Effectiveness of using E-learning systems during COVID-19 in Saudi Arabia: Experiences and perceptions analysis of engineering students

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Abstract
The COVID-19 epidemic has affected most countries across the globe since it was declared in December 2019 and forced most educational institutions to shift from face-to-face learning style to E-learning or distance education. This study aims to analyze and investigate the experiences and perceptions of using Blackboard as a distance learning (online) platform. The study was conducted in one of the top universities in Saudi Arabia and the Middle East. A survey-based study is constructed and distributed among undergraduate students including males, and females in an engineering college. Two hundred thirty-five students participated in this study; males represent (74%) and (26%) for females. Ten phases containing 38 items of advantages and disadvantages are considered in the survey study to understand the advantages, constraints, and difficulties of the Blackboard. Two nonparametric statistical tools of Mann–Whitney and Kruskal–Wallis are used for analyzing the survey. The study shows significant results regarding difference perceptions on Blackboard between gender and engineering disciplines. The results of this study can help the educational decision-makers in the ministry of education and universities improve the quality and increase the sustainability of the EL resources. Moreover, the findings reveal that males, females, and engineering disciplines have different perceptions towards the use of virtual learning.

Keywords Blackboard · COVID-19 and E-learning · E-learning technology · E-learning in engineering education

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1 Introduction

The COVID-19 epidemic has affected most countries across the globe since it was declared in December 2019 and forced all educational institutions to shift from face-to-face learning style to e-learning or distance education. 1.5 billion children and young people in 186 countries worldwide had to stay remotely from their homes after the lockdown of schools and universities (Affouneh et al., 2020). This institutional closure affected about 73.8% of the total admitted learners (UNESCO, 2020).

Consequently, most of learning institutions shifted to an online mode, to provide another way of course delivery, using a variety of distance learning (online) platforms, such as Blackboard, Microsoft Teams, Zoom, and Google classrooms. Distance learning (Open Distance Learning ODL) or electronic-learning (EL) is a type of learning that has been considered for a long time and has made a prolonged debate about the essential need to combine it into the educational process. Koumi (2006) addresses that the EL becomes as a result of artificial intelligence (AI) and the Internet of Things (IoT), as well as the information technology revolution that intervene into the classroom and becomes an integral part of it. This style of learning can provide learning seekers with the resources to become more self-learner (Khine, 2003). Sife et al. (2007) state that the virtual learning is an essential means to the traditional method of teaching i.e., (face-to-face). Therefore, the success of virtual learning depends on several factors such as simplicity, accessibility, and reliability of the platforms, availability of the course contents, different assessment methodologies, and discussion boards. E-learning like any style of teaching has many advantages and disadvantages that can influence the educational process and impact on students and instructors. It can provide a flexible timing, availability of many learning resources no matters of locations and time, offering online courses regardless, paper less, and it delivers less operational cost for institutions (Gibbons & Fairweather, 2000; Rosenberg, 2001; Chumley-Jones et al., 2002; Horton, 2001). On the other hand, there are some disadvantages to EL such as copying in exams, reduces the level of interactions among the students comparing to face-to-face learning, technical issues, low motivation and interactions between students and instructors, and difficulty of conducting lab experiments.

Since the COVID-19 has declared as a pandemic in December 2019, the education learning means in Saudi Arabia’ shifted to virtual learning in 2020 for all its institutions. There are 61 universities and colleges in Saudi Arabia transferred to EL during the pandemic. There were more than 35 million learning sessions provided by 76 thousand faculty members to more than 1.4 million students (NDR, 2021). The EL infrastructure in Saudi Arabia had the ability to handle more than 69 million logins with over 300,000 courses taught and exceeded 25 million assessments and tests. According to National Digital Report NDR (2021), the average per capita data usage increased to 900 MB/sec during the COVID-19 pandemic curfew period, after it was 600 MB, which represents three times higher than the global average. Moreover, the number of internet users in 2020
increased in Saudi Arabia to 97.86% of the population (World Bank, 2021). Currently, most of Saudi’s universities use the platform of Blackboard as EL system, which is extensively used around the world. The Blackboard is EL educational system and course management system established by Blackboard Inc in 1997 in USA. It is a Web-based server software which features course management, customizable open architecture, and scalable design that allows interactions with student information systems through authorized protocols. Its main objectives are to provide online materials to courses that used to be offered traditionally face-to-face and to develop entirely online courses with no physical meetings.

Despite the statistics provided by the National Digital Report that shows the capabilities of the EL systems in Saudi Arabia by accommodating massive numbers of students and instructors using EL resources during the COVID-19 period, it is essential to identify the factors that are influencing EL systems. This study aims to determine and analyze the main challenges of Blackboard learning system at one of the renowned public universities in Saudi Arabia and Middle east. Therefore, to assess the performances of the Blackboard on acceptance, reliability, implementation, and adjusting during the COVID-19, the perceptions of engineering college students (males and females) are surveyed and analyzed.

The engineering discipline deals with some distinct characteristics not available in other specialties. Engineering students must learn physics and mathematical theories in the classrooms to conduct experimental works in labs that enable them to handle real-world problems. Therefore, a well-planned and organized process is intended to develop specific education to achieve optimum learning outcomes. Indeed, the impact of COVID-19 on shifting from physical learning to E-learning needs a high number of studies for the engineering discipline. Besides, the student gender is considered to investigate the different abilities and skills between males and females that can be used to develop specific E-learning strategies.

The results of this study can help the educational policymakers in the ministry of education and universities improve the quality, increase the sustainability, and improve the learning outcomes of the E-learning resources in Saudi Arabia or any countries.

2 Literature review of relevant studies

Since the past three decades, the EL has been gradually growing and spreading in many learning institutions showing its feasibility to be utilized and embedded in teaching courses partially or entirely. Undoubtedly, in the 21 century the virtual learning becomes a top priority in the higher educational systems (Bagnato, 2004). Instructors in the EL environments consider to be as a consultant who sustain close advising, but do not interact with learners’ efforts to address the problem they may encounter (El Zawaidy & Zaki, 2014). Learners are required to perform with initiative and passion, think efficiently and creatively with a flexible and practical knowledge base and observe and evaluate their capabilities to accomplish desired outcomes. Over several years, the research has discovered significant findings for the effectiveness of virtual learning (Rossett et al., 2003). Indeed, as a new technology,
virtual learning environments have the potential to improve the way of teaching and learning (DeNeui & Dodge, 2006). Moreover, the responsibilities of instructors become more critical and require great attention to maintain the minimum level of the quality standards regarding the E-learning process. Blackboard, a learning environment system, is an advanced technology and can add the virtual feature to traditional face-to-face learning and offer blended education that merges online and on-campus elements (Coates, 2007; Malikowski et al., 2007). Hence, it is essential to explore how these technologies are being employed and affected the users.

Studies related to findings on the performance of Blackboard and its impact on students have been addressed and discussed in the literature for a significant period of time. It has been noticed that a significant number of researches shed light on different learning strategies that are specifically suitable for a specific field. Thus, it is important not to generalize strategies applied to all disciplines using virtual learning. The engineering students are considered in a study by (Khan & Abid, 2021) to investigate significant factors and strategies influencing the E-learning process. Class capacity, schedule registration, materials quality, time flexibility, E-learning teaching tools, cost-effectiveness, limitation of the virtual lab, and assessment methodologies are vital areas to improve the E-learning process. A new methodology using web-based model assessment proposes by Tian et al. (2019) to evaluate engineering students in exams. The results show that the new method of the proposed form can provide close scores compared to the paper-based model by a deviation of 0.6%. Another recent study by Alexa et al. (2022) investigates the relationship between using the E-learning features and engineering students. The research surveys 134 engineering students and reveals that regardless the engineering students know much better the technologies than other filed, the students are still facing difficulties in accommodating E-learning advantages and including them in their study routine. Alhumaid et al. (2020) discusses the impact of virtual learning on instructors during the COVID-19 period in Pakistan. The study analyzes the perceptions and attitudes regarding online learning using Technology Acceptance Model and finds a significant positive relationship between technology acceptance and the EL, impacting the students’ performances.

Since the majority of the studies in the literature propose new E-learning strategies to improve the learning outcomes, the effects of technological skills of engineering students’ gender are important to explore. The expectations regarding the skills in E-learning and gender is theoretical (Hartman & Hartman, 2006). This study aims to empirically investigate and differentiate between the opinions of males and females regarding the EL in higher education during COVID-19. These differences between perceptions can help decision-makers with EL implementation strategies.

Several studies find the gender factor, with other variables such as age and academic level, has a significant effect on the perception of the E-learning experiences (Bogle et al., 2009; Venkatesh et al., 2003; Khechine et al., 2014).

Shahzad et al. (2021) compare the perceptions of males and females in the quality and satisfaction of the EL system in Malaysian universities during COVID-19. The study uses the partial least square statistical model in the perception analyzing process and finds that E-learning is more focused in females than males in
Malaysian Universities. Many engineering courses are engaged with laboratories to help students study, conduct, and analyze experiments to solve real-life problems. The transition from on-campus lab to the virtual lab through E-learning has a significant influence on the E-learning outcomes in the engineering courses. Gunawan et al. (2018) investigate the difference between student performances (cognitive skills) through virtual lab based on gender. Male students demonstrate higher scores than female students in higher-order cognitive skills (analyzing, creating, and forming). On the other hand, the female students perform higher than male students in the lower-order cognitive skills (memorizing, understanding, and illustration). The results present significant contributions in a virtual lab that can be considered to create strategies based on gender. Therefore, evaluating the quality of education and its infrastructure capabilities in virtual learning systems are in significant demand, and institutions adapt their teaching styles using intellectual resources (Alvino et al., 2020; Di Vaio et al., 2020).

Cuadrado-García et al. (2010) apply a statistical analysis using ANOVA to investigate the significance differences between the assessment’s results and the E-learning activities by gender students in two European universities. The statistical results show significant differences between the gender and their motivation and satisfactions toward the E-learning.

A massive survey is applied in a study for more than 19,000 students in Austria to explore the potential influence of gender on learning engagement and bias in receiving teacher support in E-learning during COVID-19 lockdown (Korlat et al., 2021). The results significantly show that the female students receive higher teacher support and learning engagement than male students.

El Zawaidy and Zaki (2014) discuss the challenges that face instructors using Blackboard in different universities in Saudi Arabia. The study analyzes the perceptions of faculty members involved in teaching with EL systems and finds that lack of training in using IT for EL, internet connection problems, and weak IT supports are the main obstacles in using Blackboard in teaching virtual classes.

Alhussain (2017) studies the impact of using Blackboard on a blended learning students at the Saudi Electronic University (SEU) using questionnaire designed by IS-Impact Measurement Model. Two phases are considered in this study; the first is to collect demographical information on the students; the second phase contains 37 measures on four dimensions of quality. The findings show how the Blackboard enhance the students learning and improve the overall productivity and learning outcomes.

Muthuprasad et al. (2021) analyze the perceptions and preferences of 307 agricultural students for using the EL environment in India during the COVID-19 pandemic. The study results show that virtual learning is flexible and convenient, whereas the weak internet signals in rural areas make learning difficult. Such as in most engineering courses, most agriculture education courses are delivered practically or in a lab. Thus, transferring ultimately to virtual learning may not be possible or difficult in these courses and needs to be a blended learning system.

Lecture time duration is considered to be one of the most challenging factors in virtual learning that can impact on understanding levels. A study by Gupta et al. (2021) was conducted in medical colleges in India during COVID-19 to investigate
the faculty members’ and students’ perceptions and experiences regarding online teaching environments. Results show a significant finding that the most favored duration of a class lecture is between thirty minutes and one hour. Faculty members find that including virtual learning in curriculums is feasible when the on-campus classes resume after the pandemic.

Communication between instructors and students is considered a significant challenge in all E-learning that ultimately impacts the level of understanding. A recent study by Afshari et al. (2020) investigated how the medical students behaved about the E-learning during the COVID-19 in Iran. The study investigates different factors of material quality, communications effectiveness, availability of IT supports, E-learning platform management, and class motivations. Results analysis significantly shows the lack of communication, low-skilled instructors in E-learning, and less motivation influence the E-learning process.

From the author’s reading perspective on the literature review, most of the studies analyze perceptions of students and instructors regarding the EL system performances and the feasibility of including it as blended learning. This article empirically explores and investigates more insight into how students’ disciplines in an engineering college differ regarding perceptions on the EL system, using the Blackboard as a learning environment. Moreover, since few studies consider gender perceptions in analyzing perceptions on EL, this study includes a comprehensive exploration of males’ and females’ opinions.

3 Methods

3.1 Measurement

Several studies in the literature identify the challenges that instructors and students face in using E-learning systems. Almaiah et al. (2020) address the issues that influence using E-learning during the COVID-19 pandemic, such as technological issues, availability of technical support, information technology skills for the instructors and students, and the quality of the provided materials. Moreover, Mailizar et al. (2020); Mohammadi et al. (2021); Bamoallem and Altarteer (2021) discuss general critical areas of teaching styles, students, instructors, programs, communication infrastructure, and financial factors that can influence E-learning. Consequently, we observed that these factors could be grouped into ten specific phases or categories: (1) flexibility scheduling; (2) class capacity; (3) digital tools along with Blackboard (E-learning); (4) assessment credibility; (5) group interacting and activities; (6) diversity of learning styles; (7) communicating with an instructor; (8) low motivation; (9) virtual lab activities; (10) internet communication issues.

Two surveys of pre and primary are developed and deployed to collect responses regarding the experiences that engineering students encountered during the E-learning. Pre-survey intends to identify the significant advantages and disadvantages of using E-learning platforms, such as the ability to understand using E-learning compared to physical learning, internet issues, Blackboard technical problems, technical supports, lack of understanding technical courses, and
an end open question regarding other suggestions and concerns. Therefore, the pre-survey can direct us to infer general issues that students encountered during the E-learning and help in constructing the final survey. To achieve the study’s objectives, the final survey is constructed to include respondent gender (males and females) and the engineering disciplines (Industrial, Civil, Mechanical, Electrical, Chemical, Aerospace, and Nuclear) with 10 phases that include 38 items (advantages and disadvantages of E-learning using Blackboard. These variables are classified as the most influenced factors affecting the E-learning obtained from the pre-survey. Each item is evaluated on a scale of 5-point Likert element (1 = lowest impact, 2 = less impact, 3 = moderate, 4 = impact, 5 = highest impact).

Figure 1 shows the survey structure.

The reliability of the instruments is tested to ensure the validity of the collected information by using the Cronbach Alpha test. Two non-parametric statistical techniques are used in the analysis phase (Mann–Whitney, Kruskal–Wallis). These tests used to identify the significance of the advantages and disadvantages of the Blackboard.

Table 1 lists all relevant literature review for each suggested hypothesis in this study.

Table 1 shows different studies about the significant challenges of the E-learning platforms regarding performances, feasibility, and implementation through applying empirical studies to identify difficulties, make comparison studies, determine room for improvements, and suggest strategies.

Drawing upon the literature reviews and pre-survey the study classifies the following hypothesis into two main groups (advantages and disadvantages):

Advantages of E-learning

H1: E-learning provides more flexibility in course registration process with different time slots.

H2: Class capacity in Blackboard can allow students to enroll in any course they prefer.

Fig. 1 Process structure of research design and proposed hypothesis
| Hypothesis number | Factors affecting E-learning | Literature                                                                 |
|-------------------|-----------------------------|-----------------------------------------------------------------------------|
| H1                | Class capacity              | Akir et al. (2012); Khan (2001); Nagel and Kotzé (2010)                    |
| H2                | Registration flexibility    | Albert and Johnson (2011); Xu et al. (2003); Andersson (2008)              |
| H3                | Various E-learning tools    | Bhatia (2011); Maatuk et al. (2021)                                       |
| H4                | Assessment credibility      | Jones et al. (2008); Nágappan (2015); Thomas (2021)                        |
| H5                | Communication in group activities | Afshari et al. (2020); Martha et al. (2021); Gunasekaran et al. (2002)         |
| H6                | Different learning styles in E-learning | Kanninen (2009); Bencheva (2010); Villaverde et al. (2006); Azis and Leatemia (2021) |
| H7                | Communication with instructors | Maatuk et al. (2021); Lee et al. (2019)                                    |
| H8                | Technical issues            | Alavudeen et al. (2021); Ahmed et al. (2018); Mtebe and Raphael (2018)   |
| H9                | Motivation in E-learning    | Harandi (2015); Wang et al. (2020); Cuadrado-García et al. (2010); Sandybayev (2020) |
| H10               | Virtual lab                 | El Zawaidy and Zaki (2014); Muthuprasad et al. (2021); Liu et al. (2015); Huba and Kozák (2016) |
H3: E-learning can provide various E-learning tools such as cell phone applications, discussion boards in Blackboard, and on-demand university services.

Disadvantages of E-learning

H4: Course assessments and result by using E-learning is not credible and cannot provide an authentic evaluation of the students.

H5: E-learning influences negatively in the level of communication among students who work in groups.

H6: The diversity and effectiveness of learning styles are limited in E-learning systems.

H7: Communicating between student and instructors are less effective in E-learning systems.

H8: E-learning’s technical issues impact the ability to study and attend an online class.

H9: Motivation and encouragement are affected by using E-learning and have no impact on understanding a course topic.

H10: Conducting lab experiments (virtual lab works) and activities in E-learning affect in lack of understanding the outcomes from the experiments.

Presenting together, grouping the hypotheses are illustrated graphically in Figs. 2 and 3 for E-learning advantages and disadvantages, respectively.

3.2 Data collection

The sample of this study includes 227 and 235 respondents for pre and primary surveys, respectively, from a college of engineering, at one of a top university in Saudi Arabia and the Middle East. Pre-survey intends to explore the problem statement and identify the factors that have the highest impact on the E-learning system. On the other
hand, a primary survey aims to gather responses about using Blackboard in studying virtually.

### 3.3 Data analysis

The responses from the survey are analyzed using SPSS V.25. Descriptive analysis and non-parametric Wilcoxon-Mann–Whitney (rank sum) test is suggested as an alternative to the t-test. In addition, the Kruskal–Wallis, a non-parametric test, is used to test the null hypothesis which states that ‘k’ number of samples has been obtained from the same population with the same median. This test is proposed as an alternative of the parametric test one-way ANOVA (Fagerland & Sandvik, 2009; Feltovich, 2003; McElduff et al., 2010).

The reliability of the survey items is tested using the Cronbach’s Alpha coefficient of the 10 phases containing 38 items of advantages and disadvantages of EL. The result of the analysis shows that Cronbach’s Alpha value is 0.761. Since the Cronbach’s Alpha is above 0.7, the survey reflects the internal consistency instead of irrelevancies, and thus the survey’s items are reliable and valid (Cortina, 1993; Van & Ferry, 1980).

### 4 Methodology

This study aims to investigating and exploring the impact of EL environment, using Blackboard, of the college of engineering students’ perceptions in terms of advantages and disadvantages.

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**Fig. 3** Conceptual model – hypotheses of E-learning disadvantages
The two-sample t-test is one of the most popular parametric statistical tests. Its goal is to test the hypothesis that the distribution of two groups is equal. The t-test assumes that the two samples (variables) are normally distributed. The assumption of normality, however, is not valid in this study. Thus, for the analysis purposes, Mann–Whitney U nonparametric test is applied to differentiate between two groups. In other words, it intends to detect the differences by comparing the distributions of the independent variable (Male, Female) and the dependent variable (perception measured for the 10 hypotheses on the 5-point Likert element, i.e., from "lowest impact agree" to "highest impact").

Using Mann–Whitney, the test statement for each hypothesis is as follows:

H: Median of perception scores for male and female students is equal.

The Kruskal–Wallis H is a nonparametric test, an alternative to the parametric test ANOVA, used to compare the median (differences) between two or more groups. It is used to determine the statistical difference between engineering disciplines and the survey items. Particularly, it is applied to understand whether the perceptions regarding the stated hypothesis differed based on the engineering discipline (i.e., the dependent variable is the perception measured for the 10 hypotheses on the 5-point Likert element, and the independent variable is the engineering discipline).

Using Kruskal–Wallis, the test statement for each hypothesis is as follows:

H: All medians of perception scores for each discipline are equal.

5 Results and discussion

A total of 235 students in the faculty of engineering participated in this study. Most of the students were male, with (74%) and (26%) females. Moreover, there were seven different engineering majors in the study. The description of participants’ disciplines are as follows: Industrial engineering (32%); Electrical engineering (25%), Mechanical engineering (12%); Chemical engineering (11%), Aerospace engineering (7%); Civil engineering (7%); nuclear engineering (6%).

5.1 Perception analysis on gender

The impact of using Blackboard on gender using the Mann–Whitney U test is shown in Table 2, along with the hypothesis statements for the 10 phases of the study survey. The Mann–Whitney analysis in Table 2 shows the p-value for each hypothesis that tests perceptions homogeneity (same opinions) across gender. When the p-value is <0.05, the hypothesis is rejected and concluded that the perceptions of this hypothesis are not homogenous and statistically significant. One of three EL advantages phases are found significant (class capacity), and five out seven disadvantages are significant (results credibility, teams interacting, students’ limitations, communicating with the instructor, and low motivation).
Table 2 Results of Mann–Whitney test on testing hypothesis across student gender

| Hypothesis number | Hypothesis statement                                                                 | U test Statistic | P—Value |
|-------------------|--------------------------------------------------------------------------------------|------------------|---------|
| H1                | The perceptions of flexibility in scheduling are homogenous across categories of gender | 5698             | 0.285   |
| H2                | The perceptions of class capacity in Blackboard affect in understanding using EL are homogenous across categories of gender | 4240             | 0.019*  |
| H3                | The perceptions of flexibility in using various EL tools are the same across categories of Gender | 4743             | 0.235   |
| H4                | The perceptions of results credibility are homogenous across categories of gender     | 6352.5           | 0.011*  |
| H5                | The perceptions of effectiveness of group interacting are homogenous across categories of gender | 7567.5           | 0.000*  |
| H6                | The perceptions of feasibility in providing different teaching styles are homogenous across categories of gender | 7466.5           | 0.000*  |
| H7                | The perceptions of ability in communicating with instructor are homogenous across categories of gender | 5833.5           | 0.000*  |
| H8                | The perceptions of facing technical issue are homogenous across categories of gender  | 5662             | 0.332   |
| H9                | The perceptions of lack of motivation and participations are homogenous across categories of gender | 6148.5           | 0.035*  |
| H10               | The perceptions of conducting lab experiments on Blackboard affect in lack of understanding are homogenous across categories of gender | 5484.5           | 0.588   |

* Denotes significant difference $p < 0.05$
These statistical significances mean that the perceptions are not homogeneous across gender; hence preferences are present. The perceptions of class capacity are found inconsistent across gender, which means one group finds this feature of class capacity affects using Blackboard over the other group. A total of 76 male students finds the class capacity is highly impacted in learning using Blackboard, representing 43% compared to 23% in this category for female students. This result is expected because both genders do not share the same teaching facilities. In addition, the number of students in the male section is larger than the female section, and class sizes are limited by the university rules and standards, such as the accreditation board of engineering and technology (ABET), to be 15–25 students in a class on average. The opinion regarding the resulting credibility of course assessment tools is explored to be incompatible over the gender. The majority of female students (78%) rates the results’ credibility as an influenced variable using Blackboard compared to 59% same rating class for male students. Therefore, the female students determine Blackboard as a non-trustable assessment tool. This opinion represents a significant finding regarding using Blackboard. This result is supported by the studies that show that the males have an obvious advantage over females in the levels of their information and communication technologies (ICT) abilities (Mumtaz, 2001; Durndell & Haag, 2002; Broos, 2005; Broos & Roe, 2006; Drent and Meelissen, 2008). Besides, other studies discuss that females are less familiar with computers and internet systems (Adamus et al., 2009; Cuadrado-García et al., 2010; Dorman, 1998; Kayany & Yelsma, 2000).

Regarding the perception of group interacting effectiveness, it is found to be significantly different across gender. According to 42% of female students, the level of communication with instructors is an important variable affected by Blackboard compared to 14% of male students that find this variable as high impact. This result provides that the female students tend to be more on communication and planning; thus, they may engage in more discussion boards in the E-learning, leading to more valuable outcomes (González-Gómez et al., 2012; Zhan et al., 2015).

In response to the lack of motivations and participations on Blackboard during the online class, 48% of female students answered with high impact affecting their learning, while 17% of male students feel this variable is essential. Consequently, this outcome shows that the female students are influenced by body language and means of communications than male students. Lack of body language in E-learning needs to introduce new strategies to handle this issue. For instance, instructors can open a camera for presentation and interact with students to motivate students to answer questions using the poll or discussion room options in Blackboard.

Conducting virtual lab experiments during an online session is classified as having a high impact on EL by 39% male students compared to 18% female students for the same level of importance. This result shows that the male students prefer to physically work with the lab’s tools and equipment more time than female students. Several factors influence the significant differences between gender in understanding via virtual lab, for instance, physical knowledge, previous experience of conducting lab experiments, sensing, and creativity. Thus, it can be inferred that the female students tend to understand better in virtual lab environment that physical class setting,
and this conclusion is in line with (Kepple, 2017; Eom et al., 2006). This finding can introduce further research on the variables, skills, and strategies that can affect the success of a virtual lab and how this can be applied to reduce gender differences.

5.2 Perception analysis on engineering disciplines

A Kruskal–Wallis test is conducted to investigate and evaluate the differences between engineering disciplines’ perceptions on using Blackboard. Table 3 lists the hypotheses that are found significant by the Kruskal–Wallis test with H and p values. The reason behind using the Kruskal–Wallis test is because the independent variable (discipline) has more than two levels (Green & Salkind, 2013; Huck, 2012; Ventura et al., 2010) Tables 3 and 4 show the results of the Kruskal–Wallis test on testing hypotheses across engineering disciplines and descriptive statistics on the significant hypothesis, respectively. The item of class capacity is statistically significant, \( p\text{-value} = 0.005 < 0.05 \), indicating a significant difference among engineering disciplines on perceptions of class capacity. For this item, the perceptions of civil engineering students are the highest (67%) in rating the importance of class capacity. This result is not surprising because the civil engineering has more students and less faculty members, thus E-leaning relaxes the constraints of the class capacity and has the ability to accommodate a high number of students. Perceptions regarding result credibility in exams using Blackboard are significantly different among disciplines with \( p\text{-value} = 0.014 \). The highest-rated for this item is by the civil engineering students with 68% as high impact. The civil engineering curriculum has many courses that offer oral classes and lab experiments; therefore, the students in this field do not prefer the assessment tools taken over the E-learning system, such as blackboard. Recently, the majority of the universities in Saudi Arabia are conducting exams and other assessments in class instead of E-learning platforms. Group interacting is found significant with \( p\text{-value} = 0.001 \) among different disciplines. The perceptions in this item influence are significantly high in the industrial engineering discipline (25%). This result is substantial because the students in this discipline use more active learning styles and work in groups in many courses (active classes). The Kruskal–Wallis test shows a significant difference between the perceptions of engineering disciplines on the ability that Blackboard can provide different teaching styles, with \( p\text{-value} = 0.011 \). On this item, the perception of electrical engineering is rated the highest (36%) among other disciplines, showing that the students tend to prefer different learning styles, which Blackboard cannot provide. This result is essential regarding proposing and offering different learning styles that can improve the students’ outcomes based on their field. For example, the policymakers in the college of engineering can suggest sensing and active groups learning styles in this field, since it has been shown its advantages for electrical engineering students (Omar et al., 2015).

The Kruskal–Wallis test on the perception of technical issues of Blackboard is statistically significant and indicates a significant difference between the disciplines and the rating of technical issues with a \( p\text{-value} = 0.030 \). Electrical and industrial engineering students rate this disadvantage of Blackboard with a high
| Hypothesis number | Hypothesis statement                                                                 | H (Chi-Square) test Statistic | P—Value |
|-------------------|--------------------------------------------------------------------------------------|-------------------------------|---------|
| H1                | The perceptions of flexibility in scheduling are homogenous among different engineering disciplines | 12.453                        | 0.053   |
| H2                | The perceptions of class capacity in Blackboard affect in understanding using EL are homogenous among different engineering disciplines | 18.472                        | 0.005*  |
| H3                | The perceptions of flexibility in using various EL tools are homogenous among different engineering disciplines | 10.684                        | 0.099   |
| H4                | The perceptions of results credibility are homogenous among different engineering disciplines | 15.980                        | 0.014*  |
| H5                | The perceptions of effectiveness of group interacting are homogenous among different engineering disciplines | 22.122                        | 0.001*  |
| H6                | The perceptions of feasibility in providing different teaching styles are homogenous among different engineering disciplines | 16.567                        | 0.011*  |
| H7                | The perceptions of ability in communicating with instructor are homogenous among different engineering disciplines | 9.487                         | 0.148   |
| H8                | The perceptions of facing technical issue are homogenous among different engineering disciplines | 13.981                        | 0.03*   |
| H9                | The perceptions of lack of motivation and participations are homogenous among different engineering disciplines | 9.009                         | 0.173   |
| H10               | The perceptions of conducting lab experiments on Blackboard affect in lack of understanding are homogenous among different engineering disciplines | 2.062                         | 0.914   |

* Denotes significant difference $p < 0.05$
impact of 49% and 48%, respectively. The high rating from these two disciplines is reasonable because electrical and industrial engineering students are more frequent software users than other disciplines. In addition, most students open live web for a specific software training during virtual, causing server delay and technical issues on virtual classes. To reduce the problem associated with this issue, the policymakers may suggest providing more servers specifically for engineering

Table 4  Descriptive statistics on significant hypothesis using Kruskal–Wallis test

| Hypothesis | Discipline | Mean | Median | SD  |
|------------|------------|------|--------|-----|
| H2 IE      | 4.13       | 4    | 0.954  |
| CVE        | 4.67       | 5    | 0.577  |
| AE         | 4.33       | 4.5  | 0.816  |
| CE         | 2.9        | 3    | 1.101  |
| ME         | 4.5        | 4.5  | 0.548  |
| EE         | 3.91       | 4    | 0.931  |
| NE         | 3          | 3    | 1.414  |
| H4 IE      | 3.71       | 4    | 1.035  |
| CVE        | 4.67       | 5    | 0.577  |
| AE         | 2.67       | 3    | 1.506  |
| CE         | 3.6        | 4    | 0.843  |
| ME         | 3.17       | 3    | 0.983  |
| EE         | 3.95       | 4    | 1.067  |
| NE         | 2.5        | 2.5  | 0.707  |
| H5 IE      | 3.64       | 4    | 0.894  |
| CVE        | 2.67       | 3    | 1.528  |
| AE         | 2          | 2    | 0.894  |
| CE         | 3.6        | 4    | 0.843  |
| ME         | 3.67       | 4    | 0.516  |
| EE         | 3.89       | 4    | 1.033  |
| NE         | 2.5        | 2.5  | 0.707  |
| H6 IE      | 3.62       | 4    | 1.036  |
| CVE        | 2          | 2    | 1      |
| AE         | 4.17       | 4    | 0.753  |
| CE         | 3.5        | 4    | 0.707  |
| ME         | 3.5        | 3.5  | 0.548  |
| EE         | 3.97       | 4    | 1.075  |
| NE         | 4.5        | 4.5  | 0.707  |
| H8 IE      | 4.2        | 4    | 0.909  |
| CVE        | 3.33       | 3    | 1.528  |
| AE         | 3.5        | 4    | 1.761  |
| CE         | 3.7        | 4    | 0.949  |
| ME         | 2.83       | 3    | 1.169  |
| EE         | 4.28       | 5    | 0.91   |
| NE         | 4          | 4    | 1.414  |
and other technical colleges since the students deal with many live web activities during the E-learning classes.

6 Conclusion

Undoubtedly, the students’ perceptions are one of the most critical factors influencing all services provided for the educational environment. Perceptions are essential to understand and evaluate the experiences that students encounter while using virtual learning in terms of advantages and disadvantages. This study highlights the differences between gender perceptions on Blackboard using the Mann–Whitney U test. Moreover, a Kruskal–Wallis test is conducted to investigate and evaluate the differences between engineering disciplines’ perceptions on using Blackboard. Differences between males and females are found significant for one of three Blackboard advantages phases (class capacity), and five out seven disadvantages are significant (results credibility, teams interacting, students’ limitations, communicating with the instructor, and low motivation). Engineering disciplines and perceptions are found significant in-class capacity, results’ credibility, group interacting, variety of teaching styles, and technical issues.

Lessons can be gained and strategies can be developed from the COVID-19 pandemic in education to improve the technological infrastructure for E-learning, propose different learning styles, and develop the instructors’ skills in dealing with ICT. Most importantly, both significant advantages and disadvantages presented can direct new improvements and innovations for the E-learning methods. For example, developing discussion boards for better communication, increasing the number of servers for technical colleges, developing workshops for the Blackboard features, applying different teaching styles for a specific discipline. More focus on improvements is needed toward female students on communication and technical skill regarding virtual learning and its platforms. The virtual lab can be improved by introducing software or online applications that can mimic and imitate the real lab, which are available by many lab providers. Improving the results credibility and reduce cheating in the E-learning can be enhanced by using exam cheating detecting tools, such as disable internet browser and open camera during the exam time. To motivate students, instructor could give more bonuses or awards to increase the motivation level and aware the students of the requirements for sitting up suitable educational environment in their places. Technical issues can be reduced by setting the blackboard to send confirmation messages to students’ cellphone when finishing an exam, submitting, uploading a file, or reminding them before class or assignments due dates.

Future research is essential for further investigation with different factors or hypotheses to study the nature of different disciplines and gender on virtual learning.

Data availability Data are collected by surveying engineering students.
Declarations

Conflicts of interest None.

References

Adamus, T., Kerres, M., Getto, B., Engelhardt, N. (2009). “Gender and E-tutoring – a concept for gender sensitive E-tutor training programs,” in 5th European Symposium on Gender & ICT Digital Cultures: Participation – Empowerment – Diversity (University of Bremen: Center for Gender Studies).

Affouneh, S., Salha, S., & Khlaif, Z. N. (2020). Designing quality E-learning environments for emergency remote teaching in coronavirus crisis. Interdisciplinary Journal of Virtual Learning in Medical Sciences, 11(2), 1–3.

Afshari, P., Abedi, P., Eslami, K., Rokhafrooz, D., Maraghi, E., Beheshtinasab, M. (2020). The views of medical students about e-learning during pandemic of COVID-19 in Iran. https://doi.org/10.21203/rs.3.rs-47582/v1.

Ahmed, M. U., Hussain, S., & Farid, S. (2018). Factors influencing the adoption of e-learning in an open and distance learning institution of Pakistan. Electronic Journal of e-Learning, 16(2), 148–158.

Akir, O., Eng, T. H., & Malie, S. (2012). Teaching and learning enhancement through outcome-based education structure and technology e-learning support. Procedia-Social and Behavioral Sciences, 62, 87–92.

Alavudeen, S. S., Easwaran, V., Mir, J. I., Shahrani, S. M., Aseeri, A. A., Khan, N. A., Almodeer, A. M., & Asiri, A. A. (2021). The influence of COVID-19 related psychological and demographic variables on the effectiveness of e-learning among health care students in the southern region of Saudi Arabia. Saudi Pharmaceutical Journal, 29(7), 775–780.

Omar, N., Mohamad, M. M., & Paimin, A. N. (2015). Dimension of learning styles and students’ academic achievement. Procedia-Social and Behavioral Sciences, 204, 172–182.

Alburt, L. J., & Johnson, C. S. (2011). Socioeconomic status–and gender‐based differences in students’ perceptions of e‐learning systems. Decision Sciences Journal of Innovative Education, 9(3), 421–436.

Alexa, L., Avasilcai, S., Pislaru, M., Bujor, A., Avram, E., & Lucescu, L. (2022). Exploring Romanian engineering students' perceptions of Covid-19 emergency e-learning situation. A mixed-method case study. Electronic Journal of E-Learning, 20(1), 19–35.

Alhumaid, K., Ali, S., Waheed, A., Zahid, E., & Habes, M. (2020). COVID-19 & elearning: Perceptions & attitudes of teachers towards E-learning acceptance in the developing countries. Multicultural Education, 6(2), 100–115.

Alhussain, T. (2017). Measuring the impact of the blackboard system on blended learning students. Learning, 8(3).

Almaiah, M., Al-Khasawneh, A., & Althunibat, A. (2020). Exploring the critical challenges and factors influencing the E-learning system usage during COVID-19 pandemic. Education and Information Technologies, 25(6), 5261–5280.

Alvino, F., Di Vaio, A., Hassan, R., Palladino, R. (2020). Intellectual capital and sustainable development: A systematic literature review. Journal of Intellectual Capital.

Andersson, A. (2008). Seven major challenges for e-learning in developing countries: Case study eBIT, Sri Lanka. International Journal of Education and Development Using ICT, 4(3), 45–62.

Azis, Y. M., & Leatemia, M. (2021). The effectiveness of e-Learning, learning styles, prior knowledge, and internet self efficacy in business mathematics courses. Kreano, Jurnal Matematika Kreatif-Inovatif, 12(2), 353–364.

Bagnato, K. (2004). Learning virtually. Communication. College Week.

Bamoallem, B., Altarteer, S. (2021). Remote emergency learning during COVID-19 and its impact on university students perception of blended learning in KSA. Education and Information Technologies, 1–23.

Bencheva, N. (2010). Learning styles and e-learning face-to-face to the traditional learning. Научни Трудове На Русенския Университет, 49(3.2), 63–67.

Bhatia, R. P. (2011). Features and effectiveness of E-learning tools. Global Journal of Business Management and Information Technology, 1(1), 1–7.
Bogle, L., Cook, V., Day, S., & Swan, K. (2009). Blended program development: Applying the quality matters and community of inquiry frameworks to ensure high quality design and implementation. *Journal of the Research Center for Educational Technology, 5*(2), 51–66.

Broos, A. (2005). Gender and information and communication technologies (ICT) anxiety: Male self-assurance and female hesitation. *CyberPsychology & Behavior, 8*(1), 21–31.

Broos, A., & Roe, K. (2006). The digital divide in the playstation generation: Self-efficacy, locus of control and ICT adoption among adolescents. *Poetics, 34*(4–5), 306–317.

Chumley-Jones, H. S., Dobbie, A., & Alford, C. L. (2002). Web-based learning: Sound educational method or hype? A review of the evaluation literature. *Academic Medicine, 77*(10 suppl), S86–S93.

Coates, H. (2007). A model of online and general campus-based student engagement. *Assessment & Evaluation in Higher Education, 32*(2).

Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology, 78*(1), 98.

Cuadrado-García, M., Ruiz-Molina, M. E., & Montoro-Pons, J. D. (2010). Are there gender differences in e-learning use and assessment? Evidence from an interuniversity online project in Europe. *Procedia-Social and Behavioral Sciences, 2*(2), 367–371.

DeNeui, D. L., & Dodge, T. (2006). Asynchronous learning networks and student outcomes: The utility of online learning components in hybrid courses. *Journal of Instructional Psychology, 33*(4), 256–259.

Di Vaio, A., Palladino, R., Hassan, R., & Alvino, F. (2020). Human resources disclosure in the EU Directive 2014/95/EU perspective: A systematic literature review. *Journal of Cleaner Production, 257*, 120509.

Dorman, S. M. (1998). Enhancing school physical education with technology. *The Journal of School Health, 68*(5), 219.

Drent, M., & Meelissen, M. (2008). Which factors obstruct or stimulate teacher educators to use ICT innovatively? *Computers & Education, 51*(1), 187–199.

Durandell, A., & Haag, Z. (2002). Computer self efficacy, computer anxiety, attitudes towards the Internet and reported experience with the Internet, by gender, in an East European sample. *Computers in Human Behavior, 18*(5), 521–535.

El Zawaidy, H., & Zaki, H. (2014). Using blackboard in online learning at Saudi universities: faculty member’s perceptions and existing obstacles. *International Interdisciplinary Journal of Education, 3*(7), 45–154.

Eom, S. B., Wen, H. J., & Ashill, N. (2006). The determinants of students’ perceived learning outcomes and satisfaction in university online education: An empirical investigation. *Decision Sciences Journal of Innovative Education, 4*(2), 215–235.

Fagerland, M. W., & Sandvik, L. (2009). The wilcoxon–mann–whitney test under scrutiny. *Statistics in Medicine, 28*(10), 1487–1497.

Felton, J. (2003). Nonparametric tests of differences in medians: Comparison of the Wilcoxon–Mann–Whitney and robust rank-order tests. *Experimental Economics, 6*(3), 273–297.

Gibbons, A., & Fairweather, P. (2000). Computer-based instruction. In S. Tobias & J. Fletcher (Eds.), *Training & Retraining: A Handbook for Business, Industry, Government, and the Military* (pp. 410–442). Macmillan Reference USA.

González-Gómez, F., Guardiola, J., Rodríguez, Ó. M., & Alonso, M. Á. M. (2012). Gender differences in e-learning satisfaction. *Computers & Education, 58*(1), 283–290.

Green, S. B., & Salkind, N. J. (2013). *Using SPSS for Windows and Macintosh* (7th ed.). Pearson.

Gunasekaran, A., McNeil, R., & Shaul, D. (2002). E-learning: research and applications. *Industrial and Commercial Training, 34*(2), 44–53.

Gunawan, G., Suranti, N. M. Y., Nisrina, N., Ekasari, R. R., & Herayanti, L. (2018). The effect of virtual labs toward students’ understanding of physics based on gender. *Advances in Social Science, Education and Humanities Research, 173*(1), 128–131.

Gupta, S., Dabas, A., Swarnim, S., & Mishra, D. (2021). Medical education during COVID-19 associated lockdown: Faculty and students’ perspective. *Medical Journal armed Forces India, 77*, S79–S84.

Harandi, S. R. (2015). Effects of e-learning on Students’ Motivation. *Procedia-Social and Behavioral Sciences, 181*, 423–430.

Hartman, H., Hartman, M. (2006). Attitudes To Group Work: Gendered Differences? In 2006 Annual Conference & Exposition (pp. 11–259).

Horton, W. (2001). *Evaluating E-learning*. American Society for Training and Development.
Huba, M., Kozák, Š. (2016). From E-learning to Industry 4.0. In 2016 International Conference on Emerging eLearning Technologies and Applications (ICETA) (pp. 103–108). IEEE.

Huck, S. W. (2012). Reading Statistics and Research (6th ed.). Pearson Education.

Individuals Using The Internet (% Of Population) - Saudi Arabia | Data. (2021). Data.Worldbank.Org. https://data.worldbank.org/indicator/IT.NET.USER.ZS?end=2020&locations=SA&start=2020. Accessed 6 Dec 2021.

Jones, K. O., Reid, J., & Bartlett, R. (2008). E-learning and E-cheating. Communication & Cognition, 41(1), 61.

Kanninen, E. (2009). Learning styles and e-learning. Tampere: Tampere University of Technology, 1, 5–29.

Kayany, J. M., & Yelsma, P. (2000). Displacement effects of online media in the socio-technical contexts of households. Journal of Broadcasting & Electronic Media, 44(2), 215–229.

Kepple, C. M. J. (2017). Distance Learning in Physics: an Investigation of Possible Benefits to Female Students in an Online Laboratory Environment. University Honors Theses. Paper 398. https://doi.org/10.15760/honors.394.

Khan, Z., Abid, M. (2021). Distance learning in engineering education: Challenges and opportunities during COVID-19 pandemic crisis in Pakistan. The International Journal of Electrical Engineering & Education, 002070292098849. https://doi.org/10.1177/0020702920988493.

Khan, B. H. (2001). A framework for e-learning. LTI magazine.

Khechine, H., Lakhal, S., Pascot, D., & Bytha, A. (2014). UTAUT model for blended learning: The role of gender and age in the intention to use webinars. Interdisciplinary Journal of E-Learning and Learning Objects, 10(1), 33–52.

Khine, M. (2003). Creating a technology-rich constructivist learning environment in a classroom management module’. In M., Khine, & D., Fisher (eds), Technology-Rich Learning Environment : A Future Perspective, World Scientific, New Jersey, London, Singapore, Hong Kong, 1-20.

Korlat, S., Kollmayer, M., Holzer, J., Lüftenegger, M., Pelikan, E. R., Schober, B., & Spiel, C. (2021). Gender differences in digital learning during COVID-19: Competence beliefs, intrinsic value, learning engagement, and perceived teacher support. Frontiers in Psychology, 12, 849.

Koumi, J. (2006). Designing Educational Video and Multimedia for Open and Distance Learning. Routledge.

Lee, J., Song, H. D., & Hong, A. J. (2019). Exploring factors, and indicators for measuring students’ sustainable engagement in e-learning. Sustainability, 11(4), 985.

Liu, D., Valdiviezo-Díaz, P., Ríofrío, G., Sun, Y. M., & Barba, R. (2015). Integration of virtual labs into science e-learning. Procedia Computer Science, 75, 95–102.

Maatuk, A. M., Elberkawi, E. K., Aljawarneh, S., Rashaideh, H., Alharbi, H. (2021). The COVID-19 pandemic and E-learning: challenges and opportunities from the perspective of students and instructors. Journal of Computing in Higher Education, 1–18.

Mailizar, A., Abdulsalam, M., & Suci, B. (2020). Secondary school mathematics teachers’ views on e-learning implementation barriers during the COVID-19 pandemic: The case of Indonesia. Eurasia Journal of Mathematics, Science & Technology Education, 16(7), 1–9.

Malikowski, S. R., Thompson, S. R., & Theis, J. G. (2007). A model for research into course management systems: Bridging technology and learning theory. Journal of Educational Computing Research, 36(2).

Martha, A. S. D., Junus, K., Santoso, H. B., & Suhartanto, H. (2021). Assessing undergraduate students’ e-learning competencies: A case study of higher education context in Indonesia. Education Sciences, 11(4), 189.

McElduff, F., Cortina-Borja, M., Chan, S. K., & Wade, A. (2010). When t-tests or Wilcoxon-Mann-Whitney tests won’t do. Advances in Physiology Education, 34(3), 128–133.

Mohammadi, M., Mohibi, A., & Hedayati, M. (2021). Investigating the challenges and factors influencing the use of the learning management system during the Covid-19 pandemic in Afghanistan. Education and Information Technologies, 26(5), 5165–5198.

Mtebe, J., & Raphael, C. (2018). Key factors in learners’ satisfaction with the e-learning system at the University of Dar es Salaam, Tanzania. Australasian Journal of Educational Technology, 34(4), 107–122.

Mumtaz, S. (2001). Children’s enjoyment and perception of computer use in the home and the school. Computers & Education, 36(4), 347–362.
Muthuprasad, T., Aiswarya, S., Aditya, K. S., & Jha, G. K. (2021). Students’ perception and preference for online education in India during COVID-19 pandemic. Social Sciences & Humanities Open, 3(1), 100101.

Nagappan, A. (2015). Assessments in the 21st Century: No more cheating during e-Examinations!!!. Second 21st Century Academic Forum at Harvard, 5, 331–345.

Nagel, L., & Kotzé, T. G. (2010). Supersizing e-learning: What a CoI survey reveals about teaching presence in a large online class. The Internet and Higher Education, 13(1–2), 45–51.

National Digital Transformation Reports. [online] Available at: https://ndu.gov.sa/ar/our-reports. Accessed 18 Dec 2021.

Rosenberg, M. (2001). E-Learning: Strategies for Delivering Knowledge in the Digital Age. McGraw-Hill.

Rossett, A., Dougls, F., & Frazee, R. V. (2003). Strategies for Building Blended Learning. ASTD's Source For E-Learning.

Sandybayev, A. (2020). The impact of e-learning technologies on student’s motivation: Student centered interaction in business education. International Journal of Research in Tourism and Hospitality (IJRTH), 6(1), 16–24.

Shahzad, A., Hassan, R., Aremu, A. Y., Hussain, A., & Lodhi, R. N. (2021). Effects of COVID-19 in E-learning on higher education institution students: The group comparison between male and female. Quality & Quantity, 55(3), 805–826.

Sife, A. S., Lwoga, E. T., & Sanga, C. (2007). New technologies for teaching and learning: Challenges for higher learning institutions in developing countries. International Journal of Education and Development Using ICT, 3(2), 57–67.

Thomas, D. (2021). The relationship among academic dishonesty, E-learning readiness, and procedural justice. Human Behavior Development and Society, 22(3), 32–41.

Tian, T., DeMarra, R. F., & Gao, S. (2019). Efficacy and perceptions of assessment digitization within a large-enrollment mechanical and aerospace engineering course. Computer Applications in Engineering Education, 27(2), 419–429.

UNESCO. (2020). COVID-19 Educational disruption and response. https://en.unesco.org/themes/education-emergencies/coronavirus-school-closures. Accessed 23 Nov 2021.

Van, D. V., & Ferry, J. (1980). Measuring and assessing organizations. Wiley.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly, 425–478.

Ventura, A. K., Gromis, J. C., & Lohse, B. (2010). Feeding practices and styles used by a diverse sample of low-income parents of preschool-age children. Journal of Nutrition Education and Behavior, 42(4), 242–249.

Villaverde, J. E., Godoy, D., & Amandi, A. (2006). Learning styles’ recognition in e-learning environments with feed-forward neural networks. Journal of Computer Assisted Learning, 22(3), 197–206.

Wang, R., Chen, L., & Solheim, I. (2020). Modeling dyslexic students’ motivation for enhanced learning in E-learning systems. ACM Transactions on Interactive Intelligent Systems (TiiS), 10(3), 1–34.

Xiaozhao, D., & Jianhui, R. (2009). Users’ privacy in the second life library. IT in medicine & education. IEEE International Symposium on IT in Medicine, 1, 337–340.

Xu, Z., Yin, Z., Saddik, A. E. (2003). May. A web services oriented framework for dynamic e-learning systems. In CCECE 2003-Canadian Conference on Electrical and Computer Engineering. Toward a Caring and Humane Technology (Cat. No. 03CH37436) (vol. 2, pp. 943–946). IEEE.

Zhan, Z., Fong, P. S., Mei, H., Chang, X., Liang, T., & Ma, Z. (2015). Sustainability education in massive open online courses: A content analysis approach. Sustainability, 7(3), 2274–2300.

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