# The two-step cluster analysis of pre-COVID-19 experience and cybersecurity concerns about online education for academic staff in Saudi universities

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A R T I C L E   I N F O

A B S T R A C T

The purpose of this research is to learn about the attitudes of the academic staff of the medical, business, humanities, and science and engineering disciplines concerning online education during the COVID-19 pandemic at Umm Al-Qura University (UQU), Saudi Arabia. While research in online education focuses on learning experiences such as facilities, learning materials, and learning interests, several elements of online education in this research were investigated, including advantages, features, and cybersecurity. The research data were gathered through a survey containing three demographic items, four items on perceptions of online education, and seven questions on perceptions of cybersecurity. Responses obtained from 238 academic staff were used for statistical analysis. After the routine descriptive analysis analyses, the response data were subjected to unsupervised k-means centroid cluster analysis. Two clusters of academic staff differing in teaching disciplines, and pre-COVID experience in online education were identified. Cluster 1 had medical and business and humanities academic staff, predominated by those without pre-COVID experience in online education, and perceived online education and cybersecurity at neutral to a slightly low level. Cluster 2 consisted of science and engineering discipline academic staff predominated by those with pre-COVID online education experience and perceived online education and cybersecurity in the range of neutral to slightly high levels. The result of this study shows that academic staff in the medical, business, and humanities disciplines have less expertise with online education software and a low level of awareness about online education security. On the other hand, academic staff of science and engineering disciplines fields has more expertise with online educational technologies and a better level of understanding of online education security.

## 1. Introduction

The COVID-19 pandemic has negatively impacted the education of students and academic staff all over the world due to the need for movement restrictions and social distancing (Alghamdi, 2021). Most countries switched to online education mode to solve this problem and ensure that the education of students is least affected (Mishra et al., 2020). Saudi Arabia has also been using this strategy since the

time the pandemic assumed serious proportions. Currently, the threat of new waves of attacks by new variants of the virus prevents the restoration of classroom education for some more time. At present, in order for online education to be effective, it is vital to understand what elements contribute to their desire for online education now and after the pandemic. It mostly relies on whether and how people perceive the benefits of online education. Another factor that affects the successful use of online education, even if students and academic staff want to use it, is the implicit cyber threats associated with public internet platforms. Attack of hackers can crash the systems and thereby, interfere with their learning process. Hence, the students and academic staff may want the administrators of online education platforms to provide guaranteed

cybersecurity. Therefore, the aim, in terms of a research question was as follows:

What benefits are perceived by Saudi universities' academic staff of online education and the relevance of cybersecurity when using online platforms for learning?

## 2. Literature review

The perceptions of the benefits of online education for English language students at Indonesian colleges were positive as reflected in their responses to the open-ended question. However, they encountered issues with the accessibility and sustainability of internet connections, the accessibility of educational media, and the compatibility of media access technologies. The need for more student and academic staff-friendly learning platforms was suggested. These problems were more serious in rural areas (Agung et al., 2020).

According to the findings of an online survey of Indian agricultural students, Muthuprasad et al. (2021) discovered that most students opted to use online classrooms to cope with the pandemic. For learning, most students used smartphones to access learning platforms. To increase the efficacy of learning, academic staff preferred recorded lessons with a quiz at the end of each class. Online education users perceived the attractiveness of online classes due to their flexibility and convenience, comfortable environment improves technical skills. More interactions and greater ability to concentrate and self-discipline and responsibility. However, broadband connectivity issues in rural areas, data limit and speed, absence of face-to-face interactions, high requirement of self-discipline, lack of devices, poor learning environment, and technophobia were some constraints. Factors related to the success and failure of online education were also enumerated. Based on these, improvement suggestions were also made by both academic staff and students. Agricultural education being more practical oriented, online mode alone may be inadequate and a hybrid mode may be more desirable.

The Mizoram University in India implemented online teaching and learning and subsequent semester examinations to address problems in education due to the COVID-19 pandemic. Mishra et al. (2020) used a mixed approach to identify the perspectives of students and academic staff in this regard. The purpose of this study was to determine how effective change management processes were in implementing online teaching-learning processes in the education system during the outbreak to overcome the ongoing academic disruption and ensure the resumption of educational activities and discourses as a normal course of procedure in the university education system. Prior to the COVID-19 pandemic, online education was only done by open universities. Other universities and various stakeholders were not equipped to handle the sudden change over to online mode. A change management model for successful implementation starts with the UGC (the central organization in charge of higher education in the country as a whole) and stretches to students as its lowest-level end-users to the final outcome. It is easier to use social media platforms like Facebook, WhatsApp, and Twitter, which facilitate the utilization of online educational platforms such as WebEx, Teams, and Zoom. Many of these are free and user-friendly. Therefore, there is no need to panic search for a new technology for online education.

Most of the stakeholders already use the smartphone in which these applications are already pre-loaded. Mizoram University has an IT department and a Learning Management System (LMS) for the implementation and seamless monitoring of online education. Yet some academic staff and students were hesitant due to their doubt about their own capability to handle the technological aspects of online education. The authors used a survey for both teaching faculty and students covering all major departments of the University. For interviews, 20 faculty and 20 students were used. Besides the University's own LMS, both academic staff and students were using various other online education platforms, some of which were named above.

New tools like those recently developed by the Mizoram digital TV teaching in higher education (DTH) educational platform of 24 channels were also being used by a few participants. The attempt of the University had been successful so far in teaching and evaluation through semester examinations and academic staff make improvements on teaching based on feedback in the LMS. Time-bound relevance and criticality of the issue have compelled all stakeholders to rise to the occasion and accept the change, albeit with some hesitation on the part of a few of them. It is likely that post-COVID, a hybrid educational method consisting of both classroom and teaching will continue to be followed.

Polish medical students perceived the ability to stay at home, have continuous access to learning material, learn according to their own pace, and enjoy ability and comfortable surroundings, as the benefits of online education. The main disadvantages were a lack of interactions with patients and IT equipment problems. But e-learning was perceived to be less effective than face-to-face learning, as they were less active compared to classrooms (Bączek et al., 2021).

The survey results of an Indonesian study by Laili and Nashir (2021) on English language degree students revealed that although flexibility was a positive factor, unstable signals, lower motivation, greater difficulty in conversation practice, and high internet costs were negative factors. Face-to-face learning was preferred by over 90% of students. Solving the problems listed by the students may enhance the acceptability of online education by academic staff and students. A small sample size of

107 could also have affected the acceptance of online education by the surveyed students. In a study of a similar type of students in Indonesia, Nugroho et al. (2020) noted that the academic staff used Google Classroom for the theoretical part, Google Meet for interactions, and the free translation memory tool (Omega T) for translation practice. In interviews, most students said that did not like the online method of teaching due to difficulties. But questionnaire survey responses showed 90% of students happy with Google Classroom and Omega T. In another similar Indonesian study by Allo (2020), interview responses of students revealed online learning to be helpful to them during this pandemic period. Problems with internet access, financial issues, and implementation of online education were also highlighted by the students. Academic staff suggested lecturer facilitate access to free messenger applications in the learning management system, internet availability to ensure physical distancing, and group tasks to help friends and explanations to precede material and assignments in the online content. Effective use of voice notes was implied in the implementation aspect. In a study by Budur (2020), since English language students at a university in Iraq received lower than what was expected, a little less than half of them were satisfied with online education, which was implemented to prevent the loss of the academic year for both academic staff and students.

According to Sujarwo et al. (2020), they discovered that before the pandemic, academic staff and students did not use internet learning and solely classroom education. With the outbreak of the COVID-19 pandemic, students got eager in embracing online education owing to its convenient accessibility from anywhere and at any time. Academic staff and students used WhatsApp most commonly as they found it the best. Consequently, despite the pandemic, the attitudes of both about online learning were positive.

From the results of a survey of Pakistani undergraduate and postgraduate students, Adnan and Anwar (2020) concluded that online education is not suitable for underdeveloped countries like Pakistan due to inaccessibility and cost issues for a majority of students. Inadequacies of face-to-face interactions with academic staff, classroom socialization, and response time were also given as the reasons by both of them. Then, how else education can proceed in the current pandemic situation of the country, remains unanswered.

The specific vulnerability of online medical education during this COVID-19 pandemic was discussed by Shah et al. (2020) in a commentary based on published literature. Large-scale propagation of unfounded content and imposters through social media is also a cybersecurity threat to online education during this pandemic. The need for updating regulatory mechanisms to ensure the privacy and cybersecurity of telemedicine transactions during education in clinical practices was stressed. Cybersecurity was highlighted by Jayakumar et al. (2020) as one of the seven lessons learned from the COVID-19 pandemic due to the increased vulnerability of interacting platforms, which includes online education. A respond-recover-reimagine strategy for the digital resilience of online higher education, including elements of cybersecurity, was suggested by Bhagat and Kim (2020).

Nambiar (2020) conducted a survey on the perceptions of academic staff and students in India on online education, revealing that about one-third of academic staff agreed that online classes are not safe and secure methods of teaching.

## 3. Methodology

### 3.1. Research design

The method adopted for this primary research was a quantitative survey as it was most suitable to answer the research question 'What' benefits perceived by Saudi universities' academic staff of online education and the relevance of cybersecurity when using online platforms for learning? Questions like 'What' demands a list of factors and relationships among them. So, they are best answered through surveys, as has been explained by Creswell (2012). The survey used a Likert scale from 1 to 5. The rating scale was: 1-low, 2-slightly low, 3-Neutral, 4-slightly high, and 5-high.

### 3.2. Population sampling and survey development

There are about 1.6 million university students and 850,000 universities academic staff in Saudi Arabia in MOE (2022). Given the country's rapid development of higher education as part of its Vision 2030 objectives, this figure may now be greater. Umm Al-Qura University has roughly 4538 academic staff on its rolls out of this total population. 400 of the university's male academic staff were chosen at random for the survey. They have been contacted by email once the survey was posted to the online survey provider Survey Monkey. 280 replies were received in total, for a response rate of 70 percent. Out of these replies, 238 were deemed sufficient for a reliable statistical analysis.

Based on literature and discussions with specialists, the researcher adopted the survey instruments. 11 questions about online education and cybersecurity were included in the questionnaire, along with 3 questions about demographic factors. Table 1 shows the survey of the study.

### 3.3. Data analysis using a two-step clustering algorithm

SPSS software was used to analyze the data. Descriptive statistics and unsupervised centroid cluster analysis were used in the analysis. The

clustering method was created by Chiu et al. (2001). It is capable of handling both metric and non-metric variables. According to Banfield and Raftery (1993), extending the model-based distance metric applied to scenarios with the aforementioned variables achieves this. Using a two-step clustering methodology similar to the one used by Zhang et al. (1996) as it utilized the cluster method. It has the ability to calculate the ideal number of clusters automatically. When there is no introduction material, this strategy is again preferred. If the intended number of clusters is unknown, the SPSS cluster component will automatically give the appropriate number of clusters.

**Table 1:** Survey of the study (Nambiar, 2020)

| Construct | Items Code | Questions |
| --- | --- | --- |
| | D1 | What is your age (years)? |
| Demographic | D2 | The discipline you are teaching: -Medical -Business and humanities -Science and engineering |
| | D3 | Did you have any experience with online education before COVID-19? |
| | B1 | How would you evaluate the advantages of online education in comparison to traditional education? |
| Benefit of Online Education | B2 | In online education, rate the degree of interaction between students and academic staff. |
| | B3 | How comfortable were you preparing examinations and tests while teaching online? |
| | B4 | How tough is it to manage your time when teaching online? |
| | I1 | How frequently did you consider cybersecurity issues when teaching online? |
| | I2 | How much do you want to know about cybersecurity issues in online education? |
| | I3 | How essential do you believe cybersecurity risks are in online learning portals? |
| Importance of Cybersecurity | I4 | How essential do you believe it is for universities to teach students about cyber safety for online learning? |
| | I5 | Evaluate your understanding of cyber safety guidelines for online education. |
| | I6 | Do you believe an information security assistant is necessary for online education? |
| | I7 | In light of the rise in online education, how crucial do you believe it is to be aware of data privacy? |

To the researcher's best knowledge and the limitations of academic staff perceptions studies, a few papers on the use of cluster analysis on students' perceptions are reviewed below to provide justification for using the method in this study.

### 3.4. Use of cluster analysis to study the perceptions of online education during COVID-19

A cluster analysis of survey responses obtained from 703 Brazilian undergraduate students during the current COVID-19 pandemic was done by Azzi et al. (2022). Data on sociodemographic characteristics, burnout syndrome (BS), quality of life (QoL), physical activity levels, study locations, and attitudes toward online learning (OL) were gathered. The analysis revealed three clusters (profiles) of students. The profiles showed that quality of life affected by psychological disorders and BS were associated with perceptions of OL. Higher quality of life and lower BS were associated with decreasing age, married to not married and children to no children status, increasing physical activity and courses studies influenced the perceptions of OL from negative to positive (Azzi et al., 2022).

Using a k-means cluster analysis of survey data on 1826 German higher education students, Händel et al. (2020) discovered two groups of students who were substantially different from one another in terms of their preparation for digital learning as determined by the availability of technological equipment, past e-learning experiences, and competencies for digital learning.

Also, cluster membership was associated with their socio-emotional (especially, stress-related) perceptions. Four variables were used for cluster analysis, information sharing, tool application e-learning experience, and technology equipment availability. An ideal number of clusters was determined using average silhouette width. In this manner, two clusters with average silhouette width between them 0.26 were identified. Cluster analysis was validated by the Silhouette coefficient, Dunn coefficient, and average distance between and within clusters. Distance between clusters was 3.07 and within clusters was 2.22. Cross-validation with a subsample showed a high correlation with Cohen's value of k=0.82 (p<0.001). External validation was done using student characteristics in the clusters, univariate ANOVA with cluster membership as an independent variable, and study variables as independent variables. Students who were well equipped with digital devices, high skills, and high experience with e-learning enrolled in higher semesters. The chi-square test was significant for different faculties. Multivariate analysis showed significant differences in clusters due to socio-emotional factors.

K-means cluster analysis was used also by Hernández-García et al. (2021) to separate the surveyed 200 Cuban medical students into three clusters of medical stress due to the COVID situation significantly differing centers with the participants distributed unequally. Cluster 2 had the highest number of students. Cluster 3 had the highest stress score, and this was used as the cut-off point to group the students into two, one below the cut-off point meaning no stress, and the other above the cut-off point meaning with stress, statistically different between the two.

In another paper by Biwer et al. (2021), k-means cluster analysis of survey responses by 1800 Dutch university students in the Netherlands identified four profiles of students into overwhelmed, surrenderers, maintainers, and adapters of resource management strategies in their COVID-related online

education. The clusters were identified by partitioning data to minimize within-cluster variance and maximize between-group variance. Both the overwhelmed and surrenderers could not regulate their effort, attention, and time adequately leading to lower levels of motivation to study than the pre-crisis motivation level. On the other hand, adapters welcomed the increased level of autonomy offered by online education and were able to self-regulate their learning better. The maintainers adopted fairly stable self-regulatory strategies to be in between the two extremes. The four clusters were selected on the best model fit basis (minimum 50% variance explainable) using ANOVA for 2 to 6 clusters. Double-split cross-validation was done to test the stability of clusters and Cohen k estimations.

Using a simple cluster analysis based on cluster centers of survey responses from a Finnish secondary school, Niemi and Kousa (2020) identified two clusters of students into independent learners and more support-needed learners. These clusters were significantly different as per ANOVA test results. The school implemented online education soon after the pandemic started and had completed two months when the study was done.

A two-step cluster analysis of survey responses of 4419 Wits University students, combined with chi-square analyses resulted in the identification of four clusters of students differing in their attitudes and online educational experiences. This was done in order to respond to the study question: To what degree are there recognizable views concerning COVID-19 and its influence on higher education that draw comparable students from each group? Cluster 1 consisted of students with the least positive self-regulation towards COVID-19-based higher education and the least positive attitudes towards teaching, learning, and assessment in COVID-19-based higher education (LOW-LOW students). In cluster 2, students with the least positive self-regulation towards COVID-19-based higher education but with positive attitudes toward teaching, learning, and assessment in COVID-19-based higher education (LOW-HIGH students). Students with the most positive self-regulation towards COVID-19-based higher education but with moderate positive attitudes toward teaching, learning, and assessment in COVID-19-based higher education (HIGH-MODERATE students) were included in Cluster 3. Cluster 4 included students with both the most positive self-regulation toward COVID-19 based-education and the most positive attitudes toward COVID-19-based teaching, learning, and assessment. Chi-square tests revealed significant differences among the four clusters, with some themes being significant and some others not (Ojo and Onwuegbuzie, 2020).

Thus, many studies on student perceptions of online education during COVID-19 have used cluster analysis. The k-means method was used more frequently, which includes centroid as the method of the exact location of the clusters.

## 4. Results

### 4.1. Demographics

The descriptive statistics of the surveyed academic staff are shown in Table 2.

**Table 2:** Descriptive statistics of surveyed academic staff

| Demographics | Frequency | Percentage (%) |
|---|---|---|
| **Age** | | |
| <35 | 70 | 29.4 |
| 35–50 | 117 | 49.2 |
| >50 | 51 | 21.4 |
| **Teaching discipline** | | |
| Medical | 16 | 6.7 |
| Business and humanities | 151 | 63.4 |
| Science and engineering | 71 | 29.8 |
| **Experience of online education before COVID-19** | | |
| No | 148 | 62.2 |
| Yes | 90 | 37.8 |

The majority of academic staff age was between 35-50 years (49.2%), followed by less than 35 years old (29.4%) and the lowest was greater than 50 years old (21.4%).

Moreover, as shown above, Table 2 shows the number of academic staff involved in the three different categories of teaching disciplines as the majority of 151 (63.4%) of the academic staff were pursuing business and humanities. Another 71 (29.8%) of the academic staff were pursuing science and engineering disciplines. The rest of the 16 (6.7%) of them were teaching medical discipline.

To evaluate the perceived benefits of online education, the pre-COVID period experience of online education was asked of the participant academic staff and their response frequencies are presented in Table 2. It shows, 148 (62.2%) of the academic staff did not have any pre-COVID experience in online education. That leaves the rest 90 (37.8%) of the participants as having pre-COVID experience in online education. For them, therefore, the introduction of online courses during the pandemic is only a continuation of what they were already doing.

### 4.2. Statistical results of survey constructs

This study's main focus was on how academic staff saw the value of online learning and the significance of cybersecurity. The 11 items on online education and cybersecurity had a Cronbach's alpha value of 0.77, which is higher than the minimum value of 0.7 necessaries for adequate reliability (Cheah et al., 2018). Table 3 shows the descriptive statistics of their answers.

On the basis of the Likert scale used in this survey, none of the mean responses were high or low. They fell into the two categories of neutral to slightly low (2 to 3) and neutral to slightly high (3 to 4). Notably, the highest two values were for those related to the importance of cybersecurity and not for the benefits of online education. I3 and I4 in the above list had nearly similar values. This trend shows that the academic staff was more concerned

about whether cybersecurity affects their online education and how to prevent them.
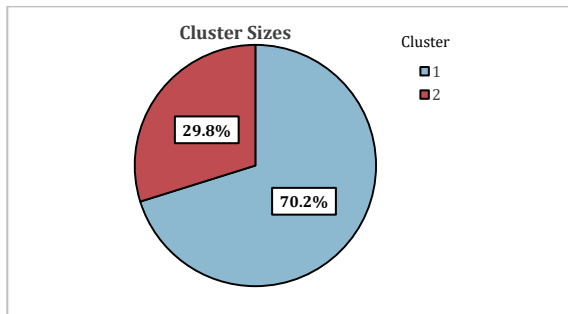
## 4.3. Cluster analysis

An unsupervised centroid cluster analysis was conducted with all the data collected from the survey. The analysis clustered the data into two distinct clusters (referred to as clusters 1 and 2). About 70.2% of the cases which reflect 167 academic staff were assigned to cluster 1, and the balance of 29.8% was 71 to cluster 2. Other details of cluster analysis are given in Fig. 1. The frequencies for the categorical variables by cluster membership are shown below in Table 4.

The medical, business, and humanities disciplines' academic staff fell in the first category and the entire science and engineering discipline academic staff fell in the second category. Out of 148 academic staff who had no pre-COVID experience in online education, 133 (89.9%) fell in cluster 1 and 15 (10.1%) fell in cluster 2. Out of those who had pre-COVID experience in online education, 34 (37.8%) fell in the first cluster and 56 (62.2%) fell in the second cluster.

In the two-step algorithm, 11 inputs were divided into two clusters. The standards of cluster quality as Silhouette measure of cohesion and separation show the requirement of a value above 0.5 for any cluster to be at least fair.

**Table 3:** Descriptive statistics of benefits of online education and the importance of cybersecurity

| Items Code | Mean | Std. Deviation | Cronbach's alpha | Category |
|---|---|---|---|---|
| B1 | 3.25 | 1.29 | 0.72 | Neutral to slightly high |
| B2 | 2.61 | 1.23 | 0.71 | Neutral to slightly low |
| B3 | 3.62 | 1.08 | 0.79 | Neutral to slightly high |
| B4 | 3.73 | 1.05 | 0.81 | Neutral to slightly high |
| I1 | 2.07 | 1.07 | 0.74 | Neutral to slightly low |
| I2 | 2.56 | 1.22 | 0.70 | Neutral to slightly low |
| I3 | 3.86 | 1.05 | 0.91 | Neutral to slightly high |
| I4 | 3.84 | 1.08 | 0.82 | Neutral to slightly high |
| I5 | 2.49 | 1.18 | 0.90 | Neutral to slightly low |
| I6 | 2.84 | 1.26 | 0.71 | Neutral to slightly low |
| I7 | 3.71 | 1.16 | 0.72 | Neutral to slightly high |



| Algorithm | Two-Step |
|---|---|
| Inputs | 14 |
| Clusters | 2 |

| Size of Smallest Cluster | 71 (29.8%) |
|---|---|
| Size of Largest Cluster | 167 (70.2%) |
| Ratio of Sizes: Largest Cluster to Smallest Cluster | 2.35 |

**Fig. 1:** Model summary and cluster quality and sizes

**Table 4:** Cluster-wise frequencies of teaching disciplines and pre-COVID experience of online education

| Assessment approach | | | Cluster 1 | Cluster 2 | Combined |
|---|---|---|---|---|---|
| Teaching disciplines | Medical | Frequency | 16 | 0 | 16 |
| | | % | 100 | 0 | 100 |
| | Business and humanities | Frequency | 151 | 0 | 151 |
| | | % | 100 | 0 | 100 |
| | Science and engineering | Frequency | 0 | 71 | 71 |
| | | % | 0 | 100 | 100 |
| Pre-COVID experience of online education | No | Frequency | 133 | 15 | 148 |
| | | % | 89.9 | 10.1 | 100 |
| | Yes | Frequency | 34 | 56 | 90 |
| | | % | 37.8 | 62.2 | 100 |

Mean responses and standard deviations of participants for each item falling into the two clusters (cluster centroids) and their combination have been shown in Table 5 and Fig. 2. The two clusters do not differ appreciably in their mean values for the items: B4 in Benefit of Online Education and I3 in Importance of Cybersecurity. Additionally, the ANOVA test was used to test the differences between the two clusters and to measure the significance of the survey constructs. The results are given in Table 6.

**Table 5:** The cluster centroids analysis

| Items of the survey | | Centroids | | |
|---|---|---|---|---|
| | | Cluster 1 | Cluster 2 | Combined |
| B1 | Mean | 3.29 | 3.14 | 3.25 |
| | SD | 1.28 | 1.31 | 1.29 |
| B2 | Mean | 2.53 | 2.80 | 2.61 |
| | SD | 1.18 | 1.34 | 1.23 |
| B3 | Mean | 3.48 | 3.96 | 3.62 |
| | SD | 1.13 | 0.84 | 1.08 |
| B4 | Mean | 3.71 | 3.79 | 3.73 |
| | SD | 1.13 | 0.84 | 1.05 |
| I1 | Mean | 1.89 | 2.49 | 2.07 |
| | SD | 1.00 | 1.09 | 1.07 |
| I2 | Mean | 2.53 | 2.63 | 2.56 |
| | SD | 1.27 | 1.11 | 1.22 |
| I3 | Mean | 3.86 | 3.86 | 3.86 |
| | SD | 1.05 | 1.06 | 1.05 |
| I4 | Mean | 3.72 | 4.10 | 3.84 |
| | SD | 1.13 | 0.91 | 1.08 |
| I5 | Mean | 2.22 | 3.13 | 2.49 |
| | SD | 1.04 | 1.25 | 1.18 |
| I6 | Mean | 2.77 | 2.99 | 2.84 |
| | SD | 1.20 | 1.40 | 1.26 |
| I7 | Mean | 3.63 | 3.92 | 3.71 |
| | SD | 1.22 | 0.98 | 1.16 |
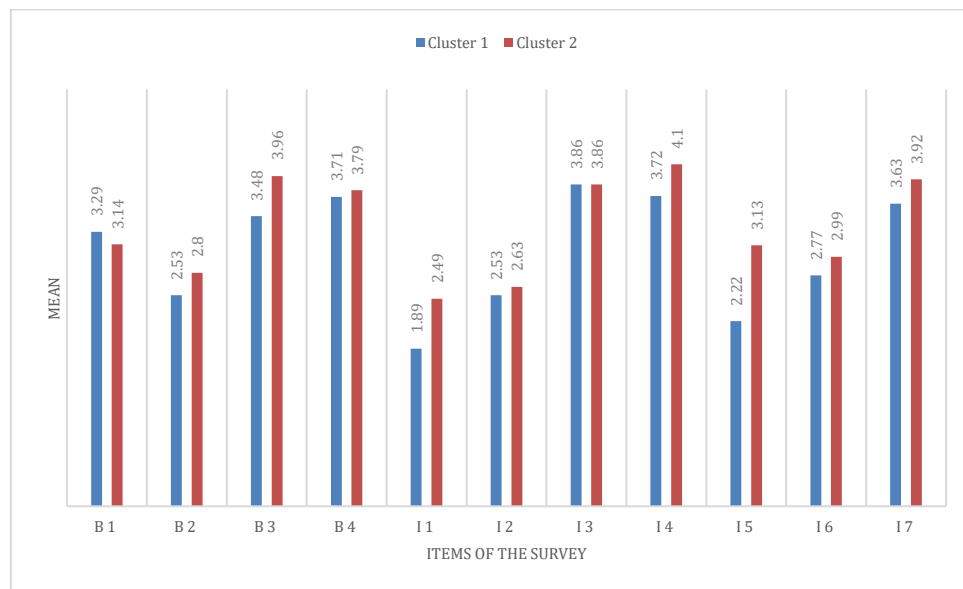


**Fig. 2:** The mean of clusters' analysis

**Table 6:** ANOVA results

| Items code | Cluster | | Error | | F | Sig. | Result |
|---|---|---|---|---|---|---|---|
| | Mean square | df | Mean square | df | | | |
| B1 | 2.129 | 1 | 1.662 | 236 | 1.281 | .259 | Non-significant |
| B2 | 0.897 | 1 | 1.523 | 236 | 0.589 | .444 | Non-significant |
| B3 | 2.434 | 1 | 1.151 | 236 | 2.116 | .147 | Non-significant |
| B4 | 0.186 | 1 | 1.113 | 236 | 0.168 | .683 | Non-significant |
| I1 | 2.355 | 1 | 1.130 | 236 | 2.085 | .150 | Non-significant |
| I2 | 0.701 | 1 | 1.500 | 236 | 0.468 | .495 | Non-significant |
| I3 | 0.001 | 1 | 1.115 | 236 | 0.001 | .982 | Non-significant |
| I4 | 3.463 | 1 | 1.166 | 236 | 2.971 | .086 | Non-significant |
| I5 | 23.643 | 1 | 1.296 | 236 | 18.244 | <.001 | Significant |
| I6 | 0.263 | 1 | 1.595 | 236 | 0.165 | .685 | Non-significant |
| I7 | 6.632 | 1 | 1.322 | 236 | 5.017 | .026 | Significant |

ANOVA indicated significant differences between the cluster centroids for the following variables: I5-I7.

## 5. Discussion

The research question of the study was: What benefits are perceived by Saudi universities' academic staff of online education and the relevance of cybersecurity when using online platforms for learning?

UQU academic staff, largely medical, and business and humanities disciplines academic staff with limited prior experience with online learning before the pandemic, exhibited neutral to favorable attitudes toward the benefits of online education

during the pandemic. They also perceived cybersecurity as an important issue affecting the benefits of online education during the pandemic.

Cluster analysis identified two clusters. Cluster 1 consisted of 167 participants, whose teaching medical, business, and humanities disciplines, generally with a low level of pre-COVID experience in online education, low level of cybersecurity issues when teaching online (1.89), neutral to a slightly high level of perception on the importance of awareness of cybersecurity risks in online learning portals (3.86). Cluster 2 consisted of the remaining 71 participants, who were, only those teaching science and engineering discipline, generally with some pre-COVID online learning experience, neutral to slightly low level of cybersecurity issues when teaching online (2.49), and high level of perception for universities to teach students about cyber safety for online learning (4.1). The ratio of the number of academic staff in the two clusters was approximately 70:30 ratio. The academic staff in both clusters had neutral to slightly high perceptions of the difficulty to manage time in online education (3.71 and 3.79) and on cybersecurity concerns related to online education portals (3.86 for both clusters).

The perceptions studied by researchers were generally related to the operational aspects of online learning. The majority of papers even if positive about online education, also listed some problems with it. They included internet availability, accessibility (Agung et al., 2020), data speed absence of face-to-face interactions, hybrid mode better for practical-oriented courses (Muthuprasad et al., 2021), doubt on the capability to handle (Mishra et al., 2020), many benefits, but less effective than face-to-face (Bączek et al., 2021), face-to-face better despite the flexibility of online, other limitations also (Laili and Nashir, 2021), not preferred in interviews, but happy with it in the survey (Nugroho et al., 2020), helpful despite problems, cost (Allo, 2020), lower than expected and not fully satisfied (Budur, 2020), positive due to flexibility of access anywhere and anytime and need of the hour (Sujarwo et al., 2020), not suitable for underdeveloped countries (Adnan and Anwar, 2020).

Positive perceptions of online learning, whether COVID or not, was observed by Muthuprasad et al. (2021), although it is particularly useful in the pandemic period as the only option to continue education. The inadequacy of interactions between academic staff and students was highlighted in their paper. A slightly low level of interaction was also reported in this study. Perceptions of comfortability with tests and exams online were slightly high levels in this study. So, support for the results of this study is mixed. But the study of Mishra et al. (2020) showed very good results with online tests and exams, which was perceived at a low level in this study.

Cybersecurity in online education as an important issue was highlighted by Jayakumar et al. (2020), with reasons like not secure and safe by Shah et al. (2020) and Nambiar (2020), knowledge of cybersecurity practices like response-recovery-realign was suggested by Bhagat and Kim (2020).

Overall, this study helped to identify some important dimensions related to online education and cybersecurity issues, during the current period of the COVID-19 pandemic.

## 6. Conclusion

The purpose of this study, as stated in a research question, was to investigate how Saudi higher education academic staff perceive the benefits of online education and the relevance of cybersecurity when using online platforms for learning.

The results revealed varied levels of perceptions for four aspects of online education and seven aspects of cybersecurity in online education. The academic staff as participants could be categorized into two clusters of neutral to low-level and neutral to high-level perceptions of online education and cybersecurity as they differed in teaching discipline and pre-COVID experience in online education. Moreover, the results show that academic staff for medical, business, and humanities disciplines (70%) have less experience using online education software and have a low level of awareness about the security of online education. In contrast, academic staff of science and engineering disciplines (30%) have more experience in using online educational tools and have a higher level of awareness of cybersecurity in online education.

As a limitation of this study, the results do not provide a clear picture of the online education acceptance, implementation outcomes, and problems and issues including cybersecurity from the limited questions asked in this study. This research was done only in one university. More extensive research with more specific questions on online education and cybersecurity with appropriate predictor identification methods is for future research.

Further expansion of this study to more universities in Saudi Arabia, with a greater range of specific questions on online education and cybersecurity related to the current COVID period, should throw more light on this phenomenon.

## Compliance with ethical standards

## Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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