S. (2008). Evaluation of the mental health continuum–short form (MHC–SF) in setswana-speaking South Africans. Clinical Psychology & Psychotherapy, 15(3), 181–192. https://doi.org/10.1002/cpp.572

Li, L., Gow, A. D. I., & Zhou, J. (2020). The Role of Positive Emotions in Education: A Neuroscience Perspective. Mind, Brain, and Education, 14(3), 220–234. https://doi.org/10.1111/mbe.12244

Lindqvist, H., Weurlander, M., Wernerson, A., & Thornberg, R. (2017). Resolving feelings of professional inadequacy: Student teachers' coping with distressful situations. Teaching and Teacher Education, 64, 270–279. https://doi.org/10.1016/j.tate.2017.02.019

Lopez, C. E. (2015). Un modelo de investigación orientado a la implementación de programas estructurados en ambientes virtuales de aprendizaje. Dialnet. https://dialnet.unirioja.es/servlet/articulo?codigo=7558484

Lovón, M. A., & Cisneros, S. A. (2020). Repercusiones de las clases virtuales en los estudiantes universitarios en el contexto de la cuarentena por COVID-19: El caso de la PUCP. Propósitos Y Representaciones, 8(SPE3). https://doi.org/10.20511/pyr2020.v8nspe3.588

Marques, A. M., Fóz, A. Q. B., Lopes, E. G. Q., & Tanaka, L. H. (2020). Emotional education program: a participative intervention with teachers. Qualitative Research Journal, 21(3), 274–285. https://doi.org/10.1108/qrj-07-2019-0052

Matsumoto, D. (1990). Cultural similarities and differences in display rules. Motivation and Emotion, 14(3), 195–214. https://doi.org/10.1007/bf00995569

Maya, N., & Rivero, R. (2012). Neurociencia y Educación: Una aproximación interdisciplinar. Neurociencia Y Educación: Una Aproximación Interdisciplinar. https://repositorio.uam.es/handle/10486/678991

Mellouk, W., & Handouzi, W. (2020). Facial emotion recognition using deep learning: review and insights. Procedia Computer Science, 175, 689–694. https://doi.org/10.1016/j.procs.2020.07.101

Meyer, D. K., & Turner, J. C. (2002). Discovering Emotion in Classroom Motivation Research. Educational Psychologist, 37(2), 107–114. https://doi.org/10.1207/s15326985ep3702_5

Moga, H., Sandu, F., Danciu, G. M., Boboc, R., & Constantinescu, I. (2013). Extended control-value emotional agent based on fuzzy logic approach. 2013 11th RoEduNet International Conference. https://doi.org/10.1109/roedunet.2013.6511734

Morales, M. G., Moreno, K. C., Romano, M. M. D. S., & García, M. D. R. (2020). Gestión del conocimiento, a través de plataformas y herramientas digitales de aprendizaje ante la migración de clases presenciales a en línea. Revista Geon (Gestión, Organizaciones Y Negocios), 7(2), 1–19. https://doi.org/10.22579/23463910.217

Morcom, V. (2014). Scaffolding social and emotional learning in an elementary classroom community: A sociocultural perspective. International Journal of Educational Research, 67, 18–29. https://doi.org/10.1016/j.ijer.2014.04.002

Moro, C., Birt, J., Stromberga, Z., Phelps, C., Clark, J., Glasziou, P., & Scott, A. M. (2021). Virtual and Augmented Reality Enhancements to Medical and Science Student Physiology and Anatomy Test Performance: A Systematic Review and Meta-Analysis. Anatomical Sciences Education, 14(3), 368–376. https://doi.org/10.1002/ase.2049

Nash, G., Crimmins, G., & Oprescu, F. (2015). If first-year students are afraid of public speaking assessments what can teachers do to alleviate such anxiety? Assessment & Evaluation in Higher Education, 41(4), 586–600. https://doi.org/10.1080/02602938.2015.1032212

Pakdaman, M., Nazari Moghadam, M., Dehghan, H. R., Dehghani, A., & Namayandeh, M. (2019). Evaluation of the Cost-Effectiveness of Virtual and Traditional Education Models in Higher Education: A Systematic Review. Health Technology Assessment in Action. https://doi.org/10.18502/htaa.v3i1.5715

Pekrun, R. (2014). Emotions and learning. Geneva, Switzerland: International Academy of Education (IAE).

Pekrun, R., Elliot, A. J., & Maier, M. A. (2009). Achievement goals and achievement emotions: Testing a model of their joint relations with academic performance. Journal of Educational Psychology, 101(1), 115–135. https://doi.org/10.1037/a0013383

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic Emotions in Students' Self-Regulated Learning and Achievement: A Program of Qualitative and Quantitative Research. Educational Psychologist, 37(2), 91–105. https://doi.org/10.1207/s15326985ep3702_4

Peña, A., Rangel, N., Muñoz, M., Mejia, J., & Lara, G. (2016). Affective Behavior and Nonverbal Interaction in Collaborative Virtual Environments. Journal of Educational Technology & Society, 19(2), 29–41. http://www.jstor.org/stable/jeductechsoci.19.2.29

Plakhotnik, M. S., Volkova, N. V., Jiang, C., Yahiaoui, D., Pheiffer, G., McKay, K., Newman, S., & Reißig-Thust, S. (2021). The Perceived Impact of COVID-19 on Student Well-Being and the Mediating Role of the University Support: Evidence From France, Germany, Russia, and the UK. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.642689

Purves, D., Augustine, G. J., Fitzpatrick, D., Hall, W., LaMantia, A. S., & White, L. (2019). Neurosciences. De Boeck Supérieur.

Radoff, J., Jaber, L. Z., & Hammer, D. (2019). "It's Scary but It's Also Exciting": Evidence of Meta-Affective Learning in Science. Cognition and Instruction, 37(1), 73–92. https://doi.org/10.1080/07370008.2018.1539737

Ramírez, F. (2021). Las emociones positivas en torno al aprendizaje significativo en posgrado. Educación Superior, 8(2), 67-76. http://www.scielo.org.bo/scielo.php?script=sci_arttext&pid=S2518-82832021000200009&lng=es&tlng=es

Rowe, A., & Fitness, J. (2018). Understanding the Role of Negative Emotions in Adult Learning and Achievement: A Social Functional Perspective. Behavioral Sciences, 8(2), 27. https://doi.org/10.3390/bs8020027

Rubin, R. B., Palmgreen, P., & Sypher, H. E. (2020). Affective Learning. Communication Research Measures, 81–85. https://doi.org/10.4324/9781003064343-8

Ruiz, E., Cruz, J. L., Aguirre, C. G., Corona, V. G., & Lemus Amescua, E. V. (2022). Comparación de la motivación en alumnos(as) universitarios(as) de modalidad virtual/virtual versus presencial/virtual desde el MSLQ. Revista mexicana de investigación educativa, 27(93), 369-386.

Russell, K., Allan, S., Beattie, L., Bohan, J., MacMahon, K., & Rasmussen, S. (2019). Sleep problem, suicide and self-harm in university students: A systematic review. Sleep Medicine Reviews, 44, 58–69. https://doi.org/10.1016/j.smrv.2018.12.008

Ryff, C., & Singer, B. (2008). Know Thyself and Become What You Are: A Eudaimonic Approach to Psychological Well-Being. Journal of Happiness Studies, 9(1), 13-39. https://doi.org/10.1007/s10902-006-9019-0

Sánchez, J. (2013). Búsqueda de ayuda académica, autoeficacia social académica y emociones de logro en clase en estudiantes universitarios. Revista Argentina de Ciencias del Comportamiento 5 (1), 35-41. http://www.redalyc.org/articulo.oa?id=333427385006

Schutte, N. S., Malouff, J. M., Simunek, M., McKenley, J., & Hollander, S. (2002). Characteristic emotional intelligence and emotional well-being. Cognition and Emotion, 16(6), 769–785. https://doi.org/10.1080/02699930143000482

Soffer, T., & Nachmias, R. (2018). Effectiveness of learning in online academic courses compared with face-to-face courses in higher education. Journal of Computer Assisted Learning, 34(5), 534–543. https://doi.org/10.1111/jcal.12258

https://www.scielo.org.mx/scielo.php?pid=S1405-66662022000200369&script=sci_abstract&tlng=en

Timoštšuk, I., & Ugaste, A. (2012). The role of emotions in student teachers' professional identity. European Journal of Teacher Education, 35(4), 421–433. https://doi.org/10.1080/02619768.2012.662637

Tu, C. H., & McIsaac, M. (2002). The Relationship of Social Presence and Interaction in Online Classes. American Journal of Distance Education, 16(3), 131–150. https://doi.org/10.1207/s15389286ajde1603_2

Urhahne, D. (2015). Teacher behavior as a mediator of the relationship between teacher judgment and students' motivation and emotion. Teaching and Teacher Education, 45, 73–82. https://doi.org/10.1016/j.tate.2014.09.006

Urzúa, A., & Caqueo-Urízar, A. (2012). Quality of life: A theoretical review. Terapia psicológica, 30(1), 61-71. https://dx.doi.org/10.4067/S0718-48082012000100006

Villavicencio, F. T., & Bernardo, A. B. I. (2013). Positive academic emotions moderate the relationship between self-regulation and academic achievement. British Journal of Educational Psychology, 83(2), 329–340. https://doi.org/10.1111/j.2044-8279.2012.02064.x

Wallgrün, J. O., Chang, J. S. K., Zhao, J., Trenham, P., Sajjadi, P., Simpson, M., & Klippel, A. (2022). Place-based education through immersive virtual experiences — preparing biology students for the field. Journal of Biological Education, 1–24. https://doi.org/10.1080/00219266.2022.2067580

Wedel, M., & Pieters, R. (2006). Eye Tracking for Visual Marketing. Foundations and Trends® in Marketing, 1(4), 231–320. https://doi.org/10.1561/1700000011

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. Psychological Review, 92(4), 548–573. https://doi.org/10.1037/0033-295x.92.4.548

Williams, K. H., Childers, C., & Kemp, E. (2013). Stimulating and Enhancing Student Learning Through Positive Emotions. Journal of Teaching in Travel & Tourism, 13(3), 209–227. https://doi.org/10.1080/15313220.2013.813320

Wu, C., Gong, X., Luo, L., Zhao, Q., Hu, S., Mou, Y., & Jing, B. (2021). Applying Control-Value Theory and Unified Theory of Acceptance and Use of Technology to Explore Pre-service Teachers' Academic Emotions and Learning Satisfaction. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.738959

Xu, P., Peng, S., Luo, Y. J., & Gong, G. (2021). Facial expression recognition: A meta-analytic review of theoretical models and neuroimaging evidence. Neuroscience & Biobehavioral Reviews, 127, 820–836. https://doi.org/10.1016/j.neubiorev.2021.05.023

Yavuz, M., Gülmez, D., & Özkaral, T. C. (2016). Cognitive and Affective Features of Vocational High School Students. TED EĞİTİM VE BİLİM, 41(187). https://doi.org/10.15390/eb.2016.5238

Zayas, V., & Shoda, Y. (2005). Do Automatic Reactions Elicited by Thoughts of Romantic Partner, Mother, and Self Relate to Adult Romantic Attachment? Personality and Social Psychology Bulletin, 31(8), 1011–1025. https://doi.org/10.1177/0146167204274100

Zhang, W., Wang, Y., Yang, L., & Wang, C. (2020). Suspending Classes Without Stopping Learning: China's Education Emergency Management Policy in the COVID-19 Outbreak. Journal of Risk and Financial Management, 13(3), 55. https://doi.org/10.3390/jrfm13030055

Zhao, G., Fan, M., Yuan, Y., Zhao, F., & Huang, H. (2021). The comparison of teaching efficiency between virtual reality and traditional education in medical education: a systematic review and meta-analysis. Annals of Translational Medicine, 9(3), 252–252. https://doi.org/10.21037/atm-20-2785