The Influence of Academic and Demographic Variables on E-Learning Adaptation During the COVID-19 Pandemic: A Comparative Study Across Different Fields of Study and Academic Years.

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Abstract

This study examines the preparedness of Malaysian frontline students for e-learning during the COVID-19 pandemic, utilizing a mixed-methods approach to capture diverse experiences. A survey of 471 participants identified significant challenges related to demographics, internet access, and e-learning experiences. The analysis revealed a gender disparity, with more male participants, particularly in certain academic programs. Mature students were also prevalent, highlighting the need for tailored support strategies. Notably, Social Sciences and Arts students faced the most significant e-learning difficulties, emphasizing the need for targeted interventions. Cross-analysis of age, gender, and year of study showed that older male students consistently reported higher challenges. Statistical tests confirmed that gender and field of study significantly influence e-learning problems. The findings underscore the importance of developing comprehensive, field-specific support mechanisms and regularly assessing these needs to improve e-learning experiences and ensure equitable access to resources for all students.

Keywords: *E-Learning Challenges; Mixed-Methods Approach; Higher Education; Online Learning; Gender Equality; Reduced Inequalities.*

1. Introduction

The COVID-19 pandemic has profoundly transformed the landscape of higher education, compelling institutions worldwide to shift abruptly from traditional face-to-face instruction to e-learning. This transition left lecture halls empty and campuses silent, forcing both students and educators to rapidly adapt to new modes of instruction through digital platforms (Bozkurt et al., 2020). While e-learning provided an essential solution to maintain educational continuity, it also uncovered significant challenges, particularly for higher education students. These challenges include technological barriers, gaps in digital

literacy, socio-economic disparities, and mental health concerns (Bao, 2020; Hodges et al., 2020; Adedoyin & Soykan, 2020).

E-learning, defined as the use of electronic media and information and communication technologies (ICT) in education, was intended to bridge the gap caused by physical distancing measures (Moore et al., 2011). However, the transition has been neither seamless nor equitable. In many regions, particularly those with underdeveloped digital infrastructure, students from disadvantaged backgrounds faced heightened challenges in adapting to online learning environments (Almaiah, Al-Khasawneh, & Althunibat, 2020). In Malaysia, despite a significant increase in internet penetration, issues related to digital equity persist (MCMC, 2020). This study seeks to investigate how academic variables (field of study, year of study, major/minor) and demographic variables (age) influenced students' adaptation to e-learning during the COVID-19 pandemic. By focusing on their lived experiences, this research aims to provide a comprehensive understanding of the obstacles faced and the coping strategies employed by students. The narratives of resilience, tenacity, and struggle that emerge from this study offer valuable insights into systemic issues that must be addressed to ensure equitable access to quality education.

The field of study plays a critical role in shaping e-learning experiences. Disciplines that rely heavily on laboratory work, hands-on activities, or collaborative projects, such as Natural Sciences and Engineering, faced more significant challenges in adapting to online formats compared to fields like Social Sciences and Humanities, which could more readily transition to virtual environments (Adedoyin & Soykan, 2020; Dhawan, 2020). This disparity highlights the need for tailored e-learning solutions that account for the unique requirements of different disciplines. Similarly, the year of study is a crucial factor influencing e-learning adaptation. First-year students, who are new to the university environment and less familiar with self-directed learning, often encountered greater difficulties compared to their senior counterparts. These students may lack the necessary skills and experience to navigate online learning effectively, leading to increased anxiety and lower academic performance (Crawford et al., 2020). In contrast, postgraduate students, who typically have more experience with independent research and online resources, may find the transition to e-learning smoother (Gonzalez et al., 2020).

Demographic variables, particularly age, also significantly affect students' e-learning experiences. Younger students tend to be more tech-savvy and adaptable to digital learning environments, while older students may struggle with technological proficiency and balancing educational responsibilities with other life commitments, such as employment and family (Ma et al., 2021; Xu & Jaggars, 2013). Understanding these demographic influences is crucial for developing effective support systems that cater to the diverse needs of the student population.

The motivation for this research stems from the recognition that the shift to e-learning has not been universally beneficial. While some students have adapted smoothly to the virtual environment, others have experienced significant difficulties. Understanding these challenges is critical for educators, policymakers, and institutions aiming to support students effectively (Crawford et al., 2020). This study seeks to fill the gap in existing literature by providing a detailed examination of the specific issues faced by higher education students during the COVID-19 pandemic, with a particular focus on the Malaysian context.

This research focuses on the experiences of higher education students in Malaysia, a country that has seen a rapid increase in internet penetration but still faces challenges in digital equity (MCMC, 2020). The study employs a mixed-method approach, combining quantitative analysis of survey data with qualitative insights from semi-structured interviews to gather in-depth insights from a diverse sample of students. The goal is to identify common themes and patterns that can inform targeted interventions and support mechanisms. The significance of this study lies in its potential to inform policy and practice in higher education. By highlighting the specific challenges and coping strategies of students, this research can guide the development of more effective and inclusive e-learning environments. Moreover, the study contributes to the broader discourse on digital education by providing empirical evidence from a region that is often underrepresented in global research (Trowler, 2010).

2. Methodology

2.1. Research design and participant selection
The study utilizes a mixed-methods research design, integrating quantitative and qualitative approaches to comprehensively examine students' adaptation to e-learning during the COVID-19 pandemic. This approach enhances the validity and reliability of the findings by triangulating data, thus combining the strengths of both methodologies (Creswell & Plano Clark, 2017) (Figure 1). The quantitative component involves collecting data to identify trends, correlations, and patterns related to e-learning adaptation across various demographic groups and academic disciplines. This broad overview allows for statistical analysis that highlights significant relationships and differences, providing a structured framework for understanding the overall impact of the shift to online learning (Creswell & Plano Clark, 2017).

In contrast, the qualitative component delves into the personal experiences and perceptions of students, offering rich, contextual narratives that help to interpret and add depth to the quantitative findings. This approach captures the complexity of students' adaptation processes and the nuanced challenges they faced during the pandemic (Denzin & Lincoln, 2018). The study was conducted in Malaysia, where the COVID-19 pandemic led to significant disruptions, including the closure of educational institutions. A maximum variation sampling technique was employed to ensure a diverse dataset, capturing a wide range of experiences across different sociodemographic variables, such as gender, age, academic year, rural/urban background, and enrollment at USM. This technique ensured the inclusion of varied perspectives, allowing for a more comprehensive understanding of the e-learning adaptation process (Tashakkori & Teddlie, 2010).

Participants were initially contacted via email and university communication channels, with snowball sampling employed to identify additional informants. The university facilitated interactive sessions over three weeks to actively engage students and gather qualitative data. These sessions not only promoted classroom involvement but also provided a platform for students to express their challenges and adaptations related to e-learning. This mixed-methods approach, combining quantitative data's structure with qualitative data's depth, ensures that the findings are both statistically significant and contextually grounded, offering a robust understanding of the complexities involved in e-learning adaptation during the pandemic.

2.2. Quantitative and qualitative data collection
The data collection for this study was strategically designed to capture both quantitative and qualitative insights into Malaysian frontline students' experiences with e-learning during the COVID-19 pandemic. Utilizing a snowball sampling technique, key informants were identified, ensuring a diverse range of perspectives. The data collection process spanned three weeks, during which interactive sessions were conducted to actively engage students and enrich the qualitative data. These sessions created a dynamic environment that facilitated the sharing of experiences and allowed for the emergence of new themes. The sample size was determined using the saturation criterion, which ensured that data collection continued until no new themes were identified, thus confirming the comprehensiveness of the dataset (Guest, Bunce, & Johnson, 2006).

Quantitative data were gathered through a structured online survey adapted from previous studies (Chen et al., 2020; Lau et al., 2020). This survey provided valuable insights into students' socio-economic backgrounds, access to technology, and perceptions of e-learning effectiveness. In parallel, in-depth, semi-structured interviews were conducted with a subset of participants. These interviews allowed for a deeper exploration of emerging themes and were guided by a script refined through a pilot study (Al Lily et al., 2020). Conducted online and transcribed for detailed analysis, the interviews maintained consistency while offering flexibility to address the evolving experiences of students.

The semi-structured interview approach was particularly effective in exploring key areas such as access to technology, internet reliability, and the impact of technical challenges on academic performance. Discussions also covered the financial burdens of maintaining connectivity, the influence of instructor support, and the challenges posed by home learning environments (Turner, 2010; King & Horrocks, 2010). This multi-method approach ensured a robust dataset, yielding nuanced insights that are critical for informing educational policy and support frameworks during and beyond the pandemic (Rubin & Rubin, 2011).
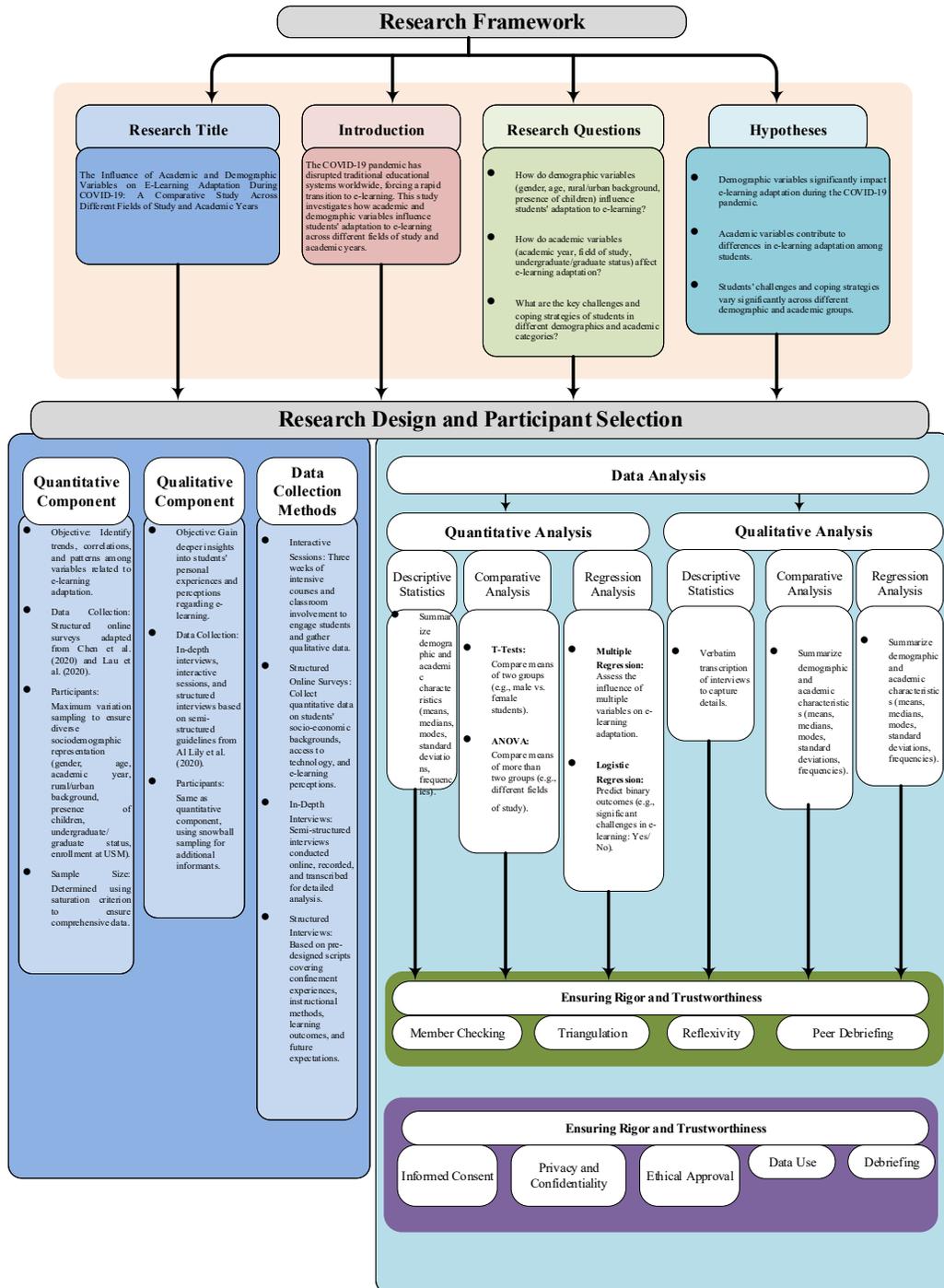

Figure 1. Research framework and design for e-learning adaptation during COVID-19

2.3. Qualitative and Quantitative analysis

The qualitative analysis in this study utilized a systematic thematic approach to delve into the complexities of students' e-learning adaptation during the COVID-19 pandemic. The process began with verbatim transcription of semi-structured interviews, ensuring that the subtleties of participants' experiences, including non-verbal cues, were preserved (Braun & Clarke, 2006). Following transcription, initial coding identified recurring themes, which were then refined through an iterative process, facilitated by NVivo software, enabling efficient data organization and management (Saldana, 2015).

A robust sample of 471 participants was strategically selected to ensure data saturation, confirming that the analysis captured the full range of students' experiences without introducing new themes (Patton, 2002). Thematic analysis was then conducted to explore complex phenomena related to e-learning adaptation, identifying and refining themes that were subsequently integrated into a coherent narrative addressing the research questions. This approach was enhanced by the use of illustrative quotes, which provided rich insights into the key challenges and coping strategies of the participants (Miles et al., 2014).

To ensure the reliability of the analysis, inter-coder reliability was employed, where multiple researchers independently coded a subset of data and compared interpretations, ensuring consistency and accuracy in the coding process (Lincoln & Guba, 1985). The quantitative data from the online survey were analyzed using descriptive statistics to summarize participants' demographic and academic characteristics, while comparative analyses, including t-tests and ANOVA, were used to explore differences in e-learning adaptation across various fields and academic years (Fowler, 2013).

2.3.1. T–Tests analysis

Independent t-tests were used to compare the means of two groups (e.g., comparing e-learning adaptation scores between male and female students) (Equation 1). This test helped in determining whether there were statistically significant differences between the groups in terms of their e-learning adaptation (Field, 2013). Mathematically we can define it as:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\dfrac{S_1^2}{n_1} + \dfrac{S_2^2}{n_2}}} \tag{1}$$

where, $\bar{X}_1$ and $\bar{X}_2$ are the means of two groups, s_1^2 and s_2^2 are the variances of the two groups, and n_1 and n_2 are the sample size of the two groups.

2.3.2. ANOVA analysis

One-way ANOVA was utilized to compare the means of more than two groups (e.g., comparing e-learning adaptation across different fields of study such as Sciences, Arts, and Social Sciences). ANOVA tests helped in identifying significant differences among multiple groups and understanding how e-learning adaptation varied across different academic disciplines (Howell, 2012). Five steps can be used to mathematically describe a one-way ANOVA:

Step 1: Calculate the Grand Mean ($\bar{X}$)

To calculate the grand mean ($\bar{X}$) in a one-way ANOVA, you first gather all observations from every group being compared. Sum these observations to get the total sum of all data points. Then, divide this total sum by the overall number of observations across all groups. The grand mean represents the average value of the entire dataset and serves as a reference point for understanding how each group's meaning compares to the overall average. This step is foundational for analyzing the variance both within and between the groups, helping to determine if the group differences are statistically significant.

Step 2: Total Sum of Squares (SST)

You evaluate the total variability in the dataset to calculate the Total Sum of Squares (SST) in a one-way ANOVA. First, subtract the grand mean (X^-) from each individual observation (X_{ij}) to find the deviation of each data point from the overall mean. Square each of these deviations to eliminate negative values and then sum all the squared deviations across all groups. This total, SST, captures the entire variation in the data, both within and between groups (Equation 2). SST is essential for partitioning the variance into components that explain differences between groups (SSB) and within groups (SSW).

$$SST = \sum_{i=1}^{n}\sum_{j=1}^{k}\left(X_{ij} - X^-\right)^2 \tag{2}$$

where Xij is the observation from group j, X^- is the grand mean.

Step 3: Between-Group Sum of Squares (SSB)

The Between-Group Sum of Squares (SSB) in a one-way ANOVA quantifies the variability between the group means and the overall grand mean. To calculate SSB, first find the mean of each group. Then, subtract the grand mean (X^-) from each group mean (X^-j) to determine how much each group's mean deviates from the overall mean. Square these deviations to eliminate negative values and multiply by the number of observations in each group (nj). Finally, sum these values across all groups. SSB represents the portion of total variability that is due to differences between the groups (Equation 3).

$$SSB = \sum_{j=1}^{k} n_j\left(X_j^- - X^-\right)^2 \tag{3}$$

where n_j is the number of observations in group j, X^-j is the mean of group j.

Step 4: Within-Group Sum of Squares (SSW)

The Within-Group Sum of Squares (SSW) in a one-way ANOVA measures the variability within each group, reflecting how individual observations differ from their respective group mean. To calculate SSW, subtract the group mean (Xj) from each observation (Xij) within that group to find the deviation of each data point. Square these deviations to remove negative values and sum them for all observations within the group. Repeat this for all groups and then sum these totals. SSW represents the portion of total variability due to differences within groups, helping to understand how much variation exists independent of group differences (Equation 4).

$$SSW = \sum_{i=1}^{k}\sum_{j=1}^{n_j}\left(X_{ij} - X_j^-\right)^2 \tag{4}$$

Step 5: F-Ratio

The F-Ratio in a one-way ANOVA is a key statistic used to determine whether there are significant differences between group means. To calculate it, first, find the Mean Square Between (MSB) by dividing the Between-Group Sum of Squares (SSB) by its degrees of freedom (number of groups minus one). Then, find the Mean Square Within (MSW) by dividing the Within-Group Sum of Squares (SSW) by its degrees of freedom (total number of observations minus the number of groups). The F-Ratio is then computed by dividing MSB by MSW. A high F-Ratio suggests significant differences between the group means, warranting further analysis (Equation 5).

$$F = \frac{MSB}{MSW} = \frac{\frac{SSB}{k-1}}{\frac{SSW}{n-k}} \tag{5}$$

where MSB is the mean square between groups, and MSW is the mean square within groups.

T-tests and ANOVA were employed to identify differences in e-learning adaptation among various student groups, revealing which demographics faced greater challenges or adapted more effectively. These statistical analyses were crucial for pinpointing areas where targeted interventions could be beneficial. Additionally, multiple regression models were developed to assess the influence of demographic and academic variables on e-learning adaptation. This method allowed for the simultaneous evaluation of multiple factors, providing a nuanced understanding of their collective impact on adaptation (Tabachnick & Fidell, 2013). Logistic regression was used when the dependent variable was binary, such as determining whether a student faced significant challenges in e-learning. This analysis predicted the probability of outcomes based on specific predictor variables (Hosmer & Lemeshow, 2013). These regression analyses were essential in identifying key predictors of e-learning adaptation, offering insights that can inform the creation of targeted support strategies to enhance adaptation among diverse student groups.

2.4. Ensuring rigor and trustworthiness

To enhance the rigor and trustworthiness of the qualitative analysis, the study employed several key strategies. Member checking was used to validate the accuracy of interview transcriptions, allowing participants to review and confirm the preliminary findings, ensuring alignment with their lived experiences. Triangulation further strengthened the research by cross-validating data from multiple sources, such as survey responses and interviews, providing a comprehensive view of e-learning adaptation. Reflexivity was maintained through a reflexive journal, where researchers documented personal reflections and potential biases, promoting transparency and objectivity in the analysis. Peer debriefing was also integral, involving discussions with qualitative research experts to validate the findings and introduce new perspectives. These strategies collectively ensured the credibility and reliability of the findings, reinforcing the study's contribution to understanding e-learning adaptation during the COVID-19 pandemic.

2.5. Ethical considerations

The ethical integrity of this study was rigorously upheld in accordance with Universiti Sains Malaysia (USM) guidelines, adhering to core principles such as respect for persons, beneficence, and justice. A key ethical consideration was obtaining informed consent, where participants were thoroughly informed about the study's objectives, procedures, potential risks, and benefits in an accessible format, ensuring their voluntary and informed participation. To protect participants' privacy and confidentiality, data anonymization was employed, with identifying information removed and replaced with unique codes. Data was securely stored in password-protected, encrypted databases, accessible only to authorized researchers, minimizing the risk of unauthorized disclosure.

The study protocol received ethical approval from the USM Ethics Committee after a comprehensive review, including a risk-benefit analysis. Measures were implemented to mitigate potential harm, such as minimizing emotional distress during interviews and ensuring strict confidentiality. The research strictly adhered to national and international ethical guidelines for research involving human subjects. Data collected was used solely for research purposes, with assurances that participants' identities would be protected in published results. A debriefing process followed participation, allowing participants to ask questions and learn how to access the study's findings, with support services contact information provided as needed. These comprehensive ethical measures underscored the study's commitment to maintaining the highest standards of research integrity and participant welfare.

3. Results and Discussions

3.1. Qualitative Results

The analysis of data from 471 higher education students in Malaysia reveals several key themes impacting their e-learning experiences during the COVID-19 pandemic. Firstly, access to technology and internet connectivity emerged as a significant barrier, with many students facing unreliable internet access and limited access to necessary devices, exacerbating the digital divide (Almaiah et al., 2020) Secondly, the learning environment at home posed considerable challenges, with students struggling to find quiet and dedicated study spaces amidst household distractions (Aldulaimi et al., 2021). Thirdly, students encountered various technical and cognitive challenges, including difficulties navigating e-learning platforms and maintaining concentration on complex concepts (Raccanello et al., 2022). These issues highlight the need for user-friendly e-learning systems and enhanced instructional design (Moore et al., 2011). Additionally, instructor support and engagement varied widely, with only 30% of students reporting high levels of support, while 20% experienced minimal support and 10% received none (Hodges et al., 2020). This inconsistency in support levels significantly influenced students' satisfaction and learning outcomes. Statistical analysis corroborates these qualitative insights, emphasizing the need for targeted interventions. To address these challenges, institutions must prioritize equitable access to technology, create supportive learning environments, improve technical support and cognitive strategies, and ensure consistent and proactive instructor engagement (Dhawan, 2020). By doing so, educational stakeholders can enhance the overall e-learning experience, making it more inclusive, effective, and resilient (Crawford et al., 2020).

3.1.1. Demographic Characteristics

The study's sample consisted of 471 higher education students from various universities in Malaysia, including both public and private institutions, to ensure a comprehensive understanding of the challenges faced by students across different educational settings. The demographic characteristics of the participants are summarized in Table 1. The gender distribution shows a higher proportion of male students (60%) compared to female students (40%). This disparity may indicate potential gender-based differences in e-learning experiences, which can provide insights into how male and female students navigate the challenges of online education. Age distribution indicates that the majority of students are in the 21-30 age group (45%), followed by those 20 and below (25%), 31-40 (20%), 41-50 (7.5%), and 51 and above (2.5%). This spread suggests that most students are young adults, likely balancing educational pursuits with other responsibilities such as employment or family obligations, impacting their e-learning experiences and challenges.

Table 1. Demographic characteristics of participants

Demographic Attribute	Frequency	Percentage (%)
Gender		
Male	120	60.0
Female	80	40.0
Age Group		
20 and below	50	25.0
21-30	90	45.0
31-40	40	20.0
41-50	15	7.5
51 and above	5	2.5
Year of Study		
Year 1	40	20.0
Year 2	50	25.0
Year 3	60	30.0
Year 4	30	15.0

Year 5	20	10.0
Monthly Income (MYR)		
1500 and below	50	25.0
1501-3000	60	30.0
3001-4500	40	20.0
4501-6000	30	15.0
6001 and above	20	10.0

The distribution across different years of study shows a relatively even spread, with Year 3 students comprising the largest group (30%), followed by Year 2 (25%), Year 1 (20%), Year 4 (15%), and Year 5 (10%). This variety allows for understanding how e-learning challenges may differ based on students' progression and familiarity with online learning environments. The monthly income data reveals economic diversity among the students. A significant portion of students (30%) have a monthly income between 1501-3000 MYR, with 25% earning 1500 and below, 20% earning 3001-4500 MYR, 15% earning 4501-6000 MYR, and 10% earning above 6001 MYR. This economic diversity highlights the digital divide, where students from lower-income brackets may face additional barriers such as inadequate devices or poor internet connectivity, further complicating their online learning experience.

The demographic diversity of the sample provides a robust foundation for understanding the multifaceted challenges faced by students in different contexts. Gender, age, year of study, and income level are critical factors influencing students' e-learning experiences. These insights are invaluable for educators, policymakers, and institutions aiming to design targeted interventions that address the specific needs of various student groups. By acknowledging and addressing these demographic differences, stakeholders can enhance the inclusivity and effectiveness of e-learning strategies, ultimately improving educational outcomes and student satisfaction in the post-pandemic era. This demographic analysis underscores the importance of tailored support systems to bridge gaps and foster a more equitable online learning environment.

3.1.2. Access to Technology and Internet Connectivity

The study's analysis of Malaysian higher education students' access to technology and internet connectivity highlights notable differences that affect how effective e-learning is. There is a definite relationship between students' monthly income and their experiences with connectivity problems, as seen in Table 2. The biggest obstacles are faced by students from lower-income families; 60% of those making 1500 MYR or less report having frequent connectivity issues. This is in sharp contrast to the comparable problems experienced by 20% of students whose monthly income exceeds 6000 MYR. These results draw attention to a critical component of the digital divide: socioeconomic status has a direct impact on students' capacity to obtain dependable internet access and, as a result, on their effectiveness in participating in e-learning.

Table 2. Monthly income and internet access

Monthly Income (MYR)	Frequency	Percentage (%)	Connectivity Issues (%)
1500 and below	50	25.0	60.0
1501-3000	60	30.0	50.0
3001-4500	40	20.0	40.0
4501-6000	30	15.0	30.0
6001 and above	20	10.0	20.0

The differences in students' access to internet connectivity are a serious problem since they have an impact on their capacity to participate in online learning, access resources, and finish assignments. Instable internet connectivity is a major learning challenge for kids from lower-income backgrounds, exacerbating the already existing educational inequality. In addition to negatively affecting academic achievement, the digital gap also negatively affects students' entire learning experiences and their capacity to stay up with

their classmates. Regular connectivity problems break the flow of instruction, causing students to miss sessions, find it difficult to participate in discussions, and struggle to finish online tests. These interruptions are especially harmful in an online learning setting where maintaining academic progress depends on regular access to digital platforms.

The results of the study demand quick action to close these gaps. Improving technology infrastructure and granting all students fair access to dependable internet service should be top priorities for educational institutions and legislators, especially for those from lower-class backgrounds (Andres et al., 2023). Subsidized internet subscriptions, the supply of required tech, and the creation of community access points where students can participate in online learning without service outages are all possible remedies (Faturoti, 2022; Kelley & Sisneros, 2020).

The findings of the research need quick action to close these gaps. Especially for kids from lower-income households, institutions and legislators need to place a high priority on updating technology infrastructure and granting equitable access to dependable internet. Some possible remedies include offering discounted internet packages, supplying the required technology, and setting up public access points where students can participate in online education without experiencing service outages.

3.1.3. Learning Environment and Distractions

Students have to adjust to home-based learning environments due to a change to e-learning, which is often fraught with distractions that impair their academic performance. As indicated by Table 3, 40% of the students who were questioned reported that their primary source of distraction is domestic obligations. This illustrates the additional difficulty that many students encounter in juggling their academic goals with household responsibilities. Another major problem that 35% of students mentioned was noise from family members, underscoring the difficulty of getting quiet, uninterrupted study time in a home setting. Additionally, 25% of students cited a primary barrier as not having a designated study area, which makes it harder for them to concentrate and give their all in their assignments.

Table 3. Types of distractions

Type of Distraction	Frequency	Percentage (%)
Household responsibilities	80	40.0
Noise from family members	70	35.0
Lack of dedicated study space	50	25.0

It is impossible to overstate how much these distractions affect students' e-learning experiences. Studying takes up time and attention that could be spent on household duties like childcare or chores. Family members' noise interferes with focus and lowers the level of involvement with the lesson subject. Students frequently work in multipurpose spaces that are not conducive to prolonged focus and production when there is no designated study space available to them. The results imply that many students' home environments are not conducive to academic work, which has a major negative impact on their capacity to gain from online learning.

A diversified strategy is needed to address these problems. Institutions of higher learning can offer advice and materials to assist students in setting up more comfortable learning spaces. It is recommended that policymakers and educational institutions take into account several solutions, including the provision of noise-canceling headphones, flexible scheduling to accommodate household duties, and the possibility of allowing access to quiet study rooms on campuses or community centers. Stakeholders may improve the overall effectiveness and inclusivity of e-learning by comprehending and reducing the environmental distractions that students encounter. This will guarantee that every student has the chance to achieve despite the difficulties presented by their home learning environment.

3.1.4. Technical and Cognitive Challenges

In the context of e-learning, students encounter various technical and cognitive challenges that significantly impact their educational experience. As detailed in Table 4, many students face technical difficulties that impede their ability to engage with e-learning platforms effectively. Specifically, 45% of students report difficulty using these platforms, which can disrupt their participation in online classes and hinder interaction with peers and instructors. This challenge is compounded by issues related to accessing course materials, affecting 40% of the students, and problems with submitting assignments, which impact 35% of the cohort. These technical barriers not only slow down the learning process but also create additional stress and frustration for students, making it difficult to maintain consistent academic performance.

In addition to technical issues, cognitive challenges play a crucial role in the e-learning environment. Many students struggle to maintain concentration during online classes and grapple with understanding complex concepts without the immediate, in-person support that traditional classroom settings offer. These cognitive hurdles are exacerbated by the lack of direct engagement and the often-passive nature of online learning, which can lead to decreased motivation and lower retention of information.

Table 4. Technical challenges

Technical Challenge	Frequency	Percentage (%)
Difficulty using e-learning platforms	90	45.0
Issues with accessing course materials	80	40.0
Problems with submitting assignments	70	35.0

The intersection of technical and cognitive challenges underscores the need for comprehensive support systems to enhance the e-learning experience. Educational institutions must invest in user-friendly e-learning platforms, provide thorough training for both students and instructors on utilizing these technologies, and ensure robust technical support is readily available. Additionally, incorporating interactive and engaging teaching methods can help mitigate cognitive challenges by keeping students motivated and better able to grasp complex material. Addressing these challenges holistically is essential for fostering an effective and inclusive e-learning environment that meets the diverse needs of all students.

3.1.5. Instructor Support and Engagement

Instructor support is a pivotal element in shaping students' e-learning experiences, as evidenced by the findings presented in Table 5. The data reveals that while 30% of students perceive their instructors as highly supportive and 40% view them as moderately supportive, a significant portion of students still experience minimal or no support 20% and 10%, respectively. This disparity in support levels underscores the critical impact of instructor engagement on students' learning outcomes and overall satisfaction with e-learning. Proactive and consistent support from instructors is essential in mitigating the challenges associated with online learning, such as technical difficulties and cognitive overload. Highly supportive instructors can provide timely feedback, foster interactive learning environments, and address individual student needs, thereby enhancing the educational experience. Conversely, minimal or lack of support can exacerbate students' feelings of isolation and frustration, negatively affecting their academic performance and motivation.

Table 5. Instructor support and engagement

Level of Support	Frequency	Percentage (%)
Highly supportive	60	30.0
Moderately supportive	80	40.0
Minimally supportive	40	20.0
Not supportive	20	10.0

These findings highlight the urgent need for professional development programs that equip instructors with the skills and strategies necessary for effective online teaching. By prioritizing instructor engagement and support, educational institutions can create a more supportive and conducive e-learning environment that promotes student success and satisfaction, addressing the diverse needs of the student population in the digital age.

3.1.6. Assessment Preferences

The shift to online learning during the COVID-19 pandemic has significantly influenced students' preferences for assessment methods, as evidenced by the survey results presented in Table 6.

Table 6. Assessment preference

Assessment Preference	Frequency	Percentage (%)
Physical Continuous Assessment	80	40.0
Online Continuous Assessment	120	60.0

The majority of students (60%) expressed a preference for online continuous assessments compared to 40% who favored traditional physical assessments. This inclination towards online assessments highlights the perceived benefits of digital formats, including greater flexibility and accessibility. Online continuous assessments allow students to complete evaluations at their own pace and from any location, which is particularly advantageous during a time of restricted physical movement and social distancing. Additionally, online assessments can be more easily integrated with e-learning platforms, providing a seamless experience that can reduce stress and logistical challenges associated with physical assessments. This preference also reflects students' adaptability to new technologies and their desire for assessment methods that accommodate diverse learning environments and individual circumstances. The findings suggest that educational institutions should consider incorporating more online assessment options to meet student preferences and enhance the overall e-learning experience. Adapting to these preferences can contribute to a more inclusive and effective assessment strategy, aligning with the evolving needs of students in a digital learning landscape.

3.2. Quantitative Results

The comprehensive design of this study, which incorporates a mixed-methods approach, provides an in-depth understanding of the preparedness of Malaysian frontline students for e-learning. By capturing a broad spectrum of experiences and perspectives, the study offers valuable insights that can guide the development of effective educational policies and support systems. The survey encompassed a wide array of questions, addressing various aspects such as participants' demographics, internet access, and their experiences with e-learning during the COVID-19 pandemic. A total of 471 participants responded to the survey, shedding light on the challenges they faced and their preferences within an online learning environment. Notably, the response rate for most questions was exceptionally high, ranging from 97% to 100%. The detailed summary of survey questions and the corresponding number of responses is presented in Table 7.

Table 7. Summary of survey questions, number of responses, and response percentages

Index	Theme	Responses	Percentage
1	Gender	467	99%
2	Age	470	100%
3	Race	470	100%
4	Marital Status	468	99%
5	Year of study	470	100%
6	Field of Study	468	99%
7	Major/Minor in Geography	459	97%
8	Are you a frontliner?	470	100%

9	Employment sector	471	100%
10	Monthly income (MYR)	470	100%
11	Are you facing problems with internet access?	471	100%
12	Is your internet access sufficient to attend Webex meetings?	471	100%
13	Internet bill per month	471	100%
14	As a Distance Education student, does providing sufficient internet access burden you?	470	100%
15	Are you facing problems in learning during the COVID-19 pandemic?	468	99%
16	Can you attend scheduled Webex meetings?	469	100%
17	Constraints on work, unpredictable schedules	469	100%
18	Difficulty focusing due to disruptions from children	466	99%
19	Not being familiar with the scheduled learning topics	469	100%
20	Feeling the importance of recorded Webex sessions because instructors will provide them	470	100%
21	Often forget date and time of scheduled Webex sessions	470	100%
22	Does attending Webex sessions help you understand the content better?	470	100%
23	Internet access issues	468	99%
24	Disturbance from noise made by other students	469	100%
25	Difficulty understanding what the instructor is conveying	471	100%
26	Do you face challenges in completing assignments given by instructors?	471	100%
27	Given the choice, would you prefer to complete individual assignments or group assignments?	471	100%
28	Does group assignment pose constraints for you in completing it?	467	99%
29	Do you have sufficient internet access during Practical Work sessions?	470	100%
30	Can you complete Practical Work within the given timeframe?	470	100%
31	Given the choice, would you prefer to answer Physical Continuous Assessment or online?	467	99%
32	Device used to answer daily Practical Work	469	100%
33	Location where you answer daily Practical Work	469	100%
34	Does your employer provide leave for scheduled Practical Work sessions?	467	99%

3.3. Distribution of Participants

The analysis of participant demographics reveals notable imbalances in gender, age, and field of study, which are crucial for interpreting the study's findings on e-learning adaptation (Figure 2).

Gender Distribution: The study sample consists of 302 male and 169 female participants, highlighting a significant gender disparity. This imbalance suggests that the academic programs surveyed may be male-dominated, which could influence the generalizability of the results (Figure 2a). The higher representation of male students allows for detailed insights into their e-learning challenges, but the lower number of female participants indicates a need for further research to explore gender-specific issues more comprehensively. Educational institutions should address this imbalance by implementing targeted support mechanisms for both genders, ensuring equitable access to resources and support. Future research should aim for a more balanced gender representation to enhance the validity and generalizability of findings.

Age Distribution: Participants are primarily grouped into ages 31-40 (over 250 students) and 21-30 (around 160 students). The substantial representation of mature students (31-40 years) suggests that e-learning strategies should address their unique challenges, such as balancing studies with work and family commitments. The 21-30 age group, which includes many recent undergraduates pursuing advanced

studies, may benefit from engagement and career support. Fewer participants are in the 20 and below, 41-50, and 51-60 age groups, indicating a need for targeted outreach to these demographics. Institutions should develop age-specific support programs, such as flexible scheduling for mature students and mentorship for younger students, to cater to diverse needs (Figure 2b).

Field of Study Distribution: Social Sciences (260 participants) and Arts (150 participants) are the most represented fields, suggesting higher enrollment or interest in these areas. Science has around 70 participants, while Management has the fewest. The high representation in Social Sciences and Arts indicates these fields may have higher enrollment rates or interest, reflecting broader trends or institutional strengths (Figure 2c). However, the lower representation in Science and Management fields highlights a need for additional research and targeted support for students in these areas. Institutions should enhance support and outreach for underrepresented fields, encourage interdisciplinary collaboration, and develop targeted interventions to address the specific challenges faced by students in less represented disciplines.

Understanding these demographic distributions can help educational institutions tailor e-learning support to meet the diverse needs of their student populations.
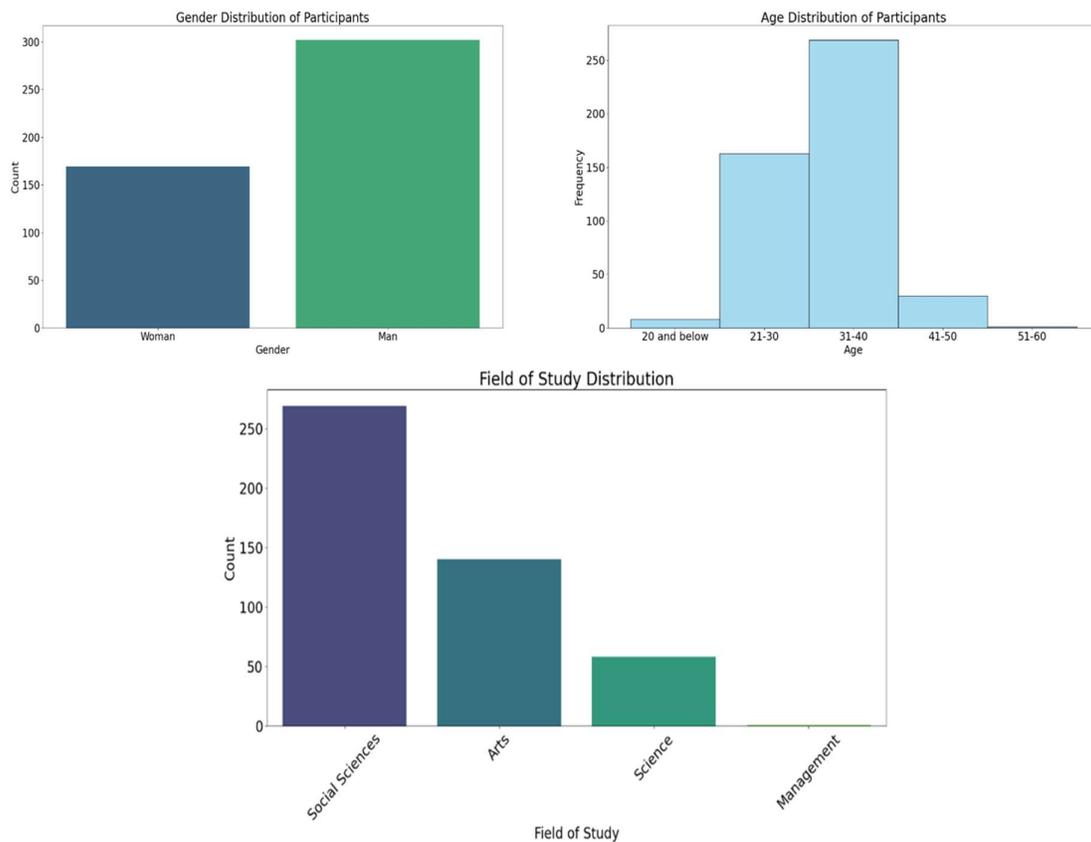

Figure 2. (a) Gender distribution of participants (b) Age distribution of participants (c) Field of Study Distribution.

3.4. Distribution of E-Learning Problems by Field of Study

The distribution of e-learning problems across different fields of study was analyzed to identify which academic disciplines experienced the most significant challenges during the COVID-19 pandemic. Figure 3 illustrates the count of participants who reported facing e-learning problems, categorized by their field of study.
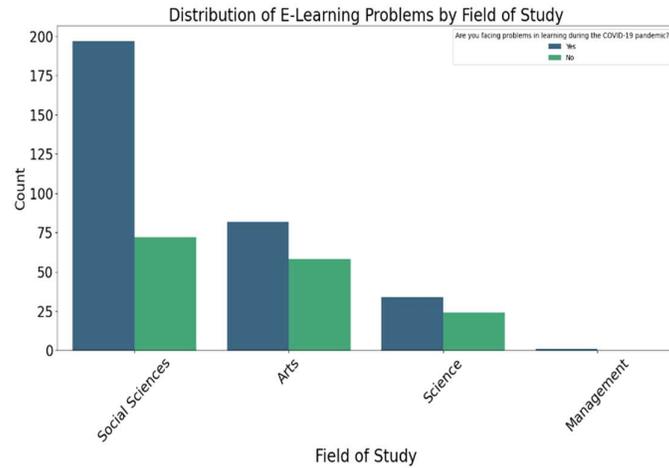
Figure 3. Distribution of E-Learning problems by field of study.

The study reveals a significant variation in e-learning challenges across different academic fields. In the Social Sciences, nearly 200 students reported e-learning problems, indicating substantial difficulties in adapting to online learning. The Arts field also faced considerable issues, with approximately 100 students experiencing challenges, highlighting the need for targeted support. The Science field reported fewer problems, with about 50 students indicating difficulties, suggesting better adaptation to e-learning. The Management field had the lowest number of reported issues, which might reflect either effective e-learning infrastructure or a smaller sample size.

These findings underscore the need for tailored interventions in Social Sciences and Arts, such as enhanced access to resources, digital literacy training, and mental health support. The relative success of Science students in adapting to e-learning should inform best practices for other disciplines. Further investigation is needed for the Management field to understand the underlying factors behind its low problem rates. Institutions should focus on providing additional support and regularly assessing e-learning challenges to improve overall student experiences.

3.5. Distribution of E-Learning problems by field of study and gender

The analysis of e-learning problems by field of study and gender reveals distinct patterns and highlights the challenges faced by different groups during the COVID-19 pandemic. The results are summarized in Table 8.

Table 8. Summary of students facing e-learning problems based on field of study and gender

Field of Study	Gender	No	Yes
Arts	Man	35 (25.0%)	65 (46.43%)
	Woman	23 (16.43%)	17 (12.14%)
Management	Man	0 (0.0%)	1 (100.0%)
Science	Man	10 (17.24%)	11 (18.97%)
	Woman	14 (24.14%)	23 (39.66%)
Social Sciences	Man	45 (16.73%)	134 (49.81%)
	Woman	27 (10.04%)	63 (23.42%)

The study reveals notable differences in e-learning challenges across various academic fields and gender groups. In the Arts, 46.43% of men and 12.14% of women reported e-learning problems, indicating that male students face more significant challenges, possibly due to varying learning styles or support mechanisms. In Management, 100% of the single male respondent reported e-learning issues, suggesting

potential systemic concerns in this field, although the small sample size limits broader conclusions. In Science, 18.97% of men and 39.66% of women reported problems, with women experiencing more difficulties, potentially linked to the technical demands of the coursework and resource access. Social Sciences students reported the highest levels of e-learning issues, with 49.81% of men and 23.42% of women facing problems, reflecting widespread challenges that may involve engagement and resource availability.

These findings underscore the need for field-specific and gender-targeted support strategies to enhance e-learning experiences. The high incidence of issues among men in the Arts and Social Sciences suggests a need for improved access to digital resources and tailored engagement strategies for male students. Conversely, the greater challenges faced by women in Science highlight the need for initiatives such as mentorship programs, peer support, and enhanced digital literacy to address gender-specific barriers. The extreme reporting of problems in Management, despite limited data, indicates potential systemic issues requiring further investigation. Overall, developing comprehensive, field-specific support mechanisms and regularly assessing e-learning challenges across demographics will be crucial in improving the e-learning environment and supporting all students effectively during and beyond the pandemic.

3.6. Year of Study, Gender and E-Learning Problems

The analysis of e-learning problems by year of study, age, and gender reveals several patterns and correlations. In Table 9, we summarized the outcomes.

Table 9. Summary of students facing e-learning problems based on year of study, age and gender

Year of Study	Age	Gender	No	Yes
Year 1	20 and below	Woman	1 (100.0%)	0 (0.0%)
	21-30	Man	8 (29.63%)	7 (25.93%)
		Woman	7 (25.93%)	5 (18.52%)
	31-40	Man	1 (6.67%)	7 (46.67%)
		Woman	4 (26.67%)	3 (20.0%)
	41-50	Man	1 (33.33%)	1 (33.33%)
		Woman	1 (33.33%)	0 (0.0%)
Year 2	20 and below	Man	1 (20.0%)	0 (0.0%)
		Woman	2 (40.0%)	2 (40.0%)
	21-30	Man	8 (15.69%)	17 (33.33%)
		Woman	8 (15.69%)	18 (35.29%)
	31-40	Man	12 (19.35%)	33 (53.23%)
		Woman	10 (16.13%)	7 (11.29%)
	41-50	Man	2 (25.0%)	5 (62.5%)
		Woman	0 (0.0%)	1 (12.5%)
Year 3	21-30	Man	12 (25.53%)	23 (48.94%)
		Woman	3 (6.38%)	9 (19.15%)
	31-40	Man	8 (11.27%)	38 (53.52%)
		Woman	10 (14.08%)	15 (21.13%)
	41-50	Man	2 (33.33%)	1 (16.67%)
		Woman	0 (0.0%)	3 (50.0%)
	51-60	Man	1 (100.0%)	0 (0.0%)
Year 4	20 and below	Man	1 (50.0%)	0 (0.0%)
		Woman	0 (0.0%)	1 (50.0%)
	21-30	Man	5 (20.83%)	10 (41.67%)
		Woman	4 (16.67%)	5 (20.83%)
	31-40	Man	10 (12.35%)	43 (53.09%)

		Woman	8 (9.88%)	20 (24.69%)
	41-50	Man	2 (40.0%)	1 (20.0%)
		Woman	1 (20.0%)	1 (20.0%)
	21-30	Man	6 (50.0%)	1 (8.33%)
		Woman	1 (8.33%)	4 (33.33%)
Year 5	31-40	Man	9 (24.32%)	20 (54.05%)
		Woman	3 (8.11%)	5 (13.51%)
	41-50	Man	1 (12.5%)	2 (25.0%)
		Woman	2 (25.0%)	3 (37.5%)

The analysis of e-learning challenges by year of study, age, and gender uncovers significant patterns and correlations. For first-year students, men aged 31-40 reported the highest prevalence of e-learning difficulties compared to other age groups, while women in the same bracket encountered fewer issues. This disparity suggests that older male students may face greater difficulties adapting to online platforms due to limited familiarity with digital tools. In the second year, men aged 31-40 continued to experience substantial e-learning problems, indicating persistent adaptation challenges. Conversely, younger women aged 21-30 also reported considerable issues, potentially due to the demands of balancing e-learning with other responsibilities.

By the third year, both men and women aged 31-40 exhibited the highest levels of e-learning difficulties, likely due to increased family or work-related responsibilities. Men aged 21-30 faced notable challenges as coursework complexity increased. In the fourth and fifth years, men in the 31-40 age group consistently reported the highest levels of e-learning issues, with women in the same age range also experiencing significant problems. This highlights the pervasive nature of e-learning challenges across genders and age groups.

To address these issues, targeted interventions are recommended, including flexible scheduling, digital literacy training, and additional resources for older students. First-year orientation programs should focus on familiarizing students with e-learning tools. Regular assessments of e-learning challenges and peer mentorship programs can further enhance support. Data visualization, including histograms, was used to compare e-learning problems across different demographic groups, illustrating a trend of increasing difficulties with advancing years of study. Specifically, men aged 31-40 reported the highest e-learning issues, particularly in Year 4. These findings emphasize the need for targeted support strategies to help senior students, especially men, effectively navigate e-learning challenges.

3.7. T-test and ANOVA Results

In our study, we utilized the T-test and ANOVA to analyze e-learning problems among students. The T-test was employed to compare mean 'Problems' scores between male and female students, determining if gender significantly influences the extent of e-learning issues. This test is particularly effective for comparing two independent groups and helps in testing hypotheses about their means. On the other hand, ANOVA was used to compare mean 'Problems' scores across multiple fields of study. ANOVA is advantageous for simultaneously analyzing the means of three or more groups and controls the overall Type I error rate more effectively than multiple T-tests, thereby reducing false-positive results. By employing these statistical methods, we aimed to identify significant differences related to gender and academic discipline, which is critical for designing targeted interventions. The results from these analyses offer valuable insights for developing tailored strategies to enhance e-learning experiences for diverse student groups. The findings from the T-test and ANOVA are summarized in Table 10.

Table 10. Summary of T-Test results.

Statistic	1.8449449255256245
p-value	0.06567583772178066
df	469.0

The T-test comparing mean 'Problems' scores between male and female students reveals subtle gender differences in e-learning challenges during the COVID-19 pandemic. The t-value of 1.845 indicates a potential difference in e-learning difficulties between genders, though the variation is not substantial. The p-value of 0.066, which is slightly above the conventional significance threshold of 0.05, suggests that while there is some evidence of gender-related differences, it is not statistically significant at the 5% level. This means the null hypothesis, which posits no difference between genders, cannot be rejected with strong confidence. However, the p-value's proximity to 0.05 indicates a marginally significant trend, implying that gender might influence e-learning experiences. With 469 degrees of freedom, the results benefit from a substantial sample size, enhancing reliability. Although not conclusive, the findings suggest that further research with larger samples or specific analyses could provide more definitive insights into gender-based differences in e-learning challenges.

Table 11. Summary of ANOVA results

	sum_sq	df	F	PR(>F)
C (Q ("Field of Study"))	2.895525	4.0	3.325542	0.010594
Residual	101.435685	466.0	NaN	NaN

The ANOVA test results reveal significant variation in e-learning difficulties across different fields of study during the COVID-19 pandemic. The Sum of Squares (sum_sq) for the 'Field of Study' variable is 2.896, indicating the proportion of total variance in e-learning problems attributed to differences among fields. The residual sum of squares is 101.436, representing the variability within each field. With 4 degrees of freedom for the 'Field of Study' and 466 for the residual, the analysis captures both inter-field and intra-field variability. The F-statistic of 3.326, reflecting the ratio of variance between fields to within fields, suggests that observed differences are meaningful. A p-value of 0.011, below the 0.05 threshold, confirms that the null hypothesis no difference in e-learning problems across fields can be rejected. This indicates that e-learning challenges significantly differ among academic disciplines. These results emphasize the need for field-specific interventions to address the unique challenges faced by students in various disciplines, improving the overall efficacy of e-learning environments.

4. Conclusion

The findings from this study underscore the multifaceted challenges faced by higher education students in Malaysia during the transition to e-learning amidst the COVID-19 pandemic. One of the most significant barriers identified is access to technology and internet connectivity. The digital divide, particularly affecting students from lower-income backgrounds, exacerbates difficulties in participating in online classes and accessing essential educational resources. This highlights the urgent need for enhanced technological infrastructure and support to ensure equitable access to e-learning. Additionally, the learning environment at home poses considerable challenges, with many students struggling to maintain focus due to household responsibilities, noise, and lack of dedicated study spaces. Addressing these environmental factors is crucial to improving students' concentration and productivity in a remote learning context.

Technical and cognitive challenges also emerged as prevalent issues, with students facing difficulties in using e-learning platforms and grasping course materials. These challenges highlight the need for user-friendly systems and instructional designs that cater to diverse learning needs. Enhanced support and training for both students and instructors can mitigate these issues, improving the overall e-learning experience. Moreover, the study revealed significant variability in instructor support and engagement, which directly impacts student satisfaction and learning outcomes. Consistent and proactive engagement from instructors is essential to foster a positive and effective online learning environment.

The study also observed a shift in students' preferences towards online continuous assessments, reflecting the adaptability of students in the digital age. This indicates that educational institutions should consider more flexible and accessible assessment methods to accurately measure student understanding and skills. The comprehensive analysis presented in this study provides valuable insights for educators, policymakers, and institutions to develop targeted interventions that support students effectively. By addressing these challenges through strategic planning and resource allocation, stakeholders can create a more inclusive, effective, and resilient e-learning ecosystem that meets the diverse needs of all students.

Declarations

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Conflict of Interest
The authors declare no conflict of interest.

Data Availability
The data supporting the findings of this study are available from the corresponding author upon request.

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