UNIVERSITI PUTRA MALAYSIA

THE EFFECTIVENESS OF ONLINE LEARNING DURING COVID-19 IN UNDERGRADUATE MEDICAL AND HEALTH SCIENCE STUDENTS: A SYSTEMATIC REVIEW

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A PROJECT PAPER SUBMITTED AS PARTIAL REQUIREMENT FOR THE DEGREE OF BACHELOR OF SCIENCE (BIOMEDICAL SCIENCES)

DEPARTMENT OF BIOMEDICAL SCIENCES
FACULTY OF MEDICINE AND HEALTH SCIENCES
UNIVERSITI PUTRA MALAYSIA

2021

ABSTRACT

The Effectiveness of Online Learning during COVID-19 in Undergraduate Medical and Health Science Students: A Systematic Review

Abdull Assyaqireen Abdull Mutalib[a], Mohamad Hasif Jaafar[b], Abdah Md. Akim[a]

[a]Department of Biomedical Sciences, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia
[b]Academy of Contemporary Islamic Studies, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Kuala Pilah

Introduction: Coronavirus disease (COVID-19) pandemic outbreak forced many learning institutions to temporarily close. This situation compelled the worldwide education system to move to online teaching. As a result, online learning was delivered through the second half of 2020, and it is expected to continue until 2021. **Objective:** This study aimed to analyze the effectiveness of distance learning during the COVID-19 pandemic in undergraduate medical and health science students using systematic review. **Methodology:** The studies were identified from 3 electronic databases: Scopus, ScienceDirect and Pubmed using PRISMA. The screening process was done based on the eligibility criteria. Out of 1486 studies, 1269 were screened. A total of 64 eligible studies obtained were included in the quantitative analysis. Quality assessment was done by using Alberta checklist. **Results:** Results were categorized into i) student attitudes (perception/satisfaction/engagement), and ii) student learning outcomes, and compared to the Kirkpatrick model. Although facing difficulties, 50% of the studies are moderately satisfied with distance learning, while 36% are highly satisfied and 17% dissatisfied. Most studies (26%) reported distance learning provides flexibility in learning. Internet issues (19%) and low interaction between learners and instructors (19%) were the most prevalent problems mentioned. Online education engages students better than traditional learning. The learning outcome was categorized into two categories: i) academic performance and ii) skill development. Most studies (72%) stated that distance learning improves academic performance, 14% reported a drop, and 14% stated no effect, while significant increase in clinical skills and communication skills were also reported. Kirkpatrick evaluation revealed 80% of the studies obtained was evaluated at level 1 (reaction), 8% at level 2 (learning), 12% at level 3 (behaviour) and none at level 4 (results). **Discussion:** Even though there are hurdles for educators and learners, online learning has been chosen as the best approach to continue offering education in this pandemic era. Transitioning from conventional to online learning is a difficult task because both traditional and online learning operates in different ways. Learners and educators must adapt to the online learning environment, by all means necessary due to non-options. Instructors and learners' reactions to online learning apps must also be observed at all times while adapting to the new changes. Not everyone is ready to make changes in a short period of time. A fixed mindset person has a hard time adapting and adjusting, but a growth mindset person adapts easily to new learning environments. **Conclusion:** Overall, this systematic review found that the online learning strategy performed better than expected during COVID-19, but the data gained is insufficient to say it is beneficial

when compared to other types of teaching approaches. However, more RCT and qualitative investigations should be undertaken in the future to derive more precise results.

Keywords: Online learning, COVID-19, effectiveness, systematic review, Kirkpatrick model

ABSTRAK

Keberkesanan Pembelajaran Dalam Talian Semasa COVID-19 Dalam Pelajar Perubatan dan Sains Kesihatan PraSiswazah: Kajian Sistematik

Abdull Assyaqireen Abdull Mutalib[a], Mohamad Hasif Jaafar[b], Abdah Md. Akim[a]

[a]Jabatan Sains Bioperubatan, Fakulti Perubatan dan Sains Kesihatan, Universiti Putra Malaysia
[b]Akademi Pengajian Islam Kontemporari, Universiti Teknologi MARA, Cawangan Negeri Sembilan, Kampus Kuala Pilah

Pengenalan: Wabak pandemik koronavirus (Covid-19) memaksa mana-mana institusi pembelajaran ditutup buat sementara waktu. Keadaan ini memaksa sistem pendidikan di seluruh dunia beralih kepada pengajaran dalam talian. Hasilnya, pembelajaran dalam talian telah disampaikan pada pertengahan tahun 2020, dan ia dijangka berterusan sehingga 2021. **Objektif:** Kajian ini bertujuan untuk menganalisis keberkesanan pembelajaran dalam talian semasa pandemik COVID-19 dalam pelajar perubatan dan sains kesihatan prasiswazah menggunakan kajian sistematik. **Metodologi:** Kajian ini meggunakan daripada 3 pangkalan data elektronik: Scopus, ScienceDirect dan Pubmed menggunakan PRISMA. Proses saringan dilakukan berdasarkan kriteria kelayakan. Daripada 1486 kajian, 1269 telah disaring. Sebanyak 64 kajian yang layak telah dimasukkan ke dalam analisis kuantitatif. Penilaian kualiti dilakukan dengan menggunakan senarai semak Alberta. **Keputusan:** Keputusan dikategorikan kepada i) sikap pelajar (persepsi/kepuasan/penglibatan), dan ii) hasil pembelajaran pelajar, dan dibandingkan dengan model Kirkpatrick. Walaupun menghadapi kesukaran, 50% daripada kajian agak berpuas hati dengan pembelajaran dalam talian, manakala 36% sangat berpuas hati dan 17% tidak berpuas hati. Kebanyakan kajian (26%) melaporkan pembelajaran dalam talian memberikan fleksibiliti dalam pembelajaran. Isu Internet (19%) dan interaksi yang rendah antara pelajar dan pengajar (19%) adalah masalah yang paling lazim disebutkan. Pendidikan dalam talian melibatkan pelajar lebih baik daripada pembelajaran tradisional. Hasil pembelajaran dinilai mengikut dua kategori iaitu: i) prestasi akademik dan pembangunan kemahiran. Kebanyakan kajian (72%) menyatakan bahawa pembelajaran dalam talian meningkatkan prestasi akademik, 14% melaporkan penurunan, dan 14% menyatakan tiada kesan, manakala peningkatan kemahiran klinikal dan kemahiran komunikasi dilaporkan. Penilaian Kirkpatrick mendedahkan 80% daripada kajian yang diperoleh dinilai pada tahap 1 (reaksi), 8% pada tahap 2 (pembelajaran), 12% pada tahap 3 (tingkah laku) dan tiada pada tahap 4 (keputusan). **Perbincangan:** Walaupun terdapat halangan untuk pendidik dan pelajar, pembelajaran dalam talian telah dipilih sebagai pendekatan terbaik untuk terus menawarkan pendidikan dalam era pandemik ini . Peralihan dari konvensional ke pembelajaran dalam talian adalah tugas yang sukar kerana pembelajaran tradisional dan dalam talian beroperasi dengan cara yang berbeza. Pelajar dan pendidik mesti menyesuaikan diri dengan persekitaran pembelajaran dalam talian, dengan segala cara yang diperlukan kerana tiad pilihan lain. Reaksi pengajar dan pelajar terhadap aplikasi pembelajaran dalam talian juga mesti diperhatikan pada setiap masa sambil

menyesuaikan diri dengan perubahan baru. Tidak semua orang bersedia untuk membuat perubahan dalam tempoh masa yang singkat. Orang yang berfikiran tetap mempunyai masa yang sukar menyesuaikan diri, tetapi orang yang berfikiran panjang akan dapat menyesuaikan diri dengan mudah ke persekitaran pembelajaran baru. **Kesimpulan:** Secara keseluruhan, kajian sistematik ini mendapati bahawa strategi eLearning menunjukkan prestasi yang lebih baik daripada yang dijangkakan semasa COVID-19, tetapi data yang diperoleh tidak mencukupi untuk mengatakan ia bermanfaat jika dibandingkan dengan pendekatan pengajaran lain. Walau bagaimanapun, lebih banyak RCT dan penyiasatan kualitatif perlu dijalankan pada masa akan datang untuk mendapatkan hasil yang lebih tepat.

Kata kunci: Online pembelajaran, COVID-19, keberkesanan, kajian sistematik,kirkpatrick model

ACKNOWLEDGEMENT

First and foremost, I want to thank my supervisor, Associate Professor Dr Abdah Md Akim, and my co-supervisor, Dr Mohamad Hasif Jaafar, for their guidance and support. They have always been there for me throughout my Final Year Research Project (FYP) adventure, and their warm encouragement has kept me going through the good and bad times. Despite the hurdles, I was able to complete my job because of their excellent advice and keen insights. As I embark on a new adventure, I will carry their wisdom with me.

My gratitude also goes out to Shafira, a fellow FYP member who has lent her invaluable power to my effort. I would not have been able to finish my studies in such a short time without her tireless assistance. She is an incredibly dependable and motivating teammate to work with. Despite the fact that our time together was brief, it was the most interesting and passionate period of learning for me, and I continue to be inspired by her profound efforts. I'd want to express my gratitude to Ayuni, Aina Nadherra, Sarah Hasran, Sarah Hanum, Ain Sofea, and Aimi for always being there for me during this incredible experience. Hazmin, Shazlan, Hagilan, and Tan Jian Wei, among my closest pals, have been tremendously supportive in every manner. Their suggestions, thoughts, and moral support were both reassuring and helpful. They offered me a lot of confidence and support in my career by sticking together during difficult circumstances.

Finally, I'd like to thank my parents and grandmother for their support. They are and always will be my primary pillars of strength. Despite the fact that I am primarily negative, their faith in me remains unshaken. As a result, I am able to concentrate and thrive in my schoolwork since I know they will always support me and love me unconditionally. This dissertation is a testimonial to everyone's help and encouragement.

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LIST OF ABBREVIATIONS

F2F	Face to Face
ICT	Information and Communication Technology
OECD	Organization for Economic Co-operation and Development
OL	Online Learning
OSCE	Objective Structured Clinical Examination
PICOS	Population, Intervention, Comparison, Outcomes, Study Design.
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomized Controlled Trial
RevMan	Review Manager
RT-PCR	Reverse Transcription Polymerase Chain Reaction
SARS CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SD	Standard Deviation
TL	Traditional learning
VM	Virtual Microscopy
VR	Virtual Reality
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

Millions of students throughout the world have been afflicted by the coronavirus outbreak. With the coronavirus spreading like wildfire across Asia, Europe, the Middle East, and the United States, all of those countries have finally taken rapid and immediate intervention to avoid a full-blown pandemic from developing. According to WHO (2021), the virus can be transmitted in tiny fluid molecules from an infected person's mouth or nose when they cough, sneeze, speak, sing, or breathe, and it can also propagate whenever anyone touches surface areas that the pathogen has already contaminated without washing their hands before touching their eyes, nose, or mouth. Because the virus spreads easily in poorly ventilated areas and in overcrowded indoor environments, governments have enforced physical separation and mobility restrictions to prevent people from coming into touch with each other (CDC, 2020).

Numerous statements about the suspension of schools and institutions have been made in the last two weeks to minimise the virus from spreading. According to the OECD, over 421 million learners are impacted by schools and institution closures declared or executed in 39 countries just since March 13. Millions of students have already been forced into temporary home-schooling circumstances as a result of these risk-management measures, particularly in some of the most severely affected countries, such as China, South Korea, Italy, and Iran. COVID-19 caused schools and

institutions all around the world to close in early 2020, resulting in about 1.2 billion learners missing out on their education because traditional learning could not continue. Educational institutions are scrambling to come up with solutions to this difficult scenario. As a result of this issue, all learners and instructors throughout the world have been introduced to online learning systems, where instruction is done remotely on online platforms (Dhawan, 2020; El Said, 2021; Tam & El-Azar, 2020). According to El Said (2021), there was already a massive increase and acceptance in education technology in 2019 and even before COVID-19, and it is anticipated that roughly 18.66 billion US dollars' worth of worldwide investments were employed during that time, with a forecast of $350 billion US dollars by 2025.

Virtual learning is a type of online learning, often known as distance education, that has long been a part of the educational system around the world (Nguyen, 2015). Online learning, sometimes known as "e-learning," is education that requires the use of the internet (Kessler, 2018). Some learners have experienced anxiety regarding online learning and problems in accomplishing homework as the popularity of digital learning grew throughout the pandemic. Institutions of higher education can establish methods to support undergraduate students in case the pandemic is not going to end or other crisis that necessitates an immediate switch to remote learning by knowing the difficulties and desires of students (Patricia Aguilera-Hermida, 2020). There is some research that suggests that online learning during a pandemic can benefit the student. According to Gallego et al. (2020), students' academic performance was examined during online learning applications. The results obtained shows students' achievement during COVID-19 enhanced as compared to a cohort from the previous year. Online education can be just as excellent as or even superior to teaching in a conventional

classroom. According to research, students who received web-based learning did a lot better than those who received face-to-face education, but it must be done correctly (Greenhow, 2020).

Next, when contemplating online learning applications as a substitute for traditional learning, online education has proven to be a valuable tool in assisting students in maintaining their skill development during school and university closures. However, there are also worries that online learning is a sub-optimal replacement for conventional teaching, despite the lack of essential systems and a lack of proper preparedness among educators and learners for the specific requirements that online education imposes (OECD, 2020). There has been no assessment of what method all institutions around the world have adopted to deal with the COVID-19 pandemic and how they are now planning for the following semester. Only anecdotal evidence from individual universities is presented, which is extremely unreliable.

There are several systematic reviews that assessed the effectiveness of online learning. According to Kusmaryono et al. (2021), during the COVID-19 epidemic, distance learning has grown in prominence as a new mode of learning. However, there is still an issue with integrating distant learning with management learning systems. In their systematic review, they examine the benefits and drawbacks of online learning and how it would affect students. Then, according to Pei and Wu (2019), They are analysing the effectiveness of online learning versus traditional learning among medical students as part of their research. Nonetheless, their findings reveal that there is no indication that offline learning is more effective.

Even though numerous favourable attributes are linked with online learning, the effectiveness of using online learning is still insufficient, especially during pandemic COVID-19. Therefore, this systematic review will review and analyse the effectiveness of online learning during the COVID-19 pandemic in undergraduate medical and health science students.

1.2 Objectives

1.2.1 General objective

This study generally aimed to review and analyse the effectiveness of online learning during the COVID-19 pandemic in undergraduate medical and health science students.

1.2.2 Specific Objective

The specific objectives of this study are to use the systematic review in other to determine the efficacy of online learning during COVID-19 in achieving the targeted learning outcomes among undergraduate medical and health science students. Then, this study also focuses on determining the undergraduate medical and health science student's reactions and attitudes following the use of online learning during COVID-19 and analysing the effectiveness of online learning based on the Kirkpatrick Model of Evaluation.

1.3 Hypothesis

It is hypothesised that this systematic review might show the clear statement of effectiveness of online learning in undergraduate medical and health science students during the COVID-19 pandemic, which can be evaluated based on students learning outcomes, student attitudes and reactions and the Kirkpatrick model.

CHAPTER 2

LITERATURE REVIEW

2.1 Online learning

Distance education in all fields has been greatly improved by rapidly evolving technology. Many universities and colleges throughout the world now offer online degree programmes and courses, allowing students to obtain higher education without having to leave their homes (Mcbrien et al., n.d.). Most distance education concepts, such as online learning, open web-based learning, and blended learning, must all have one thing in common: the capacity to use a computer, phone and other gadgets with an internet connection. Because this type of learning does not necessitate a person's presence in a classroom at a specific location, it allows them to be present and study from anywhere and at any time (Cojocariu et al., 2014). According to Leaser (2016), face-to-face learning is still the preferred method of delivery, but it is being used less frequently due to a number of challenges. As a result of this potential, the adoption of a hybrid of synchronous and asynchronous online learning has increased.

Online learning can be grouped into asynchronous and synchronous learning. Asynchronous learning is a type of engagement in which both the learners and the instructors are not required to be present at the same time. Students participating in asynchronous courses benefit from the flexibility of being able to do their work whenever they want. Using technology such as video recording, audio recording, online forums, and emails is common in this style of learning. Synchronous learning occurs when teachers and students are in separate locations at the same time. This indicates that learners and teachers are interacting in a meaningful way. Students

enrolling in synchronous courses must log on to their computers at a certain time, which is usually established by the lecturers. Conferencing tools, newsgroups, web seminars, and chat groups are common ways to deliver this type of learning (Littlefield, 2020; Singh & Thurman, 2019).

Synchronous	Asynchronous
Students interact with the live trainer/facilitator and other students	Students learn independently and potentially in isolation
Learning is scheduled and has a fixed start and end time	Learning is available anytime and potentially anywhere
Learning is linear	Learning may be linear or freeform

Table 2.1: The differences between synchronous and asynchronous learning (Leaser, 2016).

There are a few other requirements that must be met before certain online learning platforms can be employed. First and foremost, the video conferencing platform must be able to accommodate at least 50 students at the same time. Even if everything was provided online, instructors and students could still engage in an online discussion to make it more realistic. Students who do not have access to a high-speed internet connection should be able to access recorded lectures through the online platform. Next, online platforms should be available not only through computers but also through mobile devices. Last but not least, students should have the option of watching the recorded lecture again, especially if they have a problem during live online teaching. The online platform should also allow students to complete and submit work given during quizzes, tests, and online assignments (Basilaia et al., n.d.).

2.2 COVID-19

Due to an outbreak of a febrile respiratory infection caused by the coronavirus 2019-nCoV, the Chinese city of Wuhan has drawn international attention. The outbreak of pneumonia with an unknown cause in Wuhan, Hubei Province, China, is thought to be linked to the Huanan Seafood Wholesale Market, where live animals are sold. The Chinese health authorities then took immediate public health steps to prevent the virus from spreading, including intense surveillance and epidemiological studies, before deciding to close the market on January 1, 2020 (Hui et al., n.d.). Chinese scientists then discovered a new coronavirus from patients in Wuhan by January 7, 2020. The genomic sequence of the 2019 new coronavirus was acquired, and this sequence was employed in the quick construction of 2019-nCoV-specific real-time RT-PCR diagnostic assays (Chen Wang et al., 2020).

The coronavirus disease 2019 (COVID-19) pandemic is caused by the virus severe acute respiratory syndrome coronavirus 2 (SARS-CoV2). COVID-19 emerged in China around the end of 2019 and has expanded globally, infecting millions of people and killing hundreds of thousands. Finally, the World Health Organization designated COVID-19 as the sixth public health emergency of worldwide concern on January 30, 2020. SARS-CoV-2 has been found to be closely linked to two bat-derived SARS-like coronaviruses, bat-SL-CoVZC45 and bat-SL-CoVZXC21. This virus has the potential to travel from person to person via droplets or direct touch, which has resulted in the virus spreading relatively quickly, and the infection's incubation time has been estimated to be around six days (Lai et al., n.d.; Nardo et al., 2020).

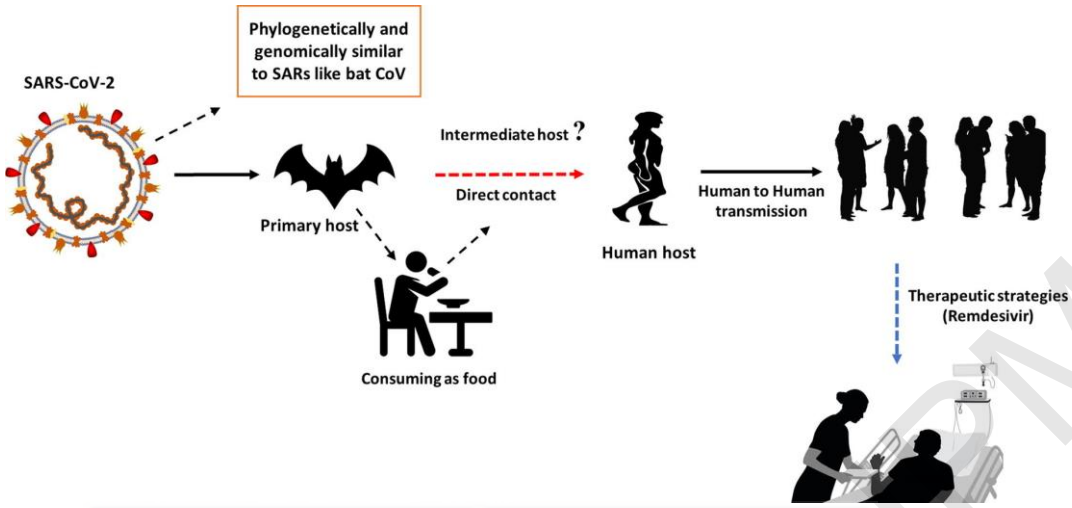


Figure 2.2: The SARS-CoV-2 is related to two bat-derived severe acute respiratory syndrome-like coronaviruses, and the transmission of the virus can happen via a human-human transmission (Shereen et al., 2020).

After the World Health Organization labelled COVID-19 a pandemic, all governments around the world finally realised that they needed to start taking safeguards to prevent the virus from spreading like wildfire. Handwashing, wearing face masks, physical distance, and avoiding big meetings and assemblies have all been used as public health initiatives. In order to flatten the curve and control the spread of the disease, lockdown and stay-at-home techniques have been implemented (Sintema, 2020b).

2.3 Relation between COVID-19 and Online Learning

The COVID-19 virus has wreaked havoc on education systems on a scale unprecedented in human history. It is estimated that almost 1.6 billion students in over 200 nations are affected. Schools, institutions, and other learning places have been closed as a result of the COVID-19 outbreak. As a result of this issue, approximately 94 per cent of the world's student population is affected by conventional learning,

which is face-to-face instruction. Many students and educators were forced to develop new ways to adapt to these significant changes in educational institutions as a result of these issues. Traditional educational processes will be considerably disrupted as a result of social separation and restricting movement laws that have been enacted. Reopening schools after the restricting movement have ended can be difficult, as the education government will need to develop a slew of new standard operating procedures to keep track of everything (Pokhrel & Chhetri, 2021).

The implementation of lockdown and social distancing tactics during COVID-19 has resulted in a paradigm shift in the way instructors offer learning. Even though there would be numerous hurdles for educators and learners, online learning or distance education has been chosen as the best approach to continue offering education in this pandemic. Transitioning from conventional to online learning is a difficult task because both traditional and online learning operates in very different ways. However, learners and educators must adapt to the online learning environment, by all means, necessary because they do not have any other options. According to Kaplan-Rakowski (n.d.), all institutions must quickly transition to an online learning model due to the constrained movement during the pandemic. Online learning tools are critical, particularly during this pandemic. Its goal is to assist educators, schools, and universities in facilitating student learning during university and school shutdown periods. Furthermore, the majority of these technologies are free, which can aid in ongoing learning during the Coronavirus pandemic. Next, instructors and learners' reactions to online learning apps must be observed at all times while adapting to the new changes. This could be because not everyone ready to make sudden changes in such a short period of time. Learners with a fixed mindset might have a hard time

adapting and adjusting, but learners with a growth mindset adapt easily to new learning environments. Furthermore, various subjects may react differently to online learning programmes. To summarise, various people and age groups necessitate different ways on how they are going to adapt to online learning (Doucet et al., 2020).

Many students, particularly those who live at home, are unable to adapt to the new adjustments as a result of these quick changes. Some people have experienced psychological and emotional discomfort, making it impossible for them to work efficiently. The use of appropriate and relevant online technologies in distance classes may be dependent on both educators' and learners' knowledge and exposure to information and communications technology. Microsoft Teams, Google Classroom, Canvas, and Blackboard are a few prominent online platforms that are free and simple to use. This type of technology is fantastic since it can benefit both students and educators in a variety of ways. It not only enables educators to exchange and teach each other through synchronous learning, but it also assists students who are having difficulties with their clinical practises by allowing them to practice and gain valuable skills online, which is very crucial while searching for employment (Petrie et al., 2020). All video meetings at work will be recorded, and the file will typically be preserved and organised in one location where students can readily examine the file and repeat the video if they want to learn more. Aside from the video, instructors can share a variety of clinical application materials with students, such as PDFs, Word documents, Excel spreadsheets, audio files, YouTube videos, and more. The application also allows instructors to track students' grasp of the material by administering quizzes and assigning clinical practice-related assignments (Pokhrel & Chhetri, 2021).

The flipped classroom can also be utilised to impart education to students because it can help students have a better comprehension of what is going on in the live classroom. Before class, instructors will provide students with learning tools such as articles, pre-recorded films, and YouTube links. As a result, students and learners can use the time in the online classroom to improve their understanding by participating in discussions with the instructors (Doucet et al., 2020). The flipped classroom has been shown to be one of the most effective methods for teaching learners problem-solving, critical thinking, and self-directed learning. Recently, the use of virtual classroom systems that include video conferencing has increased, such as Google Meet, Zoom, Cisco, and WebEx. On the other hand, Elias, Moodle, BigBlueButton, and Skype have all been recommended for usage as a cloud-based learning management platform (Pokhrel & Chhetri, 2021).

2.4 Student attitudes and Learning outcomes

Attitudes play an important role in how people connect with one another and with information. Because it incorporates a person's mental state, attitude is a complicated concept. The psyche to act or react, a manner of thinking or behaving, the way a person thinks and behaves are all examples of attitude. It's said to as a widespread inclination in others to respond favourably or unfavourably to an individual. It is a complicated mental state involving someone's beliefs and feelings in a certain situation. It involves a person's views of something and determines whether they like or detest it. In a nutshell, attitudes are personal judgments based on one's experiences in a certain situation. It determines what each person sees, hears, thinks, and does, and it can be positive or negative (Azeem et al., 2009).

Attitude is a psychological characteristic that includes cognitive, affective, and behavioural components and is a predictor of behaviour. Human behaviour is influenced by attitudes, which are one of the most important determinants. Individuals' attitudes have an impact on their actions and feelings. Attitude is a learnt phenomenon that governs all of a person's actions during their decision-making process. Attitude refers to a person's predisposition or prejudices toward a particular event or object, and it is extremely important in the teaching profession (Salih Küçüközyiğit et al., 2017).

Figure 2.4: Attitudes can be categorised into three dimensions - Cognitive, Behavioral and Emotional (Gil Angel et al., 2017).

Students' exposure and accessibility to information and communications technology (ICT) is a crucial factor that can influence their views about online learning. ICT is defined as the medium for integrating technical gadgets, and it plays a critical role in linking people in education and other areas of society. One of the most important considerations in assessing online learning performance in developing and

developed countries is determining how students get access to ICT resources. It is vital and valuable to plan and create appropriate ICT in education because it has the potential to benefit all students in the future (Ismaili, 2021). Students' attitudes toward learning are significant because they influence a variety of critical elements, including their aim, ability to solve issues, beliefs and passion for learning, inner and external motives in the learning process, and academic success. The nature of learning, anxiety caused by learning, expectancy toward learning, openness toward learning, genders, and academic achievements can all be utilised to assess university students' attitudes toward learning. Individual activity is required to comprehend what they have learned (Şen, 2013). When an online method delivers positive or negative value to the student community, student engagement, satisfaction, and perception are examples of student attitudes or reactions that can be determined (Alberti et al., 2021). According to Ediger (2001), attitudes are difficult to evaluate since they are a more subjective aspect when compared to others, and numerous factors must be considered in order to quantify and establish how good or terrible an individual's or group's attitudes are. Observation, direct questions about their sentiments and views about the subject under study, performance assessments, and directly delivering the respondents partially organised stimuli and watching how they understand and react to it are all approaches that can be used to gather data for attitudes (Azeem et al., 2009).

Learning outcomes are the requirements of what a student should learn and exhibit upon successful completion of a course of study in higher education. It can also be thought of as the desired outcome of the learning process in terms of skill and knowledge acquisition. Students must be given specific experiences, and their progress must be evaluated in order to achieve learning outcomes. Student evaluations show

where learning has occurred and where it needs to be improved (Aithal & Kumar, 2016). Online learning has had the most impact on education, particularly for students enrolled in trade schools that demand extensive training. Because online training was relatively difficult compared to traditional instruction, several learning outcomes involving particular abilities were disturbed (Harris & Clayton, 2019). According to Fjelstul (2004), The online learning strategy has had an impact on a variety of learning outcomes, as demonstrated by students' academic achievement. Learning outcomes can be defined as what students should know, comprehend, and demonstrate in terms of information, abilities, and competencies at the end of a learning process. Competencies can be either discipline-specific or generic. Competencies aren't the same as skills, although they're close. Competencies are different from skills in that they are inherited qualities in some individuals. Competencies include problem-solving, critical thinking, communication, and interpersonal skills (González & Wagenaar, 2006). Based on Mahajan and Singh (2017), learning outcomes are declarations of what successful students should be able to achieve at the end of a programme, as well as what they should know, understand, and be able to demonstrate after completing a learning process. They should also be explicit and quantitative.

2.5 Challenges during online learning

There are a growing variety of technologies that can be used for online education, but they can also cause a lot of problems. These challenges and troubles are related to current technology, such as download faults, installation issues, login issues, audio and video issues, and so on. Some students find online learning to be tedious and uninteresting. Due to the fact that some students prefer two-way interaction, which is often difficult to achieve online, personal attention is also a major issue with online

learning. Then, because students must practise and apply what they have learned, the learning process required a longer time to realise its full potential. Because all knowledge is typically delivered in theoretical only during online learning, reaching learners' full potential is difficult. This issue prevents students from practising and learning as successfully as they could with traditional instruction. Students also reported that the online approach lacks contact, that there are numerous technological issues, and that understanding the knowledge presented is a key impediment to online learning (Song et al., n.d.).

According to Parkes et al. (n.d.), Students were found to be underprepared for online learning applications because they struggle to manage their time between work, family, and social obligations. They also said it took a long time for them to adjust to the new learning environment. Students have expressed their fear of encountering difficulties, particularly in acquiring certain skills and competencies that will be critical in the future. The majority of students did not have access to cellphones or other electronic devices at home, and internet accessibility was also an issue. Certain students who do not have access to WIFI at home must purchase data packages, which can be quite expensive for some families. Students prefer synchronous learning, yet streaming an online lecture consumes a lot of data, and synchronous learning may be difficult for financially poor students. Even the lecturers expressed frustration with the new technologies. Although some students believe that pre-recorded videos are the greatest approach to impart learning, it was nonetheless difficult due to the lack of interaction between students and teachers (Pokhrel & Chhetri, 2021).

According to Sintema (2020), students' academic performance is projected to deteriorate as a result of problems with technology and a lack of communication with instructors when they are having difficulty grasping the learning process. Students also expressed dissatisfaction with online learning, claiming that they were unable to absorb and apply what they had learnt through practical and clinical work. They said that they only have access to the theoretical portion of the material, which is the foundation of knowledge. Due to a lack of quick feedback from pupils, comprehension of the learning process is also weaker than in traditional learning. This has left instructors perplexed, as they are unable to check students' comprehension while lecturing online. Students also stated that they had difficulty paying attention during lectures. Because few students are seeking to access it via lecture notes and the internet during the assessment, several instructors have reported misbehaving students during online assessments (Mukhtar et al., 2020).

Accessibility, cost, flexibility, learning pedagogy, and educational policy are all issues that arise with the online learning approach. Few countries have reported significant difficulties in obtaining a stable Internet connection or having access to digital gadgets. In many developing countries, there are also a few families who are experiencing financial difficulties, and as a result, their children are having difficulty continuing their education since they lack the necessary devices. As a result of this issue, the youngsters have fallen behind in terms of learning. As a result, it is now mandatory for every student to participate in offline activities and attempt self-exploratory learning. Another issue with the online learning technique is a lack of parental assistance, particularly for young learners, which is exacerbated when both parents work. Because it is difficult to deliver online, practical issues are also a huge

challenge. Students who are hardworking and determined will be largely unaffected in their learning because they require little monitoring and guidance, but this will become a severe problem for the vulnerable group, which includes students who are learning-challenged. Then there's online learning, which is a major concern for students who consistently perform well academically but are unable to access online learning resources due to budgetary constraints (Pokhrel & Chhetri, 2021).

2.6 Kirkpatrick evaluation

The Kirkpatrick Model is perhaps the most well-known model for assessing and analysing training and educational programme outcomes. This model was created in the 1950s by Dr Donald Kirkpatrick. It can be used to assess any type of training based on four levels of criteria. The Kirkpatrick Model of evaluation has four criteria: reaction, learning, behaviour, and results (Ardent Learning, 2020; Serhat Kurt, 2016). According to Serhat Kurt (2016), Level 1 (Reaction) analysis is frequently decided based on how individuals would react to the learning, such as student satisfaction. The assessment for Level 2 (Learning) is usually done to see if the learners truly understood the training, which can be seen if there is an increase in knowledge, skills, or experience, whereas Level 3 (Behavior) is usually analysed based on how they will use what they have learned, which can be seen if there are any changes in behaviour. Finally, it will be evaluated whether the item had a good impact on the organisation at Level 4 (Results).

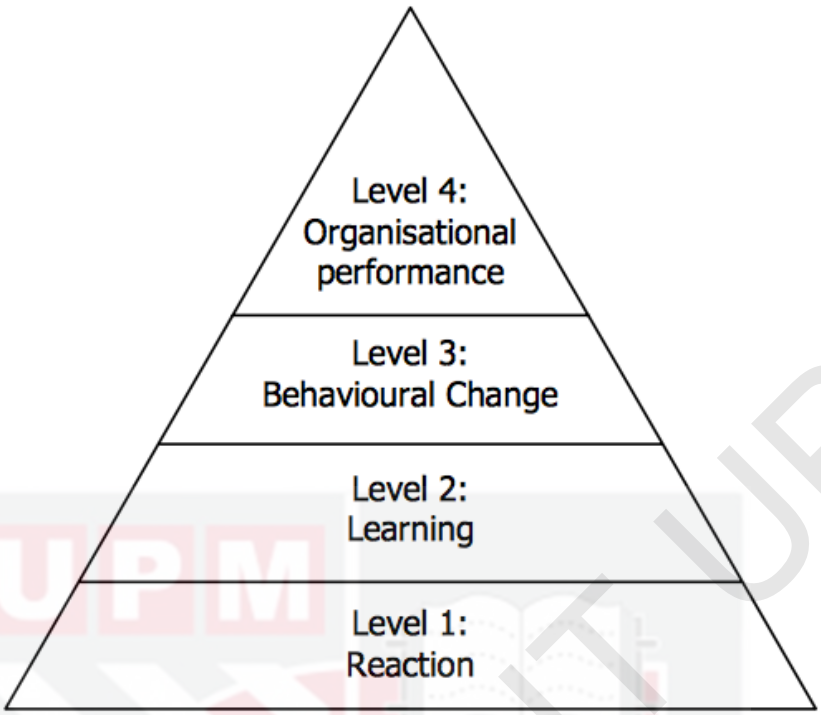


Figure 2.6: Kirkpatrick evaluation is categorised based on four levels (Serhat Kurt, 2016).

The first level of evaluation is usually simple. It assesses how people react to learning, which can be done simply by asking questions or conducting surveys to find out what they think and feel about the learning process. Then, based on the questions, we may determine whether the participants enjoyed their experience or not. A "smile sheet" is the most common name for this type of evaluation. According to Kirkpatrick, each programme must be evaluated at this level to develop the model for future usage. This level can be reached in a variety of methods, including asking learners for feedback, conducting an interview, completing an online assessment, leaving comments, and so on. When compared to level 1, evaluating at level 2 is frequently more difficult and takes longer. Learners are often assessed in terms of knowledge, expertise, and abilities at this stage. The ideal technique to examine this stage is to use a pre/post-test, in which the learners must complete the test prior to the training, and

the results will be compared afterwards. We may readily assess what the learners have learned during this course using this way. At this level, examples of procedures that can be employed include conducting an interview before and after the evaluation, utilising a control group to compare after the evaluation, and doing electronic type assessments (Ardent Learning, 2020; Serhat Kurt, 2016).

The assessing procedure takes longer at the Level 3 evaluation stage than it does at the Level 2 evaluation stage, which is predicted to take 3 to 6 months after the training. This level will examine the differences in learner behaviour after they have completed the course. We can determine if the knowledge and skills learned during the training were used in the workplace by analysing the changes made. Testing at this level is difficult since it is nearly impossible to predict when the learners will put what they have learned from the training to good use. Because of these factors, the analysis will be challenging because we don't know when the learners used it or what the best technique to evaluate a learner's post-training performance is. A survey and close observation after a period of time are required at this phase of the evaluation in order to assess major changes in the learner's behaviour. Quick tests performed immediately after training are unreliable because everyone changes in different ways at different periods. After the training, the 360-degree feedback method can be utilised to see if there is a significant difference in the learners' behaviour. The participant's viewpoint can thus become too varied, making the evaluation unreliable; therefore, ensure that assessments focus on more specified variables that can be seen, such as work outputs, rather than the learners' opinions. Finally, for level 4, it is commonly referred to as the training's major goal. During this phase, all aspects that contribute to the learning's success will be assessed. In the Kirkpatrick model, this type of stage is found at the

apex of the pyramid, and it is quite rare to observe. Simply said, this step assesses the training results and determines whether the course had any impact on the desired objective. Trainers or educators must develop pre-and post-training benchmarks in order to effectively measure training outcomes. Due to the complexity and difficulty of the Kirkpatrick methods, all training processes must begin at level 1 and work their way up to level 4. The initial level is critical because it can enable everyone on the team to experience the system's effectiveness, making it easier for everyone to adjust to it (Ardent Learning, 2020; Ben Hartwig & , 2020; Serhat Kurt, 2016).

2.7 Systematic review

Systematic reviews are a sort of review that differs from narrative reviews in a number of ways. Narrative reviews are usually descriptive in nature and do not entail a systematic search of the literature; nonetheless, this sort of review concentrates on specific research in a particular field, usually depending on the author's area of interest and availability. Even though narrative evaluations might provide a lot of information, they can also contain a lot of bias-inducing aspects. The narrative review can then cause confusion, especially when there are similar research with contradictory findings and conclusions. A robust and complete plan and search method are often used in systematic reviews. The most important goal is to decrease bias, which can be accomplished through a series of steps that include discovering, evaluating, and synthesising all relevant studies on a given issue. The inclusion of a meta-analysis component in some systematic reviews is needed. If the results required the application of statistical tools to combine data from multiple research into a single quantitative conclusion, a meta-analysis component should be included (Uman, 2011).

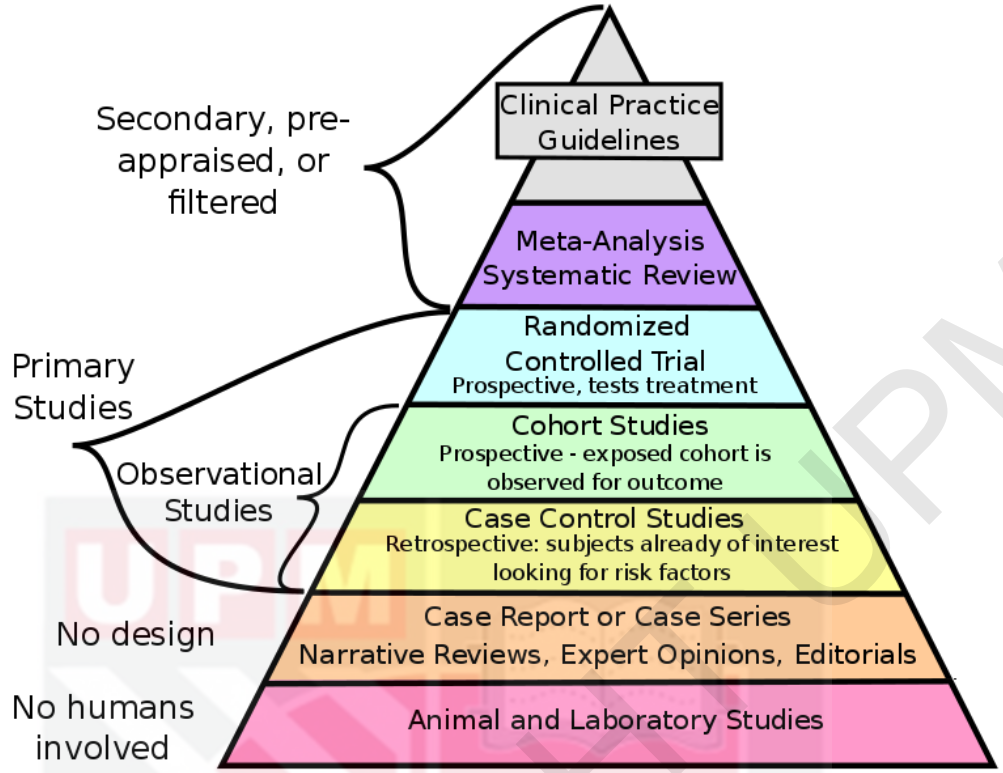


Figure 2.7: Examples types of evidence that can be obtained and systematic review/meta-analysis located at second place as the best evidence that can be obtained after clinical practice -(*Getting Started with Your Systematic Review | by Specialist Library Support | Specialist Library Support | Medium*, 2019).

There are many different types of evaluations, and each one must have its own unique characteristics, particularly in terms of technique. Some systematic reviews may take several months or years to complete, depending on the level at which you are working. If you are doing research as part of your PhD, it will take longer. According to Clarke (2011), the most credible source of evidence is a high-quality systematic review, which is especially useful in guiding researchers in clinical practice. A systematic review's goal is to compile a detailed overview of all available primary research based on specified research topics. In a nutshell, a systematic review

is one that takes all of the current research and then compiles it into a single report with a detailed summary and conclusion. Secondary research is another term for it. The findings of systematic reviews are typically employed in the healthcare sector, but they can also be used in other settings. In order to conduct a systematic review, the approach must be exceedingly accurate and detailed in every element. This is critical because we want to avoid any potential biases that may arise during the procedure. The reliability of the systematic review produced will undoubtedly improve if bias is reduced (Antman et al., 1992; Clarke, 2011).

There are a few requirements that must be followed when conducting a systematic review, including having specific aims and relevance eligibility criteria, methods that are reproducible/transparent, careful searching to locate all eligible studies, risk assessment to ensure that the included studies are valid, and how the synthesis and systematic presentation are done. A systematic review's methodology begins with the formulation of the research question. Following that, a thorough search of several databases will be conducted to find relevant studies. Following that, it will go through a screening process and be screened based on relevant criteria for the included research. The screening procedure is separated into two sections, with the first focusing solely on abstracts and titles and the second assessing the full-text article. In order to achieve inter-rater reliability, the second screening process normally involves at least two reviewers. The data will then be extracted and risk assessed in order to determine the article's legitimacy. After then, the data will be examined and synthesized. Meta-analysis may be required for data of statistical value. The Cochrane Collaboration's Review Manager tool is an example of a free statistical programme that can be employed (Clarke, 2011; Uman, 2011).

CHAPTER 3

MATERIALS AND METHODS

3.1 Protocol and Registration

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement served as the basis for the approaches used in performing this systematic analysis. The PICOS method was used to define basic keywords and look for an effective research strategy for the study's goal. (Moher et al., 2015). PRISMA is an evidence-based minimal collection of items that have been used to assist authors in publishing a wide range of systematic reviews and meta-analyses that evaluate the benefits and drawbacks of a healthcare intervention. Then, to collect data from the publications, the PICOS methodology was employed, which consists of Population, Intervention, Comparison, Outcomes, Study Design. These are approved by the Cochrane Collaboration, which is often used to identify clinical evidence components for systematic reviews.

According to the PRISMA statement, the PICOS approach was applied for this systematic review. Population involved must be undergraduate from medical or health science courses, Intervention must be included online learning during COVID-19, Comparison must involve any comparison to any teaching method, while for Outcome mentioned in the studies must be either learning outcome or students attitudes and for this systematic review, any Study design was acceptable.

3.2 Eligibility Criteria

3.2.1 Inclusion Criteria

The study must involve all undergraduate students from medical and health science students from any country who were included in this study. All studies were required to involve students that had experience with online learning during the COVID-19 pandemic. Then, the study must involve an online learning application that will be compared to any teaching methods. The primary outcome of interest was learning outcomes. The secondary outcome was attitudes reported in the study. An example of learning outcomes is how online learning during COVID-19 can affect academic performance and skills. Students' attitudes such as student's satisfaction, perception, experience and engagement also were assessed. Last but not least, all types of study designs were included in this study. These included quantitative and qualitative studies.

3.2.2 Exclusion Criteria

Studies that do not involve undergraduate students such as postgraduate students, primary school students and secondary school students will not be included. Next, studies, where there is no online learning involved and studies that include online learning but the implementation is not during COVID-19 will be excluded. Studies that do not mention about learning outcomes of the students (based on academic performance or skills) and student attitudes (based on satisfaction, perception, and engagement) will be excluded. Lastly, the studies that were not conducted in English will also be excluded.

3.3 Search Strategy and Database Used

3.3.1 Article Searching

PubMed, Scopus, and ScienceDirect were used to find papers applicable to this study. All searches were done from 23 February 2021 until 28 February 2021. The Boolean operators (OR & AND) were used to combine various components when constructing the keywords. All of the relevant articles found through the literature search were imported into Mendeley, a reference management tool. Mendeley will assist in the removal of redundant papers from any of the three databases.

The search terms used were:

- **PubMed**

(online learning OR distance learning) AND (undergraduate student OR university student) AND (learning outcome OR skills OR competences OR satisfaction OR perspective OR reaction OR engagement) AND (COVID-19 OR coronavirus OR COVID19)

- **Scopus**

(online learning OR distance learning) AND (undergraduate student OR university student) AND (learning outcome OR skills OR competences OR satisfaction OR perspective OR reaction OR engagement) AND (COVID-19 OR coronavirus OR COVID19)

- **ScienceDirect**

(online learning) AND (university student) AND (learning outcome OR skills OR competences OR satisfaction OR perspective OR engagement) AND (COVID-19)

3.3.2 First screening

The first screening was conducted after all the articles were exported to Mendeley. The titles of the articles were screened, and the abstracts of potentially relevant articles were read in full. Then, abstracts were screened during this phase, and any article that did not meet any of our requirements was eliminated.

3.3.3 Second screening

The articles that passed the first screening were subjected to full-text screening. The articles were read in full during the full-text screening, and only papers that met all of our inclusion requirements were included in this systematic review. It will then be able to go through the data extraction process after the second screening is completed.

3.4 Data Extraction

During this process, all the included studies were extracted, and all the data was collected in table form using Excel format. The data extracted includes the author & year, country, purpose of the study, study design, population, intervention, data collection method and findings. The data extraction process was done critically since the data was going to be used during data analysis.

3.5 Data Analysis

During this process, all of the data was gathered and categorised based on the results obtained from the data extraction table. A new table was created for each of the outcomes, including student perception, satisfaction, experience, engagement, and learning outcome. At the end of this procedure, a summary of the various outcomes

was conducted, which was compared to the Kirkpatrick Model of evaluation based on four levels.

3.6 Quality Assessment

The assessment was carried out using the Alberta Heritage Foundation for Medical Research's checklist (AHFMR). This step is necessary to evaluate the accuracy of the papers used in this analysis so that we can ensure that all of the information collected from them is accurate. Appraising the quality of evidence is a vital stage, but it was a difficult assignment because we had to analyse a variety of sources. Even though various checklists can be used to evaluate quantitative research, such as randomised controlled trials (RCTs), their consistency and accuracy are either unmeasured or highly varied. Due to the lack of a standard quality evaluation instrument that can be used to evaluate a range of study designs, Leanne, Robert, and Linda established the AHFMR checklist in 2004. It uses a two-score system to strategically analyse the qualitative and quantitative of the included studies. Quantitative studies were examined based on 14 items, whereas qualitative studies were examined based on 10 items.

CHAPTER 4

RESULTS

4.1 Literature Search

The keywords used as search items were (online learning OR distance learning) AND (undergraduate student OR university student) AND (learning outcome OR skills OR competences OR satisfaction OR perspective OR reaction OR engagement) AND (COVID-19 OR coronavirus OR COVID19). A total of 1486 studies were retrieved from 3 databases from 23 February until 28 February 2020: PubMed (up to 23 February to 24 February 2021), Scopus (up to 25 February to 26 February 2021) and ScienceDirect (up to 27 February to 28 February 2021). Two hundred seventeen studies were removed as duplicates by using Mendeley as a management tool and also through manual screening of similar titles and abstracts. The remaining 1269 studies were screened by title and abstract according to the eligibility criteria. After screening, 1066 studies were excluded because the population involved are not relevant, the intervention was not during COVID-19, the outcome presented was not relevant and unclear, no full-text article and article on another systematic review, while the remaining 203 studies were further reviewed in full-text assessment. One hundred thirty-nine studies were excluded as they did not meet the described eligibility criteria such as the studies must be involved all undergraduate students from medical and health science students from any country and had experience with online learning during the COVID-19 pandemic, studies involved online learning applications that will be compared to any teaching methods and also includes student attitudes and

learning outcome as the outcomes to be assessed. Only 64 remaining studies were chosen to be included for qualitative synthesis.

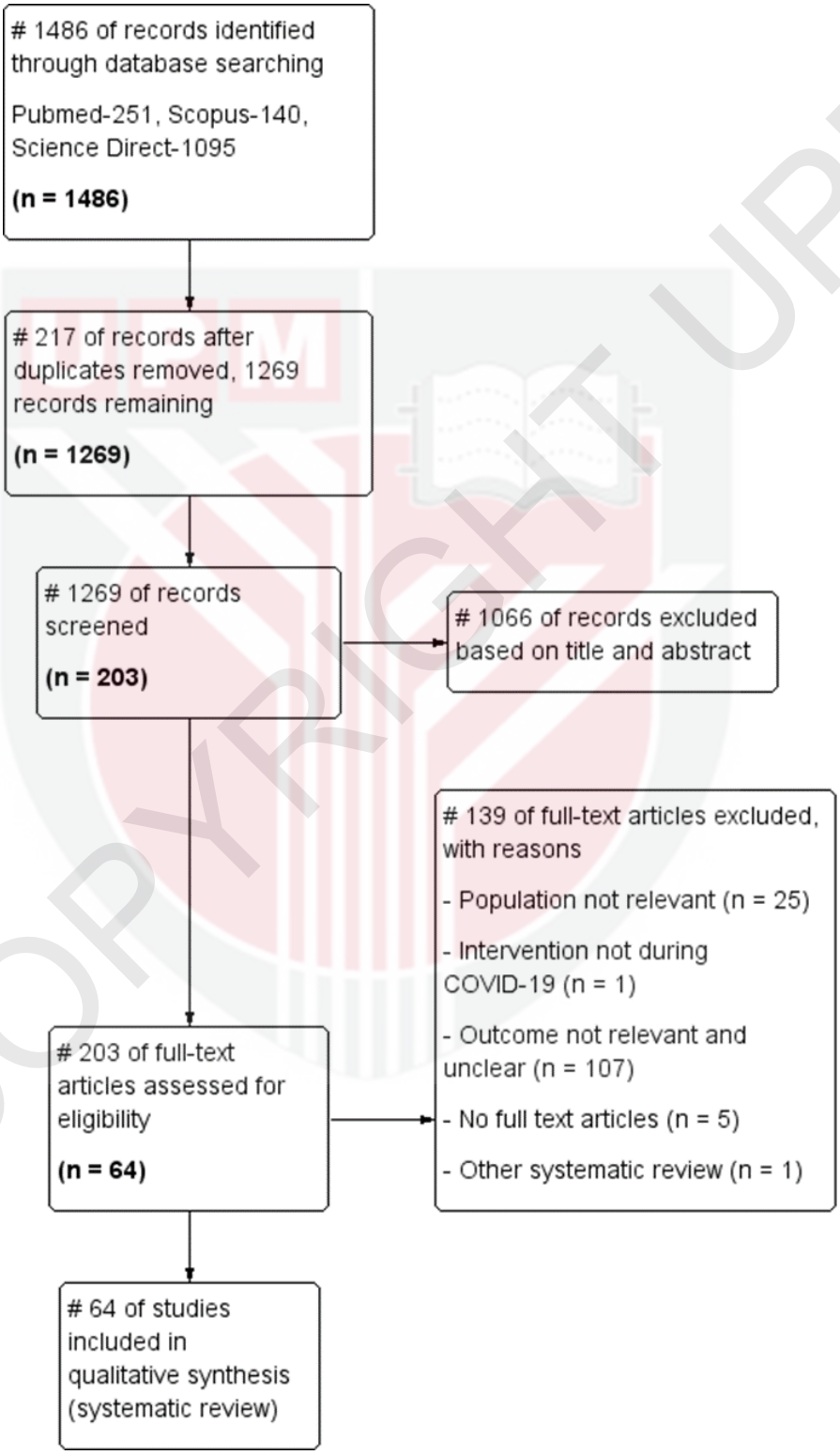


Figure 4.1: Flow of literature search according to PRISMA guidelines

4.2 Data Analysis

4.2.1 Characteristic of the included studies

Table 4.2.1.1 and 4.2.1.2 depicts the characteristics of the 64 studies included in the systematic review. The studies were classified according to the type of study design and their publication year. Among them, fifty-six papers were cross-sectional studies. Two papers were qualitative studies (Suliman et al., 2021; Khalil et al., 2020) and mixed-method studies (Khan et al., 2021; Langegård et al., 2021), while only one paper was for the retrospective comparative cohort study (Caton et al., 2020), randomised controlled trial (Suppan et al., 2021), prospective study (Atli et al., 2020, and a case-control study (Co, Chung and Chu, 2021). Most of the papers were published in 2020, with the number of studies obtained was 48, while only 16 papers were published during 2021.

Table 4.2.1.1: Characteristics of included studies categorized based on the type of study

Type of studies	Number of studies	Percentage (%)
Cross-sectional study/Descriptive study/Survey	56	87.5
Mixed method study	2	3.13
Qualitative study	2	3.13
A retrospective comparative cohort study	1	1.56
Randomised controlled trial	1	1.56
Prospective study	1	1.56
Case-control study	1	1.56

Table 4.2.1.2: Characteristics of included studies categorized based on year of publication

Year of Publication	Number of studies	Percentage (%)
2020	48	75.00
2021	16	25.00

According to Table 4.2.1.3, the results obtained for the **population** shows there were 43 studies obtained from undergraduate medical students, six from undergraduate health sciences students, five from undergraduate dentistry students, four studies from undergraduate nursing students, two studies from undergraduate veterinary students and a combination medical with nursing students, while two studies were from a combination of undergraduate medical with nursing students and pharmacy students.

Table 4.2.1.3: Characteristics of included studies categorized based on the type of population

Type of population (All undergraduates)	**Number of studies**	**Percentage (%)**
Medical students	43	67.69
Health Science students	6	9.23
Dentistry students	5	7.69
Nursing students	4	6.15
Veterinary students	2	3.08
Medical + Nursing students	2	3.08
Medical + Dentistry students	1	1.54
Pharmacy students	1	1.54

Based on Table 4.2.1.4 shows most of the included studies compared the online learning application to the traditional learning approach (62 studies), while there are two studies that were comparing online learning with the blended learning approach – combination online and traditional learning (Olum et., 2020 and Sawarkar et al., 2020).

Table 4.2.1.4: Characteristics of included studies categorized based on the type of comparison

Type of comparison	Number of studies	Percentage (%)
Traditional learning	62	96.88
Blended learning	2	3.13

Next, the summary for the outcomes for all the included studies also was obtained, and it was categorized into few main points, which include learning outcomes, student perception, student satisfaction and student engagement. There are 40 papers discussed on student perception, 37 papers on student satisfaction, 14 papers on learning outcomes, and only one paper discussing student engagement.

Table 4.2.1.5: Characteristics of included studies categorized based on the type of outcome

Type of outcome	Number of studies	Percentage (%)
Student perception	40	43.96
Student satisfaction	36	39.56
Learning outcomes	14	15.38
Student engagement	1	1.10

4.2.2 Student Perception

From all the included studies obtained, there are 40 papers that discussed student perception towards online learning. The summary of the results obtained in relation to their outcomes was summarised in Table 4.2.2.1. Student perception can be categorised into two main points, which are the advantages and disadvantages of online learning. According to the findings obtained, several advantages that have been mentioned by the students were flexibility, save time, save cost, easy to communicate, become motivated that increase engagement, more time to study, help in clinical practices, can watch and play recorded lecture at any time and place, high interaction between students and instructors and get high understanding when learning online while for disadvantages that have been reported by students were hard to communicate due to low interaction between students and instructors, related to stress and anxiety, technophobia, lack of motivation, internet connectivity problem, low teaching quality, cannot apply clinical skills, behavioural challenges, family distraction, lack of space at home, lack of technology experience, lack of networking, hard to focus during long lecture, financial problems, time-management, technological problem, more time required to prepare and different time zone. The summarization of student perception on online learning based on positive and negative perceptions was shown under Table 4.2.2.2.

Table 4.2.2.1: Summary of the included studies for student perception

Author and Year	Intervention (what used and who involved)	Assessment tool	Comparison	Study design	Findings	Kirkpatrick
(Rajab et al., 2020)	OL in undergraduate students medical education Bachelor of Medicine and Bachelor of Surgery	Online questionnaire	Traditional learning	(N = 139) Cross-sectional study	59% have problems in-person communication, 57.5% student assessment, 35.5% learning curve, 48% related to anxiety and stress, 17% technophobia, and 24.4% students evaluation of faculty.	1
(M. Al-Balas et al., 2020)	OL in undergraduate medical students from all medical universities in Jordan	Online questionnaire	Traditional learning	(N = 652) Cross-sectional study	55.9% agree that online learning has many advantages, such as saving time, flexibility, and increasing interaction between learners and instructors, while 62.1% agree that there is poor interaction (between learners and instructors), 48.3 reports low quality of teaching and 69.1% report a problem with the internet.	1
(Alsoufi et al., 2020a)	OL in undergraduate medical students from all medical universities in Libyan	Online questionnaire	Traditional learning	(N = 3348) Cross-sectional study	54.1% believe that interactive discussion can be achieved via online learning. 21.1% agreed that online learning could be applied in clinical training, while 54.8% disagree with the statement, and 24% of the is neutral.	1
(Khalil et al., 2020a)	OL In undergraduate medical students from Unaizah College of Medicine and Medical Sciences, Saudi Arabia	Online questionnaire	Traditional learning	(N = 60) Qualitative study	OL has many benefits, such as saving time, flexibility but in practising those techniques, some of them also encountered many disadvantages such as internet connectivity, behavioural challenges, and communication problems.	1

(Dost et al., 2020)	OL in undergraduate medical students from 39 medical schools in the United Kingdom	Online questionnaire	Traditional learning	(N = 2721) Cross-sectional study	19.82% agreed it could save time, 19.52% agreed it provides flexibility, 14.24% agreed it could save some costs. Disadvantages include 26.76% agreed family distraction, 21.53% internet connectivity problems, 17.31% anxiety, and 11.03% lack of space.	1
(Muflih et al., 2020b)	OL in undergraduate health science students from Jordanian universities	Online questionnaire	Traditional learning	(N = 1210) Cross-sectional study	66.8% agreed that online learning application makes them feel comfortable communicating with their instructors and instructors, 62.6% agreed that the instructor responds quickly to their question. Barriers toward online learning - 75.1% agreed lack of technology experience, 74.3% lack of using online tools in the past, 57.4% lack of motivation, and 62.7% inability to networking.	1
(Puljak et al., 2020a)	OL in undergraduate health sciences students from 9 Croatia universities	Online questionnaire	Traditional learning	(N = 2520) Cross-sectional study	48.5% of the students agreed that they were equally motivated in online learning compared to f2f lesson, 43.4% said they fell connected with each other or classmate instructors. Most of the students prefer to combine f2f and online learning in the future.	1
(L.R. Amir et al., 2020)	OL in undergraduate dentistry study from Dentistry faculty at Indonesia	Online questionnaire	Traditional learning	(N = 301) Cross-sectional study	52.6% agreed online learning provides a more proactive learning method, 87.6% provide more time to study, and 87.3% agreed that online learning gives them more time to review their study material. Disadvantageous online learning, which includes problems with an internet connection, financial problems, difficulty in focusing (longer period of lecture), and time management problems	1
(De Ponti et al., 2020a)	OL in undergraduate medical students from the University of Insubria	Online questionnaire	Traditional training	(N = 115) Cross-sectional study	77% agreed that virtual training is very effective in the clinical assessment, 94% agreed it could be used in the diagnostic activity, and 81% is used in treatment management. 28% of students believed that online learning is quite difficult to implement due to technical issues.	1
(Chandrasinghe et al., 2020)	OL in undergraduate medical students from Sri Lanka	Online questionnaire	Traditional discussion	(N = 1047) Cross-sectional study	87% of the students stated that they agree that the students gain many advantages from the discussion. 83.4 of the students agreed that the discussion helped them a lot, especially in their clinical practices, and 79.3% believed that this discussion helped them build interest in clinical medicine. Around 31% complained about having problems with internet connectivity, 25% having problems joining the discussion	1

(Ju Whi Kim et al., 2020)	OL in Undergraduate medical students from Seoul National University	Online questionnaire	Traditional learning	(N = 456) Cross-sectional study	(4.64), can watch the recorded lecture any time – (4.57), take the course anytime they want – (4.66), alter the sequence of the lecture depending on what they want – (4.07) and can play the recorded at any speed – (3.72)	1
(Yoram Sandhaus et al., 2020)	OL in undergraduate medical students from Adelson School of Medicine	Online questionnaire and telephone interview	Traditional learning	(N = 70) Cross-sectional study	The quality of teaching has also been rated very high at 85.7%, training and technical assistance have also been rated very high by students at 87.2% and 91.5%. 61.5% also reported having technical difficulties during online learning applications.	1
(K. Wang et al., 2021a)	OL in undergraduate dental students from 42 dental universities in mainland China	Online questionnaire	Traditional teaching	(N = 8740) Cross-sectional study	66% for interaction between the lecturer, 88% for the arrangement of homework, 92% for online learning material and 92% for effective time management. There are also some challenges observed during which includes network instability (62%), platform instability (33%), lack of learning motivation (72%), insufficient online learning ability (31%), lack of leaners-instructors interaction (59%) and others (8%).	1
(Jiménez-Rodríguez et al., 2020)	OL in undergraduate nursing students from University in Almeria - Spain	Online questionnaire	Traditional practical	(N = 93) Cross-sectional study	Students rated 100% in practical utility, 49.4% agreed they had improved their technical skills, and 63.43% agreed that this helps them in their clinical practices.	3
(Olum et al., 2020)	OL in undergraduate medical and nursing students from Makerere University, Uganda	Online questionnaire	Blended teaching	(N = 221) Cross-sectional study	They are higher interaction in the online platform(MUELE) reported at 96.3%. However, 60% of students believed that they need to train themselves with the online learning application to use it properly. Some challenges reported include internet problems (internet costs 93% and 84% poor internet connectivity), lack of skills regarding online learning application 50%, and technical problems such as lack of gadgets 35%.	1
(Merson et al., 2020)	OL in Undergraduate equine science course	Online questionnaire	Traditional learning	(N = 44) Cross-sectional study	The results show the students give positive feedback on the application of online learning, but still, based on Bayesian inference for ANOVA, most of the undergraduates still prefer in-person lessons ($P < 0.05$).	1
(Mahdy, 2020)	OL in Undergraduate	Online questionnaire	Traditional learning	(N = 1392) Cross-	Mean evaluation obtained for general online learning 5.1 ± 2.4 while for practical parts the is 3.6 ± 2.6. Students' perception	1

	veterinary medical students from 92 different countries			sectional study	towards online learning applications includes more convenient and flexible, more time available and save time while for challenges includes the availability of learning devices, harder to teach especially the thing that involves practical, shortness of the available time and the availability of internet for people who lives in a rural area.	
(Sawarkar et al., 2020)	OL in undergraduate medical students from Bachelor of Ayurvedic Medicine and Surgery	Online questionnaire	Blended learning	(N = 189) Cross-sectional study	Overall, 58.9% have supported online learning utilisation, while 33.9% are neutral due to the few challenges they face, including misconceptions, language barriers, and the problem with terminologies. 54% of students agreed that online learning helps them enhance user engagement, increase motivation, and build their interest in understanding more. Lastly, even though they get many advantages via online learning, compared with the teaching (online + classroom) combination, only 37.6% support online learning applications.	1
(Coffey et al., 2020)	OL in undergraduate medical students from the School of Medicine at UC San Diego	Online questionnaire	Traditional learning	(N = 132) Cross-sectional study	The students also reported getting enough internet connectivity to support online learning, while 11% reported not getting adequate space. Students also provide little feedback on what is good and bad of online application - Good: Flexibility of online learning, Increase engagement - Bad: Difficulties in time management, Lacking clinical experience, anxiety	1
(Martinez et al., 2020)	OL in undergraduate medical students from Florida Atlantic University	Online questionnaire	Traditional learning	(N = 47) Cross-sectional study	Students felt the telemedicine application was relevant to their medical education 4.68/5. Students also scored 2.89/5 regarding these sessions actually help them in their exam. They also agreed this platform helps them increase interaction between the patients even though it is online, but some technical problems are reported.	2
(Anwar et al., 2020)	OL in Undergraduate medical and dental from CMH Lahore Medical College	Online education	Traditional learning	(N = 283) Cross-sectional study	38.2% believed that online learning could provide flexibility in learning and 31.4% believed that it could save time. There are also few students; 33.2% disagreed that online can improve communication between students and lecturers. 79% of students agreed that they have enough access to technological equipment, while 83.8% feel the online learning application is encouraging, especially during this pandemic.	1
(Alqurshi, 2020)	OL in Undergraduate pharmacy	Online questionnaire	Traditional learning	(N = 703) Cross-	More than 20% of the students were having problems with an internet connection, 35% of the students agreed that student-instructor interaction was very limited, making them have	1

	students from institutions in Saudi Arabia			sectional study	difficulties understanding the lecture. 35% of the students agreed that it was harder for them to concentrate online than in f2f teaching. Due to their inability to attend the laboratory, 35% of the students reported having problems gaining knowledge and laboratory skills.	
(B. B. Shahrvini et al., 2020)	OL in Undergraduate medical students from the University of California San Diego	Online questionnaire	Traditional learning	(N = 268) Cross-sectional study	64.4% feel like online learning gives flexibility, 18% of the students feel online learning can cause digital fatigue, which leads to exhaustion, inability to focus and disengagement, 50.8% feel problems in obtaining clinical skills, and 16.7% reported a feeling of loneliness and isolation.	1
(Yoo et al., 2021a)	OL in undergraduate medical students from Korea University College of Medicine	Online questionnaire	Traditional learning	N = 108 (2020) N = 104 (2019) Cross-sectional study	They agreed that online learning could save more time, 89.5%, and use that free time to self-study 75%. The students' few benefits include repeatedly watching the recorded video 76.3% and more available time 60.5%. There are also problems arise during online learning application 61.9% reported having a problem with their internet, and 50% reported having problems with the interaction between students and lecturer.	1
(Kumar et al., 2020)	OL in undergraduate medical students from Medical School in Arabian	Online questionnaire	Traditional learning	Cross-sectional study	96% of the students agreed that the communication online was very clear, 85% feel they can maintain the online interactivity, and 92% of the students were interested in continuing with the online learning application even after the pandemic. 74% of the students agreed that all the software used in online learning is very user-friendly and easy to use. There are also few problems mentioned by students, which include limited interaction and clinical training problems.	1
(Bączek et al., 2021b)	OL in undergraduate medical students from Polish	Online questionnaire	Traditional learning	(N = 804) Cross-sectional study	69% of the students they like online learning application due to the ability to stay at home, 69% agreed that they have continuous access to online learning material and 64% agreed that online learning provides the opportunity to self-study. The major problems that arise mentioned by students 54% reported having a problem with the technological equipment, and 70% believed that there is less interaction between medical students and patients.	1
(Tuma et al., 2021a)	OL in undergraduate medical students	Online questionnaire	Traditional learning	(N = 636) Cross-	67% of the students feel like online learning is very difficult to use compared to online learning. 27% still report that online learning meets their expectations, while 67% reported not being interested	1

	from Wasit University College of Medicine in Iraq			sectional study	and fatigued while participating in online learning. Students have few challenges: a poor internet connection, unfamiliar with the online learning platform, and audio-visual media quality.	
(Langegård et al., 2021)	OL in undergraduate nursing students from Gothenburg University	Online questionnaire	Traditional learning	(N = 132) Cross-sectional study	18% of the students reported having technical difficulties continuing online learning. 2/3 students also reported having a problem with communication between students and instructors, leading to deterioration in learning. The student also reported online learning impacts their motivation in learning. More than 50% did report having a problem with their study discipline (hard for them to track everything, especially when you are at home).	1
(Elsalem et al., 2021a)	OL in Undergraduate students from Jordan University of Science and Technology	Online questionnaire	Traditional learning	(N = 730) Cross-sectional study	68.22% of the students preferred the f2f exam, and only 1/3 did the preferred online exam. 49.86% agreed that more hard work and time were required in preparation for the online exam. 62.33% of the students reported they did not achieve their objectives in their study.	1
(Jaap et al., 2021)	OL in undergraduate medical students from UK medical school	Online questionnaire	Traditional learning	(N = 447) Cross-sectional study	18.5% of students have problems finding a good environment to sit for their exam, and 84% have a very good internet connection. 51.3% reported feeling anxious before the exam because they were afraid about their internet connection issues.	2
(Schoenfeld-Tacher & Dorman, 2021)	OL in undergraduate veterinary students from North Carolina State University	Online questionnaire	Traditional learning	(N = 103) Cross-sectional study	Students agreed that the online class performs 52.6%, almost the same, and 15.8% think it is better. Students' few benefits, which include online learning, increase their motivation and flexibility of time and place. Students also stated few challenges that include a problem with internet connectivity and lack of instructor-student interaction.	2
(Guiter et al., 2021)	OL in undergraduate Medical students from Weill Cornell Medicine-Qatar	Online questionnaire	Traditional learning	(N = 29) Cross-sectional study	Students' perception of online learning; the students feel like the online learning application provides an easier ability to communicate, which leads them to engage more easily than online. The environment at home is more relaxing and saves time. There only problem stated by students regarding this elective is internet connectivity problems.	1
(Gupta et al., 2021)	OL in Undergraduate medical students	Online questionnaire	Traditional learning	(N = 248) Cross-	41.2% of students agreed that online learning could provide flexibility in time and place. Few challenges associated with online	1

	from the Delhi-NCR region			sectional study	learning include 35.9% internet connectivity problem, 29.8% reduce interaction, 27.1% problem with the sound and lack of clinical skills.	
(Co et al., 2021a)	OL in undergraduate medical students in Hong Kong university	Online questionnaire	Traditional learning	(N = 62) Case-control study	Obstacles stated include lack of face-to-face interaction, Internet connectivity, and different time zone (overseas students). Benefits reported includes: Can demonstrate the skill easily, Affordable	3
(Tigaa & Sonawane, 2020)	OL in undergraduate students who are taking chemistry courses at St. Cloud USA and College in Dhule in India	Online questionnaire	Traditional learning	(N = 150) Cross-sectional study	49% and 19% of Dhule students mentioned having problems with internet connectivity and a financial problem, while 63% and 11% were from St. Cloud. Then they also reported on not having enough electric supply to continue online learning 15% from Dhule and 57% from St. Cloud.	1
(Ibrahim et al., 2021)	OL in undergraduate medical students from King Abdul Aziz University	Online questionnaire	Traditional learning	(N = 340) Cross-sectional study	59.7% agreed that online learning could replace face to face learning. 59.2% also feel like online learning was less time-consuming than f2f teaching.74.6% of students agreed that interaction during online class was present between instructors and students, and 54.1% of students agreed that the online learning application was online could make them motivated. Problems include 84.2% agreed online learning would affect the clinical skill. 72.1% of students also agreed that their exams could be affected due to internet connectivity problems. Then, 57% agreed that there are limited resources, and 32.2% agreed they have a technology training problem.	1
(Khan et al., 2021)	OL in Undergraduate medical students from North India	Online questionnaire	Traditional learning	(N = 103) Mixed study	Students reported that the online learning application was very enjoyable, engaging, and motivating them to learn. The disadvantage was lacking practical skill classes, technical issues such as internet connectivity, lack of interaction, and hard to learn how to adapt to the new online stuff.	1
(Menon et al., 2021)	OL in Undergraduate medical students from college hospital in South India	Online questionnaire	Traditional learning	(N = 370) Cross-sectional study	The online learning barriers reported by students were connectivity problems, 44.8% and lack of peer interaction since clinical classes cannot be replaced with online classes.	1

(Sindiani et al., 2020a)	OL in undergraduate medical student from Jordan university	Online questionnaire	Traditional learning	(N = 3700) Cross-sectional study	48.7% of the students feel less interaction between the instructors than traditional teaching. Students' benefits include saving money and energy in terms of transportation 48.7% and reducing social contact reduces the spreading of the virus 58.3%. The barriers include no interaction between lecturers 45.6%, technical problems 57.7%, no clinical practices 43.9% and distraction at home 36.4%.	1
(Suliman et al., 2021)	OL in Undergraduate nursing students from 2 universities at Jordan	Online questionnaire	Traditional learning	(N = 18) Qualitative study	Students show several emotions towards online learning; some expressed fear and worries regarding their education—more time required for them to adapt to online technology and how to manage their time well. Financial burdens also have been reported by students who have a problem with internet issues. Distraction at home is also one of the major problems reported by students and also a lack of interaction between teachers and students. Lack of clinical skills also has been mentioned by the students. Benefits include watching the recorded lecture as many times as we want, spending more time with their families, saving time, and getting more relaxed.	1

Table 4.2.2.2: The summarization of student perception of online learning based on positive and negative perception

	Type of student perception	Number of studies	Reference
Positive Perception	Flexibility	12	(M. Al-Balas et al., 2020), (Khalil et al., 2020), (Dost et al., 2020), (Y. Wang & Zhang, 2020), (Coffey et al., 2020), (Anwar et al., 2020), (B. B. Shahrvini et al., 2020), (Yoo et al., 2021), (Bączek et al., 2021), (Schoenfeld-Tacher & Dorman, 2021), (Gupta et al., 2021), (Suliman et al., 2021)
	Motivated and increase engagement	7	(Puljak et al., 2020a), (Sawarkar et al., 2020), (Coffey et al., 2020), (Anwar et al., 2020), (Schoenfeld-Tacher & Dorman, 2021), (Ibrahim et al., 2021), (Khan et al., 2021)
	Save time	6	(Dost et al., 2020), (Anwar et al., 2020), (Yoo et al., 2020), (Guiter et al., 2021), (Gupta et al., 2021), (Ibrahim et al., 2021)
	High interaction between instructors and students	6	(Al- Balas et al., 2020), (Puljak et al., 2020), (K. Wang et al., 2021a), (Olum et al., 2020), (Martinez et al., 2020a), (Ibrahim et al., 2021)
	Help in clinical practices	4	(De Ponti et al., 2020a), (Chandrasinghe et al., 2020), (Jiménez-Rodríguez & Arrogante, 2020), (Co et al., 2021a)
	Save cost	3	(Dost et al., 2020), (Co et al., 2021a), (Sindiani et al., 2020a)
	Watch and play recorded video at any time and place	3	(Ju Whi Kim et al., 2020), (Yoo et al., 2020), (Suliman et al., 2021)
	Easy to communicate	2	(Muflih et al., 2020), (Guiter et al., 2021)
	More time to study	2	(Lisa R. Amir et al., 2020), (Bączek et al., 2021)
	High understanding	1	(Merson et al., 2020)
	Internet problem	16	(Al- Balas et al., 2020), (Khalil et al., 2020), (Dost et al., 2020), (Chandrasinghe et al., 2020), (K. Wang et al., 2021), (Olum et al., 2020), (Alqurshi, 2020), (Yoo et al., 2020), (Tuma et al., 2021), (Schoenfeld-Tacher & Dorman et al., 2021), (Guiter et al., 2021), (Gupta et al., 2021), (Co et al., 2021), (Tigaa & Sonawane, 2020), (Ibrahim et al., 2021), (Menon et al., 2021)

Negative Perception	Hard to communicate low interaction	16	(Rajab et al., 2020), (Khalil et al., 2020), (K. Wang et al., 2021a), (Anwar et al., 2020), (Alqurshi, 2020), (Yoo et al., 2020), (Kumar et al., 2020), (Bączek et al., 2021), (Langegård et al., 2021), (Schoenfeld-Tacher & Dorman et al., 2021), (Gupta et al., 2021), (Co et al., 2021), (Khan et al., 2021), (Menon et al., 2021), (Sindiani et al., 2020), (Suliman et al., 2021)
	Cannot apply clinical skills	11	(Al- Balas et al., 2020), (Alsoufi et al., 2020), (Mahdy, 2020), (Coffey et al., 2020), (Alqurshi, 2020), (Shahrvini et al., 2020), (Kumar et al., 2020), (Gupta et al., 2021), (Ibrahim et al., 2021), (Khan et al., 2021), (Sindiani et al., 2020)
	Lack technology experience	6	(Muflih et al., 2020), (De Ponti et al., 2020), (Y. Sandhaus et al., 2020), (K. Wang et al., 2021a), (Olum et al., 2020), (Ibrahim et al., 2021)
	Technological problems	6	(Olum et., 2020), (Martinez et al., 2020), (Bączek et al., 2020), (Langegård et al., 2021), (Sindiani et al., 2020), (Suliman et al., 2021)
	Related to stress and anxiety	5	(Rajab et al., 2020), (Dost et al., 2020), (Coffey et al., 2020), (Jaap et al., 2021), (Suliman et al., 2021)
	Technophobia	3	(Rajab et al., 2020), (Shahrvini et al., 2020), (Tuma et al., 2021)
	Family distraction	3	(Dost et al., 2020), (Sindiani et al., 2020), (Suliman et al., 2021)
	Financial problems	3	(Lisa R. Amir et al., 2020), (Tigaa & Sonawane, 2020), (Suliman et al., 2021)
	Time management	3	(Lisa R. Amir et al., 2020), (Coffey et al., 2020), (Langegård et al., 2021)
	Lack motivation	2	(K. Wang et al., 2021a), (Langegård et al., 2021)
	Behavioral challenges	2	(Khalil et al., 2020), (Suliman et al., 2021)
	Lack space at home	2	(Dost et al., 2020), (Jaap et al., 2021)
	Hard to focus (longer period)	2	(Amir et al., 2020), (Alqurshi, 2020)
	More time required to prepare	2	(Elsalem et al., 2021a), (Suliman et al., 2021)
	Low teaching quality	1	(Al- Balas et al., 2020)
	Different time zone	1	(Co et al., 2021a)
	Lack of networking	1	(Muflih et al., 2020)

Figure 4.2.2.1 Pie chart shows the percentage of positive student perception and flexibility in online learning shows the highest percentage

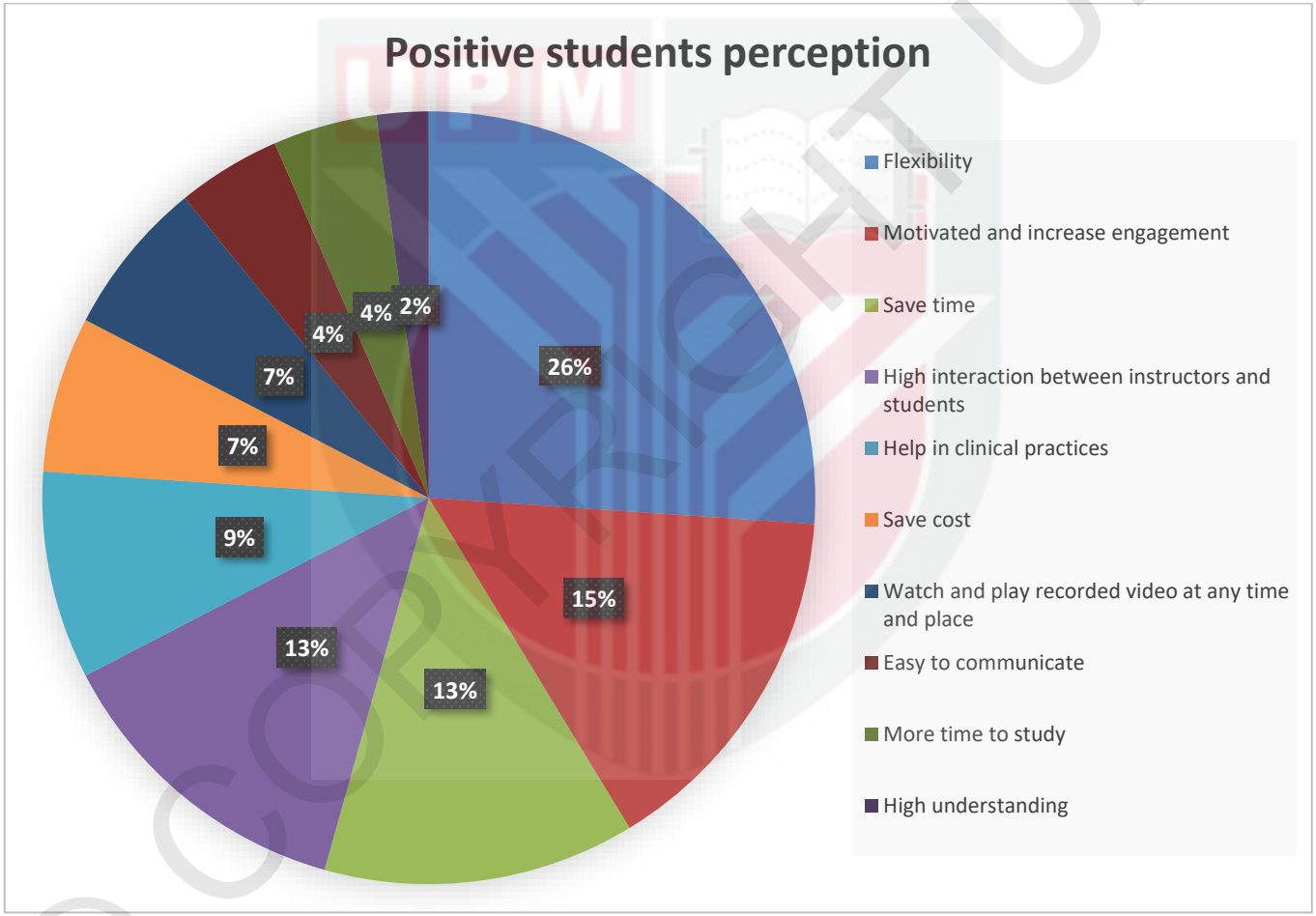
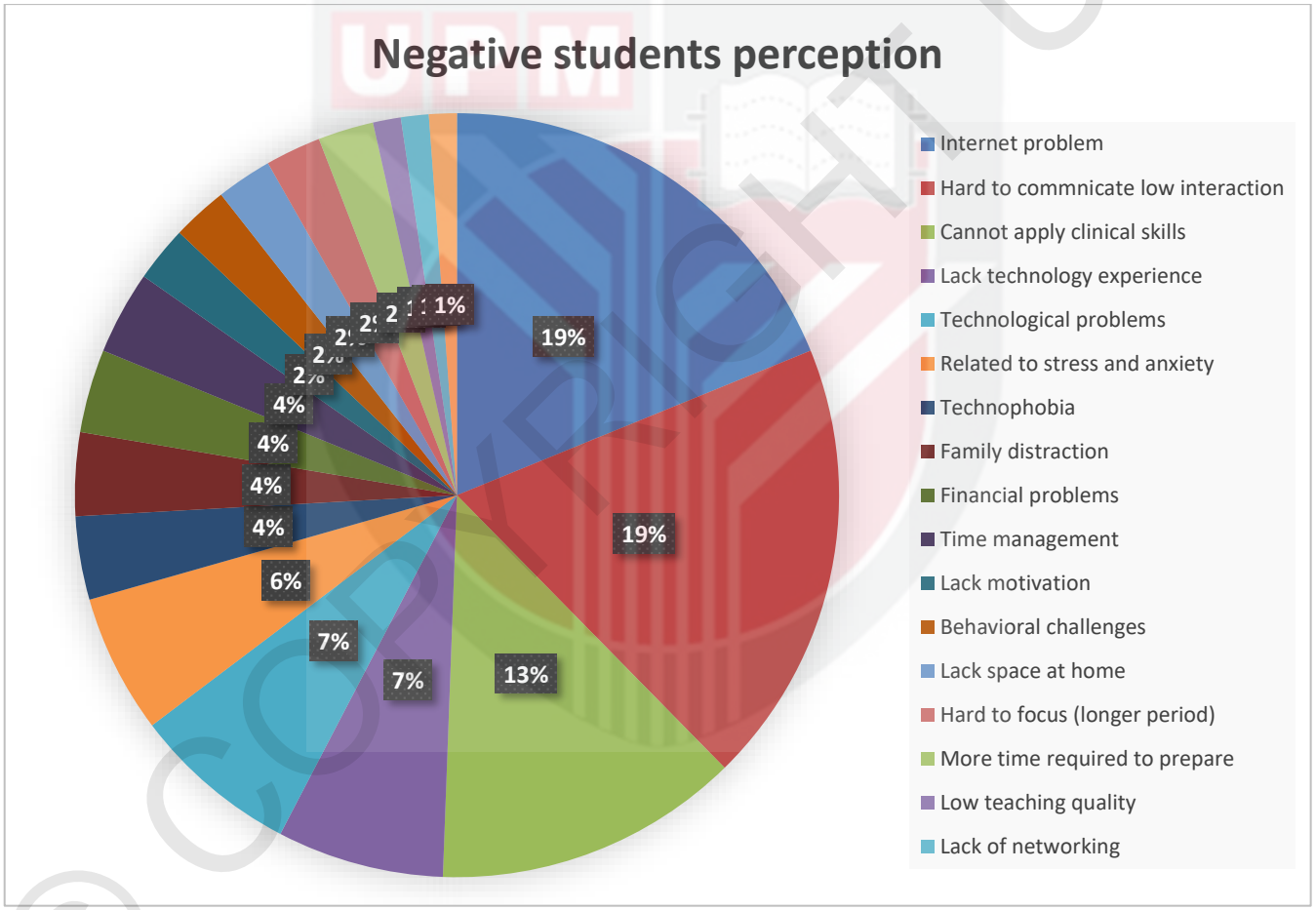


Figure 4.2.2.2 Pie chart shows the percentage of negative student perception and internet connectivity problems in online learning shows the highest percentage



4.2.3 Student satisfaction

There are 36 studies that include students' satisfaction in their studies. In 24 out of 36 studies, significant results were found to favour the online learning approach, while 13 of the studies did not favour it. The result was categorized into 3 types of satisfaction which includes dissatisfied, moderately satisfied and highly satisfied. If the satisfaction of the students mentioned by authors is under 40%, it will fall under dissatisfied criteria, while if the student's satisfaction mentioned by authors are between 40% to 70%, it will consider as moderately satisfied and if the satisfaction is more than 70% than it will then consider as highly satisfied. There are only 13 studies that show students higher satisfaction with the use of the online learning approach when compared to traditional learning, while 17 studies show that students are moderately satisfied and 6 studies reported did not satisfied. The summary of the results obtained for student satisfaction from included studies will be summarized under Table 4.2.3.1, and summarization based on a different level of satisfaction will be under Table 4.2.3.2.

Table 4.2.3.1: Summary of the included studies for student satisfaction

Author and Year	Intervention (what used and who involved)	Assessment tool	Comparison	Study design	Findings	Kirkpatrick
(Rajab et al., 2020)	OL in undergraduate students medical education Bachelor of Medicine and Bachelor of Surgery	Online questionnaire	Traditional learning	(N = 139) Cross-sectional study	66.9% report a positive view on the online learning application, 27.3% report a negative view, while 5.8% report no response.	1
(Mahmoud Al-Balas et al., 2020)	OL in undergraduate medical students from all medical universities in Jordan	Online questionnaire	Traditional learning	(N = 652) Cross-sectional study	26.77% satisfied with the online learning experience, 44.42% did not satisfy while 28.81 is neutral.	1
(Alsoufi et al., 2020)	OL in undergraduate medical students from all medical universities in Libyan	Online questionnaire	Traditional learning	(N = 3348) Cross-sectional study	64.7% disagree with online learning in Libya.	1
(Schlenz et al., 2020)	OL in undergraduate dental students from Justus-Liebig-University Giessen (Germany)	Online questionnaire	Traditional learning	(N = 299) Cross-sectional study	36.8% of student prefer f2f learning, only 5.6% stated that online learning is not that useful, and mostly half of them did agree that online platform is useful. Overall assessment regarding student perspective was obtained, which is (53.2% - mean) (24.9 - standard deviation).	1
(Elzainy et al., 2020)	OL in Undergraduate medical students from College of	Online questionnaire	Traditional learning	(N = 249) Cross-sectional study	58.82% of students show satisfaction with online learning in virtual classrooms, virtual workshops, and online assessments.	2

	Medicine Qassim University					
(Muflih et al., 2020)	OL in undergraduate health science students from Jordanian universities	Online questionnaire	Traditional learning	(N = 1210) Cross-sectional study	The mean score obtained for students' satisfaction towards online learning was 42.94, which is average.	1
(Puljak et al., 2020)	OL in undergraduate health sciences students from 9 Croatia universities	Online questionnaire	Traditional learning	(N = 2520) Cross-sectional study	The results show that student satisfaction towards online learning is 3.7 out of 5. 39.6% agreed that online learning is effective, 24.9% found online learning not effective, and the other was neutral.	1
(Lisa R. Amir et al., 2020)	OL in Undergraduate dentistry study from Dentistry faculty at Indonesia	Online questionnaire	Traditional learning	(N = 301) Cross-sectional study	44.2% of the students preferred online learning to f2f learning.	1
(C. Wang et al., 2020)	OL in undergraduate medical student from 90 medical schools in China	Online questionnaire	Traditional learning	(N = 118030) Cross-sectional study	64.97% believed that online learning is not effective, and 3.75% said that online learning is useless. The regression results obtained shows students 68.72% did not satisfy with the online learning application.	1
(De Ponti et al., 2020)	OL in undergraduate medical students from the University of Insubria	Online questionnaire	Traditional training	(N = 115) Cross-sectional study	90% gave positive feedback. 93% of the students felt like the format used to teach students online was impressive.	1
(Ju Whi Kim et al., 2020)	OL in undergraduate medical students from Seoul National University	Online questionnaire	Traditional learning	(N = 456) Cross-sectional study	62.2% of the students were satisfied with the application of online learning compared to f2f learning.	1
(Bolatov et al., 2021)	OL in undergraduate medical students	Online questionnaire	Traditional learning	(N = 619: TL), (N = 798: OL) Cross-	50.4% of the students satisfied with their academic performance during TL, while 71.6% of the students satisfied with their academic performance during OL.	1

	from Astana Medical University			sectional study		
(Yoram Sandhaus et al., 2020)	OL in undergraduate medical students from Adelson School of Medicine	Online questionnaire and telephone interview	Traditional learning	(N = 70) Cross-sectional study	The results obtained show the student very satisfied with the application of online learning 88.6% compared to traditional learning.	1
(Junod Perron et al., 2020)	OL in undergraduate medical students from Geneva Faculty of Medicine	Online questionnaire	Traditional seminars	(N = 149) Cross-sectional study	Students are very satisfied with the online seminars held by the faculty. The students still prefer face-to-face activity, but 60% still consider that online format can still be used, especially during a pandemic.	1
(Jiménez-Rodríguez & Arrogante, 2020)	OL in Undergraduate nursing students from University in Almeria - Spain	Online questionnaire	Traditional practical	(N = 93) Cross-sectional study	97.8% of the students satisfied with the application of simulated video consultations.	3
(Higgins et al., 2020)	OL (online problem-based learning (PBL) sessions) in undergraduate medical students from the College of Medicine at Qassim University	Online questionnaire	Traditional learning	(N = 674) Cross-sectional study	67.30% of the students satisfied with the online learning application and for about 64% agreed that live streaming session via Blackboard (online learning platform) was efficient.	1
(Kalleny, 2020a)	OL(Kahoot) in undergraduate medical students from the Faculty of Medicine Ain Shams University	Online questionnaire	Traditional learning	(N = 136) Cross-sectional study	Student satisfied with the application of Kahoot since the overall rating score is 4.65 out of 5.	1
(Steehler et al., 2020)	OL in undergraduate medical students from Emory University School of Medicine	Online questionnaire	Traditional learning	(N = 12) Cross-sectional study	92% reported that they were very satisfied with the online learning delivery. 92% agreed that there is increased understanding from this virtual learning application.	1

(Khalaf et al., 2020)	OL in undergraduate students from Bachelor of Dental Surgery at University of Sharjah	Online questionnaire	Traditional learning	(N = 65) Cross-sectional study	The results from the survey show the students are very satisfied with the online exam application. It is observed that students with learning experience before are more satisfied with online learning than the student who lacks experience with the online exam before ($p < 0.05$).	1
(Al-Taweel et al., 2021)	OL in undergraduate dental students from University of Baghdad, University of Sulaimani, and Dijlah University College	Online questionnaire	Traditional learning	(N = 832) Cross-sectional study	About 79% of the participants did not feel satisfied with TB learning, while only 17% agreed that online learning is better than traditional learning. Most of the students satisfied with TB learning mostly have advanced computer skills – 5th-grade students (Higher computer skills = higher satisfaction) – Odds Ratio: 3.031, 2.876, 3.644.	1
(Kaliyadan et al., 2020)	OL in Undergraduate medical students from the Dermatology department	Online questionnaire	Traditional learning	(N = 45) Cross-sectional study	The results show the students were satisfied with the online module since all the score given is more than half – Practical skills (3.28), Technical issue (3.60), Time (3.77), Assessment (3.35) and Overall content coverage (3.97). The results show a lower score for practical skills since practical usually need skills that required f2f.	1
(Co et al., 2021a)	OL in undergraduate medical students from the University of Hong Kong	Online	Traditional learning	(N = 30) Cross-sectional study	The results show that 90% of the students feel that WSSL implementation was very good and easy to understand, and most of them also did not have problems with technical problems.	1
(Jiménez-Rodríguez et al., 2020)	OL in Undergraduate nursing students from the University of Spain	Online questionnaire	Traditional learning	(N = 48) Cross-sectional study	97.6% agreed that they had learned the simulation's mistakes, 97.6% also agreed that the simulation is related to the theory. Overall satisfaction shows 95.8% felt that the simulation video was helpful.	3
(Fischbeck et al., 2020)	OL in undergraduate medical psychology and medical sociology from university in Mainz	Online questionnaire	Traditional learning	(N = 203) Cross-sectional study	Overall, most of the students agreed that all the exercise given online was very helpful while only 24% did not agree that online courses can replace f2f.	3

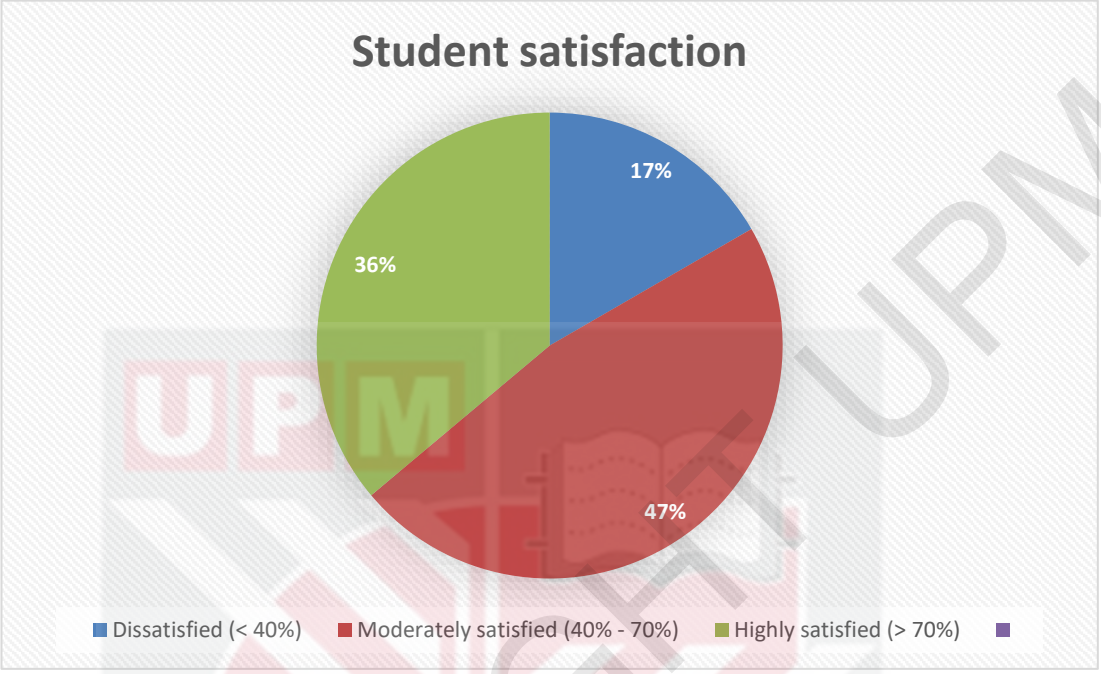
(Yoo et al., 2021)	OL in undergraduate medical students from Korea University College of Medicine	Online questionnaire	Traditional learning	N = 108 (2020) N = 104 (2019) Cross-sectional study	The results show the majority of the students, 78.6%, preferred online learning compared to f2f learning 21.2%.	1
(Bączek et al., 2021)	OL in undergraduate medical students from Polish	Online questionnaire	Traditional learning	N = 804 Cross-sectional study	The results also show that online learning application was not that effectively compares to f2f learning in term of increasing knowledge (P < .001) and also social competencies (P < .001). But still, 73% of students enjoyed online learning, while 27% did not enjoy the online learning application.	1
(Dutta et al., 2021a)	OL in Undergraduate medical and nursing students across India	Online questionnaire	Traditional learning	(N = 1068) Cross-sectional study	The results show that 37.76% of the students were very satisfied with online learning, while 42% did not feel satisfied with the online learning application.	1
(Suppan et al., 2021)	OL in undergraduate medical students University of Geneva Faculty of Medicine	Online questionnaire	Traditional learning	(N = 158) RCT	Only 40% of students are very satisfied with the online learning module compared to 15% of traditional didactic videos.	2
(Liu et al., 2021)	OL in undergraduate medical students from Shandong First Medical University	Online questionnaire	Traditional learning	(N = 512) Cross-sectional study	71.3% and 82.5% of the Histology and Embryology and Pathology course students are very satisfied with the new teaching method. Only 37% want to return to traditional teaching from Pathology course while 52.1% from Histology and Embryology.	1
(Gupta et al., 2021)	OL in undergraduate medical students from the Delhi-NCR region	Online questionnaire	Traditional learning	(N = 248) Cross-sectional study	35.4% of students preferred online learning while 43.1% are more into traditional teaching, and 21.4% remained neutral.	1
(Tigaa & Sonawane, 2020)	OL in undergraduate students who are taking chemistry	Online questionnaire	Traditional learning	(N = 150) Cross-sectional study	24% from Dhule and 15% from St. Cloud that satisfied with the online learning application, while most of them, 36% from Dhule and 22% from St. Cloud, only partially agree with the online learning practices.	1

	courses at St. Cloud USA and College in Dhule in India					
(Khan et al., 2021)	OL in undergraduate medical students from North India	Online questionnaire	Traditional learning	(N = 103) Mixed study	62%-80%, shows satisfaction toward online learning practices.	1
(Menon et al., 2021)	OL in undergraduate medical students from college hospital in South India	Online questionnaire	Traditional learning	(N = 370) Cross-sectional study	The results show that most of the students satisfied with the online learning application (31% scored high satisfaction, 53.6% scored moderate satisfaction), while only 15.4% were not satisfied.	1
(Sindiani et al., 2020a)	OL in Undergraduate medical student from Jordan university	Online questionnaire	Traditional learning	(N = 3700) Cross-sectional study	75% of the students were not satisfied with the online learning application and did not wish to use it even in the future.	1
(Zhang et al., 2020)	OL in Undergraduate medical students from Zhejiang University	Online questionnaire	Traditional learning	(N = 48) Cross-sectional study	The results show that most of the students, 54.17% preferred f2f teaching compared to the online application. Students felt that online learning could provide many advantages (mean 3.83 and SD 0.95), but still, they do not think it can replace traditional learning (mean 3.87 and SD 0.94)	1
(Elsalem et al., 2020c)	OL in Undergraduate medical sciences students from Jordan University of Sciences and Technology	Online questionnaire	Traditional learning	(N = 1019) Cross-sectional study	Majority of the students 91% that online exam is most stressful when compared to f2f teaching while 23.55% against the statement.	1

Table 4.2.3.2: The summarization based on a different level of satisfaction

Satisfaction	Number of studies	References
Highly satisfied (> 70%)	13	(De Ponti et al., 2020), (Bolatov et al., 2020), (Yoram Sandhaus et al., 2020) (Sandhaus et al., 2020), (Jiménez-Rodríguez & Arrogante, 2020), (Kalleny, 2020), (Steehler et al., 2020), (Khalaf et al., 2020), (Co et al., 2021a), (Jiménez-Rodríguez et al., 2020), (Yoo et al., 2020), (Bączek et al., 2020), (Liu et al., 2021), (Menon et al., 2021)
Moderately satisfied (40% - 70%)	17	(Rajab et al., 2020), (Mahmoud Al-Balas et al., 2020a), (Schlenz et al., 2020), (Elzainy et al., 2020), (Muflih et al., 2020), (Puljak et al., 2020), (Lisa R. Amir et al., 2020c), (Ju Whi Kim et al., 2020), (Junod Perron et al., 2020), (Higgins et al., 2020), (Kaliyadan et al., 2020a), (Fischbeck et al., 2020), (Suppan et al., 2021), (Gupta et al., 2021), (Tigaa and Sonawane, 2020), (Khan et al., 2021), (Zhang et al., 2020)
Dissatisfied (< 40%)	6	(Alsoufi et al., 2020), (Wang et al., 2020), (Al-Taweel et al., 2021), (Dutta et al., 2021), (Sindiani et al., 2020), (Elsalem et al., 2020c)

Figure 4.2.3 Pie chart shows the percentage of student satisfaction based on a different level of satisfaction, and the percentage shows students are moderately dissatisfied with the online learning application



4.2.4 Student engagement

For student engagement, there are only one study obtained. According to the result, the online learning application has been observed to increase student engagement during online classes by comparing the student question-asking behaviour during online classes and traditional classes. The student tends to ask more questions during online classes (Mean 5 and SD 3.7) compared to traditional classes (Mean 0.5 and SD 1.0).

Table 4.2.4: Summary of the included studies for student engagement

Author and Year	Intervention (what used and who involved)	Assessment tool	Comparison	Study design	Findings	Kirkpatrick
Caton et al., 2020	OL in undergraduate medical students who undergo POM (Practice of Medicine)	Compared the student question-asking behaviour (in person vs online).	Traditional teaching	(N = 8) Retrospective comparison cohort	The results show that students asked more questions during the online version with the mean five and SD 3.7 than in-person mean 0.5 and SD 1.0. The students also many questions with higher complexity online when compared with in-person. Overall, from student question-asking behaviour, higher student engagement has been observed via online version via videoconference compared to in-person teaching.	1

4.2.5 Learning Outcomes

Fourteen studies reported learning outcomes. The results were categorized into a different types of learning outcomes: 1) Based on academic performance during online learning (increase or decrease or not affected), 2) Based on skills they obtained during the online learning approach (clinical skill or communication skill). The summarization of the included studies for student learning outcomes is presented in Table 4.2.5.1. According to the result obtained after data analysis, seven studies were reported to discuss academic performance, while seven more studies were discussing what skills were obtained. Summarization based on academic performance shows there are five studies that believed that online learning increases their academic performance/marks while one study reported it to decrease the academic performance, and one study reported that online learning did not affect their academic performance. Next, summarization for what skill the obtained shows two studies believed that online learning application helps them to improve communication while five more studies reported that their clinical skills had been increased. Summarization based on a different type of learning outcome will be put under Table 4.2.5.2.

Table 4.2.5.1: Summary of the included studies for learning outcome

Author and Year	Intervention (what used and who involved)	Assessment tool	Comparison	Study design	Findings	Kirkpatrick
(Elzainy et al., 2020)	OL in undergraduate medical students from College of Medicine Qassim University	Online questionnaire	Traditional learning	(N = 249) Cross-sectional study	PBL marks that have been done online have been compared to f2f PBL marks, and the results obtained show a significant increase of PBL marks during online sessions compared to f2f learning.	2
(Ju Whi Kim et al., 2020)	OL in undergraduate medical students from Seoul National University	Online questionnaire	Traditional learning	(N = 456) Cross-sectional study	There are no significant differences in student academic achievement that can be seen in the 4-subject observed in 3 years comparison, but there are decreases in the 2-subject.	1
(Nelia Afonso et al., 2020)	OL(Virtual Respiratory Case-Based Module) in undergraduate medical students	Online questionnaire	Traditional learning	(N = 122) Cross-sectional study	The module implemented was well received by the student. The students reported that the module 93% helped them improve their telemedicine communication, 84% in the interpretation of physical exams, 95% in the development of differential diagnosis, and 93% in seeing the correlation between clinical and basic science content.	3
(Higgins et al., 2020)	Online training (RiTe module) in Undergraduate students Bachelor of Science Honors from North West England Region University	Online questionnaire	Traditional training	(N = 44) Cross-sectional study	Students feel the application of RiTe is very positive, which helps develop students experience. They strongly agreed that RiTe is very relevant to their practice and agreed that they could also learn to master their skills from the module.	2
(Mahdy, 2020)	OL in undergraduate veterinary medical students from 92 different countries	Online questionnaire	Traditional learning	(N = 1392) Cross-sectional study	96.7% agreed that this virtual application during pandemic affected their academic performance.	1
(Martinez et al., 2020)	OL in undergraduate medical students from Florida Atlantic University	Online questionnaire	Traditional learning	(N = 47) Cross-sectional study	Virtual OSCE has been conducted, and the results show the students performed during virtual OSCE (93%) is almost similar to the in-person exam (93.5%).	2

(Jiménez-Rodríguez et al., 2020)	OL in undergraduate nursing students from the University of Spain	Online questionnaire	Traditional learning	(N = 48) Cross-sectional study	62.5% have agreed that the simulation has improved their clinical skills.	3
(Fischbeck et al., 2020a)	OL in undergraduate medical psychology and medical sociology from university in Mainz	Online questionnaire	Traditional learning	(N = 203) Cross-sectional study	91% agreed that video-based situations help them become more familiar with medical conservation practice. 76% agreed that the exercise has given (Enlightenment Conversation/SPIKES Protocol) helped develop communication skills.	3
(Amer & Nemenqani, 2020)	OL in undergraduate medical students from College of Medicine, Taif University	Online questionnaire	Traditional learning	(N = 166) Cross-sectional study	The results show that 72% of the students preferred the VM application, 61.5% believed that VM was very helpful, especially during pandemic situations, and 72% agreed that VM could help them imagine the structure and help them apply it.	3
(Suppan et al., 2021)	OL in undergraduate medical students University of Geneva Faculty of Medicine	Online questionnaire	Traditional learning	(N = 158) RCT	The results show that the students who participated in the online learning module (38 correct answers) performed very well compared to traditional (35 correct answers).	2
(Jaap et al., 2021)	OL in undergraduate medical students from UK medical school	Online questionnaire	Traditional learning	(N = 447) Cross-sectional study	Regarding exam performance, Year 4 students performed better during the online exam 76.53% [SD 6.57] compared to traditional exam 72.81% [6.64], while for Year 5, the students' performance 76.02% [8.41] is almost the same as to traditional exam 77.25 [9.43].	2
(Schoenfeld-Tacher & Dorman, 2021)	OL in undergraduate veterinary students from North Carolina State University	Online questionnaire	Traditional learning	(N = 103) Cross-sectional study	Academic performance online compared to f2f learning; overall, students scored higher in diagnostic toxicology quiz online (2020) compared to f2f learning (2019).	2
(Co et al., 2021)	OL in undergraduate medical students in Hong Kong university	Online questionnaire	Traditional learning	(N = 62) Case-control study	Overall, the result concludes that students are able to do a proper surgical knot via instrumental tie. The mean score obtained for the control groups was 4.8 out of 5, while for case groups were 4.7 out of 5.	3
(Atli et al., 2020)	OL in undergraduate medical students at University Hospitals Cleveland Medical Center in Cleveland, Ohio, USA	Online questionnaire	Traditional learning	(N = 12) Prospective study	Students 100% reported increased confidence in analysing patients' cases and interpreting lab results. 50% of students also agreed that VR helps them understand according to neuroanatomy and neurosurgery, and 66% agreed that VR helps them retain surgical skills throughout this course.	3

Table 4.2.5.2: The summarization based on the different type of learning outcome

Type of learning outcome		Number of studies	Reference
Based on academic performance	Increase	5	(Elzainy et al., 2020), (Kim et al., 2020), (Suppan et al., 2021), (Jaap et al., 2021), (Schoenfeld-Tacher,& Dorman et al., 2021)
	Decrease	1	Mahdy, 2020
	Not effected	1	Martinez et al., 2020
Based on what skills they obtained	Improve communication skill	2	(Afonso et al., 2020), (Fischbeck et al., 2020)
	Increase clinical skills	5	(Higgins et al., 2020), (Jiménez-Rodríguez et al., 2020), (Amer and Nemenqani., 2020), (Co et al., 2021a), (Atli et al., 2020)

Figure 4.2.5.1 Pie chart shows the percentage of learning outcome based on academic performance, and the percentage for increasing academic performance shows the highest.

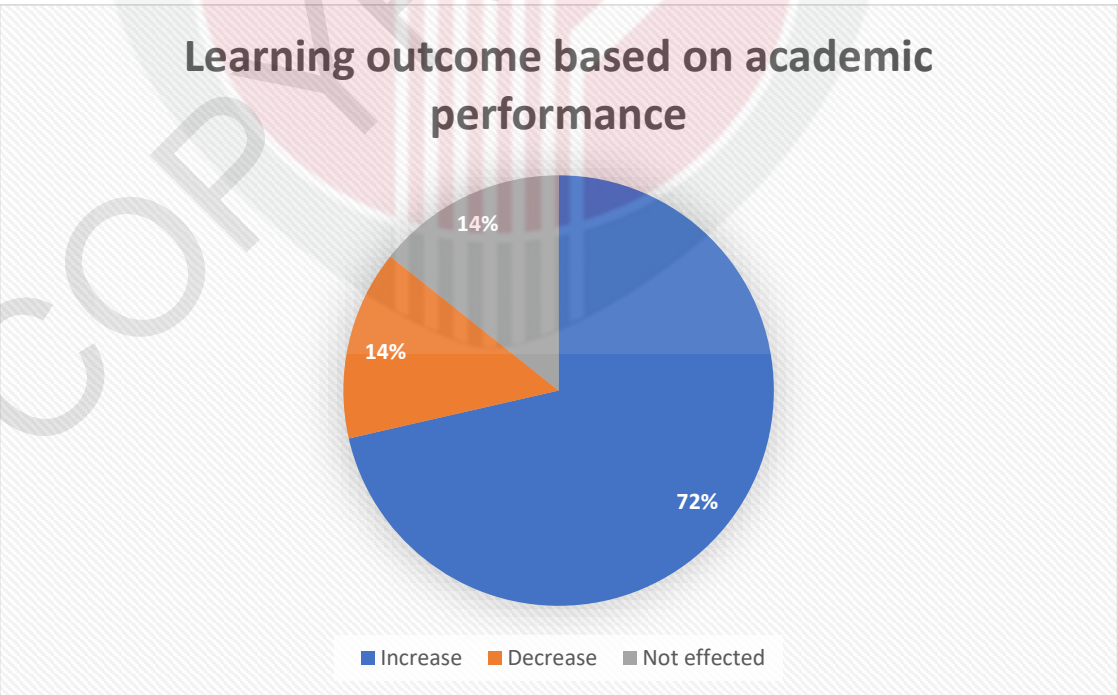
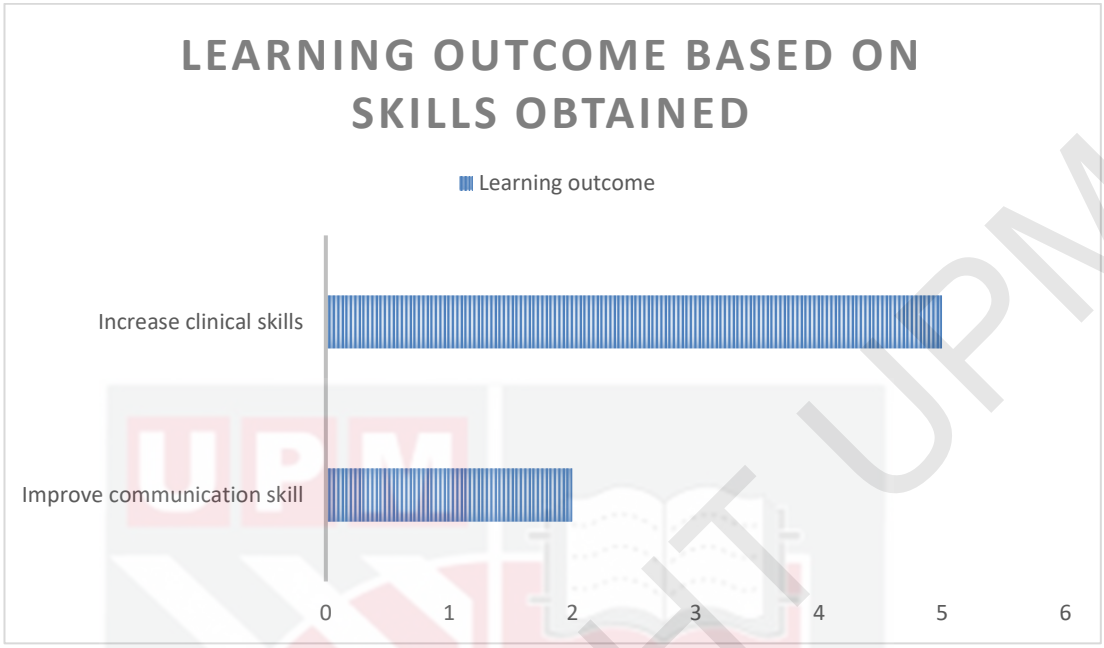


Figure 4.2.5.2 Bar chart shows the learning outcome based on skills obtained during online learning application



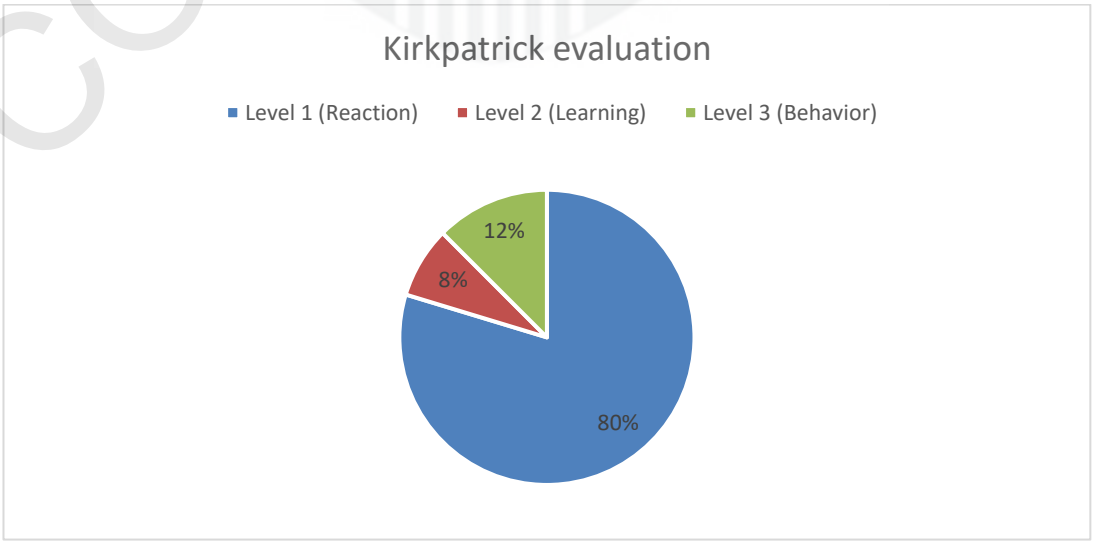
4.3 Kirkpatrick Evaluation

Overall, Kirkpatrick evaluation shows, fifty-one studies is at level 1 while five studies at level 2 (Elzainy et al., 2020; Jaap et al., 2021a; Martinez et al., 2020b; Schoenfeld-Tacher & Dorman, 2021; Suppan et al., 2021) and eight studies at level 3 (N. Afonso et al., 2020; Amer & Nemenqani, 2020; Atli et al., 2020; Co et al., 2021; Fischbeck et al., 2020; Higgins et al., 2020; Jiménez-Rodríguez et al., 2020; Jiménez-Rodríguez & Arrogante, 2020)

Table 4.3 Summary for Kirkpatrick evaluation for all included studies

Kirkpatrick evaluation	Number of studies	Remarks
Level 1 (Reaction)	51	Based on how participants respond to learning
Level 2 (Learning)	5	Based on how much did participant learn from the learning
Level 3 (Behavior)	8	Based on how participants applied what they learn

Figure 4.3 Pie chart shows the percentage for Kirkpatrick evaluation, and most of the studies are at Level 1.



4.4 Quality assessment

Quality assessment has been done by using Alberta Heritage Foundation for Medical Research (AHFMR). The results for quality assessment of the included studies were summarized under Table 4.4.1 (Quantitative studies) and 4.4.2 (Qualitative studies). In short, most quantitative studies (62 studies) are lacking three items which are 5(If the random allocation was possible), 6(If blinding of investigators was possible), and 7(If blinding of subjects was possible). After the quality assessment was done, only two studies under Table 4.4.1 show a percentage lower than 50%, while the remaining 61 studies are more than 50%. Only two studies were obtained for qualitative studies, and the percentage obtained is more than 50%

Table 4.4.1: Summary of quality assessment for quantitative included studies

Citation	Item 1 (No N/A)	Item 2 (No N/A)	Item 3	Item 4 (No N/A)	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13 (No N/A)	Item 14 (No N/A)	Per 22	Per 28	< 50%	> 50%
(Rajab et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	1	1	0	0	2	2	16			72.73
(Mahmoud Al-Balas et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	2	1	0	0	2	2	17			77.27
(Alsoufi et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	2	2	0	0	2	2	18			81.82
(Schlenz et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	1	1	2	0	2	2	18			81.82
(Elzainy et al., 2020)	2	2	2	2	N/A	N/A	N/A	1	1	1	0	0	1	1	13			59.09
(Dost et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	2	0	0	0	2	2	16			72.73
(Muflih et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	2	2	2	0	2	2	20			90.91
(Puljak et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	2	0	0	0	2	2	16			72.73
(Lisa R. Amir et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	2	2	0	0	2	2	18			81.82
(Cixiao Wang et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	2	2	0	0	2	2	18			81.82
(De Ponti et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	1	2	0	0	2	2	17			77.27
(Chandrasinghe et al., 2020)	1	2	2	2	N/A	N/A	N/A	2	2	0	0	0	2	2	15			68.18
(J.W. Kim et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	2	1	0	0	2	2	17			77.27

(Bolatov et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	2	1	0	0	2	2	17			77.27
(Yoram Sandhaus et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	1	1	0	0	2	2	16			72.73
(Junod Perron et al., 2020)	2	2	2	2	N/A	N/A	N/A	1	1	0	0	0	1	2	13			59.09
(K. Wang et al., 2021)	2	2	2	2	N/A	N/A	N/A	2	2	0	0	0	2	2	16			72.73
(Jiménez-Rodríguez & Arrogante, 2020)	2	2	2	2	N/A	N/A	N/A	2	1	0	0	0	2	2	15			68.18
(Olum et al., 2020)	2	2	2	2	N/A	N/A	N/A	1	1	2	0	0	1	2	15			68.18
(N. Afonso et al., 2020)	2	2	2	2	N/A	N/A	N/A	1	1	0	0	0	1	2	13			59.09
(Higgins et al., 2021)	2	2	2	2	N/A	N/A	N/A	1	1	0	0	0	1	2	13			59.09
(Alkhowailed et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	2	0	0	0	2	2	16			72.73
(Merson et al., 2020)	2	2	2	2	N/A	N/A	N/A	1	1	2	0	0	1	2	15			68.18
(Kalleny, 2020)	2	2	2	2	N/A	N/A	N/A	1	1	0	0	0	1	2	13			59.09
(Steehler et al., 2020)	2	2	2	2	N/A	N/A	N/A	1	1	0	0	0	1	2	13			59.09
(Mahdy, 2020)	2	2	2	2	N/A	N/A	N/A	1	2	0	0	0	1	2	14			63.64
(Sawarkar et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	1	0	0	0	2	2	15			68.18
(Khalaf et al., 2020)	2	2	2	2	N/A	N/A	N/A	1	1	1	0	0	1	2	14			63.64

(Caton et al., 2021)	1	2	2	2	N/A	N/A	N/A	1	1	1	1	0	1	2	14			63.64
(Al-Taweel et al., 2021)	2	2	2	2	N/A	N/A	N/A	2	2	1	0	0	2	2	17			77.27
(Kaliyadan et al., 2020)	2	2	2	2	N/A	N/A	N/A	1	1	0	0	0	1	2	13			59.09
(Coffey et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	1	0	0	0	2	2	15			68.18
(Martinez et al., 2020)	1	2	2	2	N/A	N/A	N/A	1	1	0	0	0	1	2	12			54.55
(Co et al., 2021)	1	2	2	2	N/A	N/A	N/A	1	1	0	0	0	1	2	12			54.55
(Jiménez-Rodríguez et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	1	0	0	0	2	2	15			68.18
(Fischbeck et al., 2020)	1	2	2	2	N/A	N/A	N/A	2	1	0	0	0	2	2	14			63.64
(Anwar et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	1	0	0	0	2	2	15			68.18
(Amer & Nemenqani, 2020)	2	1	2	2	N/A	N/A	N/A	1	1	0	0	0	1	2	12			54.55
(Alqurshi, 2020)	2	2	2	2	N/A	N/A	N/A	2	2	0	0	0	2	2	16			72.73
(B. Shahrvini et al., 2021)	2	2	2	2	N/A	N/A	N/A	2	1	1	0	0	2	2	16			72.73
(Yoo et al., 2021)	2	2	1	2	N/A	N/A	N/A	2	1	1	0	0	2	0	13			59.09
(Kumar et al., 2020)	2	1	1	2	N/A	N/A	N/A	1	1	0	0	0	2	1	11			50.00
(Bączek et al., 2021)	1	2	2	2	N/A	N/A	N/A	2	2	2	2	0	2	2	19			86.36
(Dutta et al., 2021a)	1	2	2	2	N/A	N/A	N/A	2	2	1	0	0	2	2	16			72.73
(Suppan et al., 2021)	2	2	2	2	2	0	0	2	1	2	0	2	2	1		21		75.00

(Liu et al., 2021)	2	2	2	2	N/A	N/A	N/A	2	2	2	0	0	2	2	18			81.82
(Tuma et al., 2021)	2	2	2	2	N/A	N/A	N/A	2	2	0	0	0	2	2	16			72.73
(Langegård et al., 2021)	2	2	2	2	N/A	N/A	N/A	2	2	0	0	0	2	2	16			72.73
(Elsalem et al., 2021)	2	2	2	2	N/A	N/A	N/A	2	2	2	0	0	2	2	18			81.82
(Jaap et al., 2021)	1	1	2	1	N/A	N/A	N/A	1	2	2	2	0	2	1	15			68.18
(Schoenfeld-Tacher & Dorman, 2021)	1	1	1	2	N/A	N/A	N/A	1	1	1	0	0	1	0	9		40.91	
(Guiter et al., 2021)	1	1	1	1	N/A	N/A	N/A	1	1	0	0	0	1	1	8		36.36	
(Gupta et al., 2021)	2	2	2	2	N/A	N/A	N/A	2	1	2	0	0	2	2	17			77.27
(Co et al., 2021)	2	2	2	2	N/A	N/A	N/A	2	1	1	0	1	2	1	16			72.73
(Tigaa & Sonawane, 2020)	2	2	2	2	N/A	N/A	N/A	2	1	0	0	0	2	2	15			68.18
(Ibrahim et al., 2021)	2	2	2	2	N/A	N/A	N/A	2	2	2	0	2	2	2	20			90.91
(Khan et al., 2021)	2	2	2	2	N/A	N/A	N/A	2	1	1	0	0	1	2	15			68.18
(Menon et al., 2021)	2	1	2	2	N/A	N/A	N/A	1	2	1	0	0	1	2	14			63.64
(Sindiani et al., 2020a)	2	2	2	2	N/A	N/A	N/A	2	2	1	0	0	2	1	16			72.73
(Zhang et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	1	1	2	0	1	1	16			72.73
(Atli et al., 2020)	2	2	2	2	N/A	N/A	N/A	2	1	1	0	0	2	1	16			72.73

(Elsalem et al., 2020b)	2	2	2	2	N/A	N/A	N/A	2	2	1	0	0	2	1	16			72.73

Yes = 2, Partial = 2, No = 0, N/A = non-applicable

Q1 = Question or objective sufficiently described Q2 = Design evident and appropriate to answer study question Q3 = Method of subject selection or source of information is described and appropriate Q4 = Subject characteristics or input variables sufficiently described Q5 = If the random allocation was possible, is it described? Q6 = If blinding of investigators was possible, is it reported? Q7 = If blinding of subjects was possible, is it reported? Q8 = Outcome and exposure measure well defined and robust with bias misclassification reported Q9 = Sample size appropriate Q10 = Analysis described and appropriate Q11 = Estimate of variance is reported Q12 = Controlled for confounding Q13 = Result reported in sufficient detail Q14 = Result support the conclusions

Table 4.4.2: Summary of quality assessment for qualitative studies

Citation	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Per 20	> 50%
(Khalil et al., 2020)	2	2	2	2	2	2	2	2	2	2	20	100
(Suliman et al., 2021)	2	2	2	2	2	2	2	1	2	2	19	95

Yes = 2, Partial = 2, No = 0

Q1 = Question or objective sufficiently described Q2 = Design evident and appropriate to answer study question Q3 = Context of the study clear Q4 = Connection to a theoretical framework/wider body of knowledge? Q5 = Sampling strategies described, relevant and justified? Q6 = Data collection method clearly describe and systematic? Q7 = Data analysis method clearly describe and systematic? Q8 = Use verification procedure to establish credibility? Q9 = Conclusions supported by results? Q10 = Relativity of the account?

CHAPTER 5

DISCUSSION

This study aims to determine the effectiveness of online learning in undergraduate medical and health science students based on two outcomes: student learning outcomes and attitudes. According to the previous study, even if there are many favourable outcomes with online learning, especially during a pandemic, the usefulness of online learning is still unknown (Nguyen, 2015). There have also been studies that suggest that the mix of time spent, content, and pedagogy during online learning can lead to noticeable differences in students' learning outcomes (Al-Balas et al., 2020; Choi et al., 2020; Rajab et al., 2020), but there is still no evidence that online learning is preferable as a medium for delivering learning (Nguyen, 2015). Our systematic review identified 64 studies that assessed student learning outcomes and attitudes towards online learning during COVID-19.

5.1 The students' attitudes following the use of online learning

The student's level of satisfaction can be influenced by student perception during online learning (Cheng et al., 2016). Based on Figure 4.2.3, student satisfaction towards online learning shows almost 50% of the studies stated students are moderately satisfied, 37% of the studies stated students are highly satisfied, while only 14% of the studies stated that the students are dissatisfied. Most students mentioned flexibility (26%) as the most important factor to be satisfied with online learning, possibly because most students log into online applications such as zoom or google meet at any time when they are available. Some of them also mentioned that they

would not have to concern about attempting to find time to come to campus or a specific time to meet with the instructor, especially for the student who is living in the rural area (Stone et al., n.d.; Yang & Cornelius, 2004). Students also believed that online learning helped them be more motivated (15%) because they were intrinsically motivated by their desire to learn new things and their excitement of trying new things, especially in learning new technology that can be used to assist them during studying (Gustiani, 2020). According to six studies, online learning can save time (13%), which is relevant when certain lecturers turn exams into reflective tasks like class conferences, where all students must contribute by sharing their thoughts on what they understand about the lecturer's unique topic. This form of assessment has really reduced time for both students and lecturers while also contributing to student comprehension (Anderson, 2000). High student-instructor interaction (13%) was also observed because online learning provides two types of delivery of teaching: asynchronous and synchronous tools, such as e-mail, forums, chats, and videoconferences. These tools allow for the distribution of more content to a larger number of students, and, as a result, better communication (4%) between students and instructors can be achieved (Jones, 2015). According to Coman et al. (2020), online learning actually provides more understanding (2%) compared to traditional teaching, and higher understanding can help the student to perform better, especially in clinical practices (9%). Students also agreed that online learning could help in saving money/cost (7%), especially when they do not have to spend on transportation when they are going to their university (Sindiani et al., 2020). Next, the students stated that recorded lectures during online learning are highly useful because they may repeat the material offered at any time, and because online learning saves time, it really gives the

student more time to study the content (Amir et al., 2020; Bahnson & Olejnikova, n.d.; Yoo et al., 2021).

Most students complained of internet problems (20%) and low communication between students and instructors (19%) as the factors that they were not satisfied with the online learning. High bandwidth and a robust internet connection are required to participate in online classes without difficulty, but not all students are able to obtain them, resulting in many students experiencing problems with their internet connection despite having data or Wi-Fi at home. Low communication between students and instructors may be due to a lack of interaction, which occurs when instructors are unable to monitor their students as effectively as they can in face-to-face teaching, and the instructor is unable to meet and discuss with their students as frequently as they would like, causing some students to become upset (Alawamleh et al., 2020). Because the online setting lacks body language, communicating with students in an online environment took more effort than face-to-face instruction. When lecturing in person, the lecturer can easily use body language and facial expressions to help students understand; however, when interacting online, all of those body languages and facial expressions are unavailable, making communication more difficult and resulting in low interaction between students and instructors (Saminathan, 2021).

According to Chan et al. (2020), experience-based learning is very important for the student to gain new experiences when participating in the activity involving the patients and clinical teacher. However, because of the pandemic, most activities must be completed online via ZOOM and Google Meet, as most students are at home, which directly impacts student performance in their clinical practices (13%). Students also

mentioned missing clinical training during their degree might lead to losing job opportunities (Ramos-Morcillo et al., 2020). Some students also lack familiarity with technology (7%) and have technological issues (7%) such as compatibility with the operating system on their computer, the browsers they use, and possibly the fact that some cellphones cannot support a limited number of applications (Alawamleh et al., 2020). According to Sitzmann et al. (2010), students' learning outcomes might be significantly impacted by technical difficulties, leading to an increase in student displeasure. According to previous research, online learning might create anxiety and depression among students (6%). In this quarantine situation, university students are more likely to get stress disorders and depression. Students began to feel social isolation, which can exacerbate procrastinating and a sense of worthlessness (Fawaz & Samaha, 2021). Technophobia (3%) was also linked to online learning. Technophobia is defined as a fear of technology that stems from unfavourable encounters with it, and it affects areas of their lives when they have a hesitant attitude toward it (Oluwalola, 2015).

Based on Rasmitadila et al. (2020), students tend to lose attention in online learning (2%) due to a variety of factors, including family distractions (3%) and the lack of a conducive setting for some students (2%). Family distractions, especially for those with a large number of siblings and who do not have a conducive setting (need to study in the living room), can significantly negatively impact students. Then, some of the students stated that they were having financial difficulties (3%), implying that not everyone can afford a data plan and WIFI. Students agreed that time management (3%) was extremely difficult during the pandemic. One factor that can influence a student's learning outcome is time management. Some students may find time

management difficult if they are not supervised by their lecturers (Sari et al., 2021). According to Gustiani (2020), online learning caused some of the students to lose motivation (2%) in their study, which might occur due to few factors such as learning environment (parents that think they still can ask their children in doing household during online classes). The online learning exam also resulted in behavioural changes (2%) in students, such as changing dietary behaviours, sleeping patterns, and physical exercise deterioration (Elsalem et al., 2020). Next, students complained about the length of online tests because some of them did not have enough time to answer all of the questions given, which could be due to technical issues that occurred during the online test (laptop slow -lagging), and as a result of those issues, the students believed that more time was required (2%) for them to prepare during online tests compared to traditional tests (Ilgaz & Afacan Adanır, 2020). Low teaching quality (1%) has also been recorded in one study, where students believe that the delivery of educational information via live streaming sessions by instructors requires good internet bandwidth to get the best streaming quality (Al-Balas et al., 2020b). According to (Co et al., 2021), students reported being unable to collaborate with a subject matter expert throughout the online application process, as well as a lack of networking (1%) and some international students experiencing difficulties due to various time zones (1%) in their home countries (Muflih et al., 2020).

One study found that online learning increases student engagement when compared to traditional learning methods (Caton et al., 2021). Their studies used retrospective cohort studies to examine student questioning behaviour in face-to-face versus online classes. According to the findings, students are more likely to ask questions during online learning than during face-to-face learning. When compared to

traditional education, the students' queries are also more complicated. Then, they conclude that this could be because online learning does not need students to raise their hands or speak directly to instructors in order to ask a question; instead, they can enter their question in the question or chat box and submit it anonymously. The timid student who constantly hesitates to ask a question during class can benefit from using an online learning tool to learn how to ask a question about something they don't understand. The student will be able to see the chat or question box until the end of the session, which allows other students to respond to the question.

5.2 The effectiveness of online learning based on learning outcomes

Most of the studies conducted are in medical education, and the evaluation of the effectiveness of online learning has been done based on academic performance and what skills were obtained as the outcome. Five studies (72%) reported an increase in academic performance when compared to the traditional approach, and one study (14%) reported a decrease in academic performance, while one study (14%) reported did not get affected. These results demonstrate that student performance can improve with the use of online learning during a pandemic. According to Gonzalez et al. (2020), the results show students performed better during pandemic situations and found out more students started to pass the course. They also stated that throughout the outbreak, more students finished their assignments than in prior years. As a result, they suggest that the rise in student academic performance is related to greater constancy in studying during the pandemic than in previous years. Increased exposure to the online learning environment may have an impact on student academic achievement. Academic performance may improve as a result of more exposure to an online learning environment. Finally, due to the lack of distractions, student performance may improve

during a pandemic. Some students, particularly low-performing students, maybe less distracted by their peers if they learn at home, allowing them to focus more on their studies and, as a result, improve their academic performance (Spitzer & Musslick, 2020).

Based on Figure 4.2.5.2, most of the studies agreed that online learning could help students improve their skills, such as communication and clinical skills. Five studies stated that online learning improves student clinical skills, while two studies stated that online learning could improve communication skills. According to results obtained from Gormley et al. (2009), online learning had a positive impact on students' clinical skills learning, according to the students. For clinical capabilities, the majority of them agreed that it was on par with traditional education. They claimed that students who exhibit characteristics related to deeper learning in clinical skills would perform better in their clinical skills when learning online. According to the study, students were also quite comfortable with the usage of internet video and photographs during clinical procedures. Based on Rodrigues and Vethamani (2015), student communication skills can be improved via online learning approaches. It can motivate students to practise their oral communication skills in a one-on-one learning environment, which is critical for students to develop self-confidence.

5.3 Countries affected by the application of online learning

Based on the results obtained, the highest country that did not favour online learning applications is mostly students from India (Dutta et al., 2021; Gupta et al., 2021; Tigaa & Sonawane, 2020) and Jordan (M. Al-Balas et al., 2020; Elsalem et al., 2020c; Muflih et al., 2020; Sindiani et al., 2020). The most serious difficulty that has

been observed in India is the lack of accessibility. The overall number of internet users in India is estimated to be 56.45 crores, although the entire population is around 138 crores, implying that more than half of the population still lacks access to the internet (Diwanji, 2020). Most Indian families face financial difficulties, which means that some of the family's children are unable to obtain their own equipment, such as laptops, PCs, and cellphones. Because they only have one gadget at home, some families with multiple children are having difficulty enrolling in online programmes (Siddesh & Veerabhadrappa B P, 2020). One of the issues that have been identified is a lack of electricity, particularly for students who live in remote areas. Due to a lack of electricity, internet penetration is minimal, resulting in poor internet speeds (Sharma & Singh, n.d.). According to Aljaraideh and Al Bataineh (2019), the findings show online learning infrastructure is the most frequently reported difficulty by students in Jordan. Furthermore, the report stated that weak infrastructure could be harmed as a result of a lack of proper assistance from the government and higher education's top administration.

5.4 Quality assessment

Based on Table 4.4.1, most of the studies obtained are mostly cross-sectional studies compared to other study designs. A cross-sectional study design is a type of observational study design. In a cross-sectional study, the investigator assesses the result and exposures in study subjects. A cross-sectional study's participants are chosen based on the study's inclusion and exclusion criteria, and once the participants have been chosen, the researcher continues the study to analyse the exposures and outcomes (Setia, 2016). A cross-sectional study was the highest study design chosen because it was the easiest study design that can be done, especially during pandemic conditions.

According to Levin (2006), the cross-sectional study design is relatively inexpensive compared to other study designs since most researchers just need to create a survey online, such as using google form and then being ready to be distributed to all participants involved. In addition, it also takes little time to conduct when compared to other study designs but still can assess many outcomes. For quality assessment for quantitative studies in Table 4.4.1, it can be seen that most of the studies (63 studies) are lacking item 5(If the random allocation was possible), 6(If blinding of investigators was possible), and 7(If blinding of subjects was possible). This might be because most of the studies were cross-sectional, which did not involve any blinding of the subjects or researchers and any random allocation. However, for quality assessment for qualitative study in Table 4.4.2, no problem arose during the assessment since only two studies were chosen for included studies.

5.5 Kirkpatrick Evaluation

The Kirkpatrick evaluation methodology could be used to analyse both traditional and virtual education. It was utilized to acquire a thorough grasp of how online learning influences learning and whether there is a major difference in how learners learn (Edwin, 2016). According to results obtained for the Kirkpatrick evaluation, 80% of the studies access the effectiveness of online learning based on Level 1 (Reaction), 8% of the studies access the effectiveness based on level 2 (Learning), while 12% of the studies did access the effectiveness based on Level 3 (Behaviour) and none studies were accessed based on Level 4 (Results).

In Kirkpatrick's paradigm, the reaction is the initial level of evaluation. At this level, the objective analysis is to assess an individual's responsiveness to the training

or learning offered. Level 1 evaluations are thought to be relatively simple to complete. It also does not necessitate a higher cost to accomplish, which is why the majority of the studies acquired were most likely simply evaluated at Level 1 (Bhasin, 2020). Because it is relatively simple to perform, level 1 evaluation is renowned among training experts. It can also give managers fast feedback on how beneficial the program was to users. To assess learners' satisfaction with the online learning approach, the majority of the research used surveys and feedback from the respondents. On the other hand, this form of assessment is relatively shallow and restricted to merely learning the learner's perspective on the training course (Edwin, 2016). The acquired results cannot be used as a strong foundation for making adjustments in the strategy or training process because it simply entails a fast evaluation of the learners while still in the training programme (Bhasin, 2020).

Learning is the second stage of evaluation, which entails assessing what individuals have acquired in terms of both knowledge and skills (Smidt et al., 2009). Examinations, interviewing, or assessments can be utilized to get entry to this level before and after the training (Kurt, 2018). According to the results obtained, all the studies assess the effectiveness based on pre and post examination results or quizzes given (Martinez et al., 2020; Jaap et al., 2021; Schoenfeld-Tacher and Dorman, 2021; Elzainy et al., 2020; Suppan et al., 2021). The findings acquired at this level are much more realistic than those obtained at the first level of assessment since they could provide a better comprehensive picture of the training's efficacy. This level also provides an opportunity to showcase learning transfer, which will provide the trainers with a good understanding of how knowledge, abilities, and attitudes have progressed following the training programme. However, this level of review involves more effort,

expense, and time than level one, and as a result, many organizations see this as a waste of time and energy (Bhasin, 2020; Edwin, 2016).

The trainees' ability to use their newly acquired information or skills in the job is assessed at the third level of evaluation, which is behaviour (Smidt et al., 2009). According to the results, 6 out of 8 studies mentioned the training given had affected their behaviour which was seen based on how good they are applying their clinical skill (Amer & Nemenqani, 2020; Atli et al., 2020; Co et al., 2021; Higgins et al., 2020; Jiménez-Rodríguez et al., 2020; Jiménez-Rodríguez & Arrogante, 2020) while two studies reported the training has an effect on learners' behaviour in term how they manage to improve their communication skills (N. Afonso et al., 2020; Fischbeck et al., 2020). After a period of time, assessments and thorough monitoring are required to assess substantial change and determine how long it will last (Kurt, 2018). This form of assessment can be used as a tool for tracking changes in behavioural intention. As a result, the trainer will have a better knowledge of the training's strengths and flaws (Bhasin, 2020). However, to complete this assessment level, learners must get continuous reinforcement and follow-up, which could take additional money and time (Edwin, 2016).

The fourth stage of evaluation is referred to as outcomes, and it assesses the total impact of the training (Smidt et al., 2009). Because this is the most difficult and significant level of evaluation in Kirkpatrick's methodology, no included studies have reached this level. The methods required to get to this level are time-consuming and expensive (Bhasin, 2020). It also requires a specialist because it is possible to reliably see and link the reliability of specific instruction with the outcomes (Edwin, 2016).

When the Kirkpatrick model is applied to educational evaluation, data suggest that the type of assessment used in higher education may tend to limit assessment to the model's lower levels (Steele et al., 2016). Professionals in the business sector tend to ignore the lower levels of the Kirkpatrick model and focus primarily on the upper ones, but it's a different storey and more difficult to execute this model in higher education (ALLIGER & JANAK, 1989). According to Cahapay (2021), The results of a survey of higher education assessment studies that used the Kirkpatrick model to determine the efficacy of training courses revealed a wide range of evaluation methods. Some research was only conducted at levels one and two. These restrictions are driven by how the model is employed in the learning environment. The model itself is not the problem, but to be implemented in higher education seems incompatible.

5.6 Limitation of the study

The main limitation of this study is there are too many cross-sectional study designs obtained, and only one studies obtained for Randomized Controlled trials and two studies for Qualitative studies. According to Levin (2006), the cross-sectional study is unreliable because making a causal inference is difficult, and prejudice (Neyman bias) can emerge during the procedure. Randomised controlled trials have a significant benefit over other study designs that use a randomisation technique. Allocation bias and confounding or unknown variables can be reduced by randomly assigning individuals to the test and control groups. Compared to other study designs, the RCT can also be utilised to make causal inferences and give the strongest empirical evidence (Stang, 2011). Next, qualitative research is a form of study that yields results that aren't based on statistical procedures or other quantitative methods. It can relate to research on a person's daily activities, behaviours, emotions, and moods. The

qualitative research method generates a complete explanation of participants' feelings, opinions, and experiences, as well as interpreting the implications of their activities (Rahman, 2017; Denzin, 1989). This type of study can be very reliable since this study mostly involves student feelings, opinions and emotions toward online learning applications. This study may have reached inaccurate conclusions due to the small number of RCTs and qualitative studies conducted. To summarise, in the field of education, it is not enough to just question "what works," but it is also necessary to ask "what works for whom, in what circumstances, and in connection to what" in order to reach a very reliable conclusion. (Alberti et al., 2021).

CHAPTER 6

CONCLUSION

In short, school cancellations caused by COVID-19 have caused enormous disturbances in education in many countries, and it has altered how students will be educated. This systematic review aimed to determine the effectiveness of online learning among undergraduate medical and health science students during COVID-19. Even though a few research findings have stated that the effectiveness of online learning is questionable, the effectiveness of online learning has been determined based on this systematic review, which analyses based on different factors such as student reaction and attitudes (perception/satisfaction/engagement), student learning outcome, and also based on Kirkpatrick model of evaluation. According to most studies, student satisfaction with online learning applications is higher than with conventional teaching techniques. Students' perceived online learning has numerous benefits such as flexibility, increased motivation, and time savings. At the same time, most studies did report that internet connectivity issues and low interaction between instructors and learners are the most significant drawbacks of this approach. The majority of research that looked at learning outcomes as a factor concluded that online learning could help students enhance their academic performance as well as their clinical and communication skills. According to the Kirkpatrick evaluation, the majority of the studies obtained were evaluated at Level 1, which is based on student reactions to online learning, and only a few studies were evaluated at Level 2 (Learning) and Level 3 (Behavior), and none were evaluated at Level 4 (Result). However, due to some limitations, future studies utilizing RCT and qualitative study

designs should be done, as these study designs are more dependable, allowing for more accurate conclusions to be drawn, and future research should concentrate on analyzing the effectiveness of online learning at greater levels, such as Level 3 (Behavior) and Level 4 (Result) based on Kirkpatrick Model, as these levels can yield more consistent results.

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APPENDICES

Detailed characteristics of included studies

Detailed characteristics of the included studies were illustrated in Table 1 for all types of studies, respectively. Country of origin, objective of the study, method of research design, the population involved, intervention used, data collection method with outcomes and the results for the findings were included.

Author & Year	Purpose	Method of Research Design	Population	Intervention	Data Collection method + Outcomes	Results
(Rajab et al., 2020)	This study aimed to see how the COVID-19 epidemic affected eLearning at Alfaisal University's College of Medicine (COM) in Riyadh, Saudi Arabia.	Cross-sectional study via online questionnaire (survey)	N = 139 Undergraduate students medical education Bachelor of Medicine and Bachelor of Surgery (MBBS)	Online medical education	Data collection: Online questionnaires have been done by using google forms. The email that contains a link for the online questionnaire was distributed to the target population. Outcomes: perspective and satisfaction	The result shows for the online learning experience – 37.4% (report having no experience), 48.2% (intermediate experience), 14.4% (advanced experience). Results for online learning perspectives shows 59% have problem in-person communication, 57.5% student assessment, 35.5% learning curve, 48% related to anxiety and stress, 17% technophobia, 35.5%-time management and 24.4% students evaluation of faculty. The results show 66.9% report a positive view on the online learning application, 27.3% report a negative view, while 5.8% report no response.
(Mahmoud Al-Balas et al., 2020)	Investigate the state of remote E-learning among medical students during their clinical years, as well as the obstacles, constraints, enthusiasm, and future prospects for this method of learning.	Cross-sectional study via an online questionnaire	N = 652 Undergraduate medical students from all medical universities in Jordan.	Online medical education	Data collection: The questionnaire was distributed via Facebook and WhatsApp groups (contain all the information regarding medical education) Outcomes: perception and satisfaction	For the results, 55.9% agree that online learning has many advantages, such as saving time, flexibility, and increasing interaction between learners and instructors, while only 5%, which does not agree with the application of online learning. Students' perception regarding the disadvantages of online learning – 62.1% agree that there is poor interaction (between learners and instructors), 48.3 reports low quality of teaching and 69.1% report a problem with the internet. The results show for the student's satisfaction – 26.77% were satisfied with the online learning experience, 44.42% did not satisfy, while 28.81 is neutral.
(Alsoufi et al., 2020)	Its goal was to give a general picture of medical students' experiences during the COVID-19 epidemic and to identify medical	Cross-sectional survey	N = 3348 Undergraduate medical students from all medical universities in	Online medical education	Data collection: The online questionnaire (google form) was distributed via email and social media. Outcomes: perception	From the results, most of the students, 64.7%, disagree with online learning in Libya, while 54.1% believe that interactive discussion can be achieved via online learning. 21.1% agreed that online learning could be applied in clinical training, while 54.8% disagree with the statement, and 24% of the is neutral. Only 38.2% of the students agreed that online learning could replace

	students' understanding, perspectives and practises surrounding digital medical education.		Libyan – 13 medical school			the traditional teaching method, while 73.6% totally not disagreed with the statement since some of the students are having a problem with an internet connection.
Khalil et al., 2020	Its goal was to find out how undergraduate medical students at Qassim University's Unaizah College of Medicine and Medical Sciences felt about the usefulness of synchronous online learning.	Qualitative study	N = 60 Undergraduate medical students who were studying at Unaizah College of Medicine and Medical Sciences, Saudi Arabia.	Online virtual group discussion	Data collection: The email was sent to all the participants about the website for the group discussion. Then, the students will use the online conferencing website to discuss among them. The discussion was recorded, and later, it will be analysed. Outcomes: perception	For the results for student perception towards online learning, most of them agree that online learning has many benefits such as saving time, flexibility but in practising those techniques, some of them also encountered many disadvantages such as internet connectivity, behavioural challenges(not all students is visual type some of them might be kinesthetic), communication problems(between learners and instructors), online exam and content perception(absence of clinical practices – lead to a problem when some of them want to further studies).
(Schlenz et al., 2020)	The purpose of this study was to use a questionnaire survey to analyse the viewpoints of teachers and students on the deployment of online learning as a result of COVID-19.	Cross-sectional study	N = 299 Undergraduate dental students from Justus-Liebig-University Giessen (Germany)	Online dental education	Data collection: Online questionnaire was distributed to dental students using an online survey tool. Outcome: satisfaction	For the results, 36.8% of students prefer f2f learning, only 5.6% stated that online learning is not that useful, and mostly half of them did agree that online platform is useful, which led them to become more motivated. Students feel like this online learning application is a very good alternative that can keep up in the future. Overall assessment regarding student perspective was obtained, which is (53.2% - mean) (24.9 - standard deviation).
(Elzainy et al., 2020a)	The current study provides concurrent online teaching and assessment	Cross-sectional study	N =249 Undergraduate medical students from	Online medical education	Data collection: The duration and number of online learning practices were recorded	For the results, the PBL marks that have been done online have been compared to f2f PBL marks, and the results obtained show a significant increase of PBL marks during online sessions compared to f2f learning.

	techniques at Qassim University in Saudi Arabia's College of Medicine. We also looked into the influence of e-learning and assessment on student and faculty performance and the issues of sustainability.		College of Medicine Qassim University		compared to f2f learning. Outcome: satisfaction and learning outcome	58.82% of students show satisfaction with online learning in virtual classrooms, virtual workshops, and online assessments.
(Dost et al., 2020)	To find out how medical students think online teaching will help with medical education during the COVID-19 pandemic.	Cross-sectional study	N = 2721 Undergraduate medical students from 39 medical schools in the United Kingdom	Online medical education	Data collection: The online questionnaire was distributed via social media. Likert-type question (example strongly disagree – strongly disagree). Outcome: perspective	For the results based on student engagement toward online learning, 27.71% of students used video tutorials, 26.18% used online question banks, 20.96% used pre-recorded tutorials and only 15.99% used online flashcards. Students' perception towards online learning on the advantages of online learning – 19.82% agreed it could save time, 19.52% agreed it provides flexibility, 18.63% agreed that they could study and learn at their own pace, 14.24% agreed it could save some costs. Students' perception of online learning on the disadvantage of online learning – 26.76% agreed family distraction, 21.53% internet connectivity problems, 17.31% anxiety, and 11.03% lack of space.
(Muflih et al., 2020a)	The goal of this study is to see if the COVID-19 pandemic, which compels universities to quickly offer online learning, will have an impact on undergraduate	Cross-sectional study	N = 1210 Undergraduate health science students from Jordanian universities	Online health science education	Data collection: Survey was distributed online via social media. A campaign using social media and also a Web-based survey have been done to recruit participants.	The mean score obtained for students' reactions or attitudes towards online learning was 42.94, which is average. 71.5% of students agreed that the online learning application helps them to assign for reading and their homework better than the f2f approach, 66.8% agreed that online learning application makes them feel comfortable to communicate with their instructors and also instructors, 62.6% agreed that the instructor's response to their question very quick while

	health sciences students' opinions toward online learning. It also looks into the challenges of using internet technologies.				Outcomes: perception and satisfaction	only 14.1% prefer f2f learning. The results show barriers toward online learning - 75.1% agreed lack of technology experience, 74.3% lack of using online tools in the past, 57.4% lack of motivation, and 62.7% inability of networking.
(Puljak et al., 2020b)	The goal of this study was to find out what health sciences students in Croatia thought about the total changeover to e-learning during the COVID-19 epidemic.	Cross-sectional study	N = 2520 Undergraduate health sciences students from 9 Croatia universities	Online health science education	Data collection: Survey was created via a google form, and it was distributed via email to all those participants. Outcome: perception and satisfaction	The results show that student satisfaction towards online learning is 3.7 out of 5. 39.6% agreed that online learning is effective, 24.9% found online learning, and the other was neutral. Most of the students, 72.3% satisfied with how quick they can adapt to online learning. 48.5% of the students agreed that they were equally motivated in online learning compared to f2f lesson, 55.7% agreed that they love to attend online learning classes often, 43.4% said they feel connected with each other or classmate instructors. Most of the students prefer to combine f2f and online learning in the future.
(Lisa R. Amir et al., 2020a)	In the undergraduate dentistry study programme at the Faculty of Dentistry, Universitas Indonesia, we wanted to see how DL compared to classroom learning (CL).	Cross-sectional study	N = 301 Undergraduate dentistry study from Dentistry faculty at Indonesia	Online dentistry education	Data collection: The online questionnaire was distributed at the end of the semester – Likert-type scale was used Outcome: perception and satisfaction	For the results, most first-year students agreed that online learning is better than f2p learning compared to their seniors ($p < 0.001$). There are only 44.2% of the students preferred online learning to f2f learning. The results also show that 52.6% agreed online learning provides a more proactive learning method, 87.6% provide more time to study, and 87.3% agreed that online learning gives them more time to review their study material. There are also results mentioned for disadvantageous online learning, which include problems with an internet connection, financial problems, difficulty in focusing (longer period of lecture), and time management problems.

(Cixiao Wang et al., 2020)	The goal of this study was to find out how students felt about the ongoing online education that was created in response to COVID-19. -	Cross-sectional study	N = 118030 An undergraduate medical student from 90 medical schools in China	Online medical education	Data collection: All the participants have distributed an online questionnaire via an electronic questionnaire. Outcome: satisfaction	The results show more than 70% of medical students had experience with online learning. 31.28% of students state that online learning can help them more in their study based on their prior experience, 64.97% believed that online learning is not effective, and 3.75% said that online learning is useless. From the results, the familiarity of the students with online learning was definitely associated with the student's evaluation and satisfaction. The regression results obtained shows students 68.72% did not satisfy with the online learning application.
(De Ponti et al., 2020)	The purpose of this study was to determine how medical students felt about entirely online teaching, which included simulated clinical settings during the COVID-19 pandemic.	Cross-sectional study	N = 115 Undergraduate medical students from the University of Insubria	Online medical education	Data collection: Their practical training has been done online. Then the questionnaire was distributed to all of the participants after the virtual training is finished. Outcome: perception and satisfaction	From the results regarding student's perception of online learning, 90% gave positive feedback. 93% of the students felt like the format used to teach students online was impressive. Most of the participants - 77% agreed that virtual training is very effective in the clinical assessment, 94% agreed it could be used in the diagnostic activity, and 81% is used in treatment management. 84% of the students believed that this virtual training could be used in the future. Lastly, only 28% of students believed that online learning is quite difficult to implement due to technical issues.
(Chandrasinghe et al., 2020)	It aims to provide Sri Lanka medical students with online learning opportunities.	Cross-sectional study	N = 1047 Undergraduate medical students from Sri Lanka	Online medical education	Data collection: Online learning activity was designed where all the participants involved have to join it and will discussing with each other. Then, the feedback form was distributed to the students after the online training. Outcome: perception	For the results, 87% of the students stated that they agree that the students gain many advantages from the discussion. About 955 of the students are joining all the discussion sessions. 83.4 of the students agreed that the discussion helped them a lot, especially in their clinical practices, and 79.3% believed that this discussion helped them build interest in clinical medicine. Around 31% complained about having problems with internet connectivity, 25% having problems joining the discussion due to a limited number of people who can join in the certain platform, but no students state in having difficulty using the software.

(J.W. Kim et al., 2020)	The authors describe their experience running online classes with an offline clinical clerkship during a pandemic, as well as data on student contentment, educational achievement, and preferences.	Cross-sectional study	N = 456 Undergraduate medical students from Seoul National University	Online medical education	Data collection: The online questionnaire was distributed at the end of the semester. The Likert scale is used. Outcome: satisfaction, perception and learning outcome	For the results, 62.2% of the students were satisfied with the application of online learning compared to f2f learning. Students also were asked to the rate benefits on online learning at a maximum of 5 based on the Likert scale, which can take the course anywhere they want to – (4.64), can watch the recorded lecture any time – (4.57), take the course anytime they want – (4.66), alter the sequence of the lecture depending on what they want – (4.07) and can play the recorded at any speed – (3.72. For the student academic achievement, there are no significant differences that can be seen in the 4-subject observed in 3 years comparison, but there are decreases in the 2-subject.
(Bolatov et al., 2020)	The purpose of this study was to compare the mental states of medical students who switched to online learning to those of students who received traditional learning (TL).	Cross-sectional study	N = 619(TL), 798(OL) Undergraduate medical students from Astana Medical University	Online medical education	Data collection: Online questionnaire was created during the traditional learning period in November 2019 and also during online learning started in April 2020. Outcomes: satisfaction	The results show that burnout syndrome among students during traditional learning(TL) is 27.6%, while during online learning(OL) 16.7%. For depression, 49.3% show depression symptoms during TL, while during OL there are only 27.6% was observed, while for anxiety there are 42.3% was noted in TL, and 15.5% is observed during OL. Severe somatic symptoms also show higher in students during TL (63.4%) rather than OL (19.4%). For the academic performance during TL, 50.4% of the students satisfied with their academic performance, while 71.6% of the students were satisfied with their academic performance during OL.
(Yoram Sandhaus et al., 2020)	To analyze COVID-19's possible impact on future pre-clinical medical.	Cross-sectional study	N = 70 Undergraduate medical students from Adelson School of Medicine	Online medical education	Data collection: A survey was conducted on all the participants, and also a telephone interview was also have been done to increase the reliability of the results.	The results obtained show the student very satisfied with the application of online learning 88.6% compared to traditional learning. The quality of teaching has also been rated very high at 85.7%, training and technical assistance have also been rated very high by students at 87.2% and 91.5%. 61.5% also reported having technical difficulties during online learning applications. Student participation has also

					Outcome: satisfaction and perception	been surveyed, which is 74% of students who love to participate in an online learning activity. Lastly, 68.6% believed that this online learning application could be further used in this pandemic.
(Junod Perron et al., 2020)	The purpose of this study was to assess the utility and practicality of virtual synchronous clinical communication training from the viewpoints of both students and instructors.	Cross-sectional study	N = 149 Undergraduate medical students from Geneva Faculty of Medicine	Online medical education	Data collection: Online questionnaire was created via Qualtrics software then, it was then distributed to the medical students after the seminars were finished. Outcome: satisfaction	Students are very satisfied with the online seminars held by the faculty. The student feels that the tutors were well trained and are very comfortable while using an online platform (most students rate 5 out of 5). The students also report some technical difficulties with online learning applications. Lastly, the students still prefer face-to-face activity, but 60% still consider that online format can still be used, especially during a pandemic.
(K. Wang et al., 2021)	During the crucial stage of the COVID19 outbreak, this study aims to survey the existing online undergraduate education status in dental medicine in mainland China as well as provide a better knowledge of how to use this learning technique to enhance and maintain dentistry training.	Cross-sectional study	N = 8740 Undergraduate dental students from 42 dental universities in mainland China	Online dental education	Data collection: Online questionnaires have been created and was distributed to all participants from all den schools. Outcome: perception	For the results, most of the students feel very satisfied with the online learning application – 100% rated for online learning content, 95% for style use in online learning, 66% for interaction between the lecturer, 88% for the arrangement of homework, 92% for online learning material and 92% for effective time management. There are also some challenges observed during which includes network instability (62%), platform instability (33%), lack of learning motivation (72%), insufficient online learning ability (31%), lack of leaners-instructors interaction (59%) and others (8%).
(Jiménez-Rodríguez &	The goal of our research was to find out how satisfied student nurses	Cross-sectional study	N = 93 Undergraduate nursing students from University	Online nursing education	Data collection: A questionnaire have been created and was distributed to all the	For the results, 97.8% of the students were satisfied with the application of simulated video consultations. Students rated 100% in practical utility, 49.4% agreed they had improved their technical skills, and 63.43%

Arrogante , 2020)	were with simulated video consultations.		in Almeria - Spain		students to answer. The Likert scale is used. Outcome: satisfaction and perception toward simulation.	agreed that this helps them to more are to their clinical practices. The results also show students' perception regarding the simulation video – for advantageous, the students stated about the satisfaction and enjoyment, learning and calmness during simulated video performance while for disadvantageous the students stated are technical issues and technical skills development.
(Olum et al., 2020)	Aims to gauge e-learning awareness, attitudes, preferences, and problems.	Cross-sectional study	N = 221 Undergraduate medical and nursing students from Makerere University, Uganda	Online medical and nursing education	Data collection: The online questionnaire was created via google forms and distributed to the University Makerere students via WhatsApp. Outcome: perception	The results show, 26.6% reported having good internet connectivity. They are higher interaction in the online platform(MUELE) reported at 96.3%. 60% of students believed that they need to train themselves with the online learning application to use it properly, while 75% preferred blended teaching methods. 50% of the students report that online learning can actually reduce the quality of knowledge attained and is not that efficient as usual learning. Some challenges reported include internet problems (internet costs 93% and 84% poor internet connectivity), lack of skills regarding online learning application 50%, and technical problems such as lack of gadgets 35%.
(N. Afonso et al., 2020)	To see if the virtual respirator case-based module is effective.	Cross-sectional study	N =122 Undergraduate medical students	Online medical education	Data collection: Video conferencing software is used to demonstrate the respiratory physical examination, and later the student will then conduct telemedicine. Then, the survey was distributed to see students' feedback and satisfaction towards the online module.	The results obtained show that the module implemented was well received by the students. The students reported that the module 93% helped them improve their telemedicine communication, 84% in the interpretation of physical exam, 95% in the development of differential diagnosis, and 93% in seeing the correlation between clinical and basic science content.

					Outcome: learning outcome	
(Higgins et al., 2021)	To assess the efficacy of Rite teaching in Bachelor of Science Honors courses.	Cross-sectional study	N = 44 Undergraduate students Bachelor of Science Honors from North West England Region University	Online science education - The use of the Research-informed Teaching experience (RiTe) model.	Data collection: The online survey has been conducted. It has been distributed via email to all the participants. Outcome: learning outcome	The results show that students feel the application of RiTe is very positive, which helps develop students experience. The student's perception also shows that they are strongly agreed that that RiTe are very relevant with their practice, and also, they agreed that from the module also they can learn in mastering the skills
(Alkhowailed et al., 2020)	To expose the many digital techniques used by Qassim University's College of Medicine to improve student performance and achievement.	Cross-sectional study	N = 674 Undergraduate medical students from the College of Medicine at Qassim University	Online medical education	Data collection: Online satisfaction survey have been conducted. The Likert scale has been implemented in this study. Outcome: satisfaction	The results show, 67.30% of the students satisfied with the online learning application and for about 64% agreed that live streaming session via Blackboard (online learning platform) was efficient. 88.93% agreed that the digitalisation of educational activities definitely helps in achieving learning outcomes. 83% of the students appreciated the learning management system regarding the online exams. Overall, 88.22% of student give positive response towards online learning application.
(Merson et al., 2020)	The study's goal was to gauge student replies to questionnaires sent out after the course ended in order to learn more about students' impressions of the course's success.	Cross-sectional study	N = 44 Undergraduate equine science course	Online equine science education	Data collection: Online questionnaire was done via google forms and distributed to all the participants. Outcome: perception	The results show the students give positive feedback on the application of online learning, while some of them also mention that learning online actually help them to become more understands of the learning outcome. But still, based on Bayesian inference for ANOVA, most of the undergraduate still prefer in-person lessons ($P < 0.05$).

(Kalleny, 2020)	The goal of the study was to determine how engaged and satisfied students were using Kahoot! formative assessments in the respiratory system module's histology and cell biology lab sessions.	Cross-sectional study	N = 136 Undergraduate medical students from the Faculty of Medicine Ain Shams University	Online medical education	Data collection: After the Kahoot activity was done, the survey was distributed to the participants to know the participants' immediate feedback. Outcome: satisfaction	The results show higher engagement from students from 4/6 groups consisting of 14-30 person per groups. The results of student's satisfaction show the student satisfied with the application of Kahoot since the overall rating score is 4.65 out of 5. Most of the students stated they had learnt more thing via Kahoot, and they are really recommended it to be used, especially in online learning applications during pandemic right now.
(Steehler et al., 2020)	The goal of the COVID-19 was to build and assess a virtual otolaryngology medical student elective.	Cross-sectional study	N = 12 Undergraduate medical students from Emory University School of Medicine	Online otolaryngology medical education	Data collection: The online survey has been done via Google form, and it was distributed to all the participants on the final day of the virtual otolaryngology. Likert scale is used. Outcome: satisfaction	The results show, 92% reported that they were very satisfied with the online learning delivery method (online video conference software) since most of them rated in the well -very well range. 92% agreed that there is increased understanding from this virtual learning application – good (42%) and very good (58%), and 92% also reported there are increased of interest of students in taking this course.
(Mahdy, 2020)	The goal of this study was to see how the COVID-19 lockout affected veterinary medical students' and researchers' academic performance.	Cross-sectional study	N = 1392 Undergraduate veterinary medical students from 92 different countries	Online veterinary medical education	Data collection: Online questionnaire was created via a google form, and it will then be distributed to all the participants. Outcome: learning outcome – academic performance	The results show, 96.7% agreed that this virtual application during pandemic affected their academic performance. Mean evaluation obtained for general online learning 5.1 ± 2.4 while for practical parts the is 3.6 ± 2.6. The mean score becomes lower during practical might due to veterinary medical students usually more into practical than theories. It is not easy for them to learn everything online since most of it required practical skills. Students' perception towards online learning application includes more convenient and flexible, more time available and save time while for challenges includes the availability of learning devices, harder to teach especially the thing that involves practical, shortness of the available time and

						the availability of internet for people who lives in a rural area.
(Sawarkar et al., 2020)	During the COVID-19 epidemic, researchers wanted to see how Ayurveda students felt about online learning.	Cross-sectional study	N =189 Undergraduate medical students from Bachelor of Ayurvedic Medicine and Surgery	Online medical education	Data collection: Online questionnaire was created via google forms, and it was distributed to all the participants. Likert scale is used Outcome: perception	The results show that most of the students, 63.1% find online learning application very effective and very easy to use. 67.2% agreed that online learning material prepared by faculty is understandable. Overall, 58.9% have supported online learning utilisation while 33.9% of them are neutral due to few challenges they face, including misconceptions, language barriers, and the problem with terminologies. 54% of students agreed that online learning helps them enhance user engagement, increase motivation, and build their interest in understanding more. Lastly, even though they get many advantages via online learning, compared with the combination of the teaching (online + classroom), only 37.6% support online learning application.
(Khalaf et al., 2020)	During the COVID-19 pandemic, the goal of this study was to introduce and assess the use of a comprehensive high-stakes online exam to final-year dentistry students.	Cross-sectional study	N = 65 Undergraduate students from Bachelor of Dental Surgery at University of Sharjah	Online dentistry education	Data collection: The researcher sends an email which consists of a feedback form, to all the participants involved. Likert scale is used. Outcome: satisfaction	The results from the survey show the students are very satisfied with the online exam application. It is observed that students with learning experience before are more satisfied with online learning than the student who lacks experience with the online exam before ($p < 0.05$). Some students' perception of the disadvantageous online exam includes the lack of ability to write faster than usual (handwriting>typing), solve the question that they are not sure about, and technological issues also mentioned by students. Some of them also mentioned that the online exam could cause stress; this might be because they are afraid of being disconnected during the exam.
(Caton et al., 2021)	The purpose of this research is to see if there were any	Retrospective comparison cohort	N = 8 Undergraduate medical	Online medical education	Data collection: POM usually will be conducted in person, but due to	The results show, students asked more question during the online version with the mean five and SD 3.7 compared to in-person mean 0.5 and SD 1.0. The

	differences in learner engagement.		students who undergo POM (Practice of Medicine)		COVID, it has been converted online. Then the researcher will be compared the student question-asking behaviour (in person vs online). Outcome: engagement	students also many questions with higher complexity online when compared with in-person. Overall, from student question-asking behaviour, higher student engagement has been observed via online version via videoconference compared to in-person teaching.
(Al-Taweel et al., 2021)	During the COVID19 pandemic, this study attempted to assess various elements of TB learning among undergraduate dental students.	Cross-sectional study	N = 832 Undergraduate dental students from the University of Baghdad, University of Sulaimani, and Dijlah University College	Online dental education	Data collection: The google platform created the questionnaire, and it will then be distributed to all the participants via email. Outcome: satisfaction	The results show, most of the student know about the basic of technology based-learning 40.7%, 47.5% of them are intermediate while almost half on them did not any have any experience in technology-based learning. About 79% of the participants did not feel satisfied with TB learning, while only 17% agreed that online learning is better than traditional learning. Most of the students satisfied with TB learning mostly have advanced computer skills – 5th-grade students (Higher computer skills = higher satisfaction) – Odds Ratio: 3.031, 2.876, 3.644. Overall evaluation of lecturers shows female students give higher satisfaction (11.5± 5.8) than males (9.9± 7.2).
(Kaliyadan et al., 2020)	To examine undergraduate students' experiences with an online Dermatology programme.	Cross-sectional study	N = 45 Undergraduate medical students from the Dermatology department	Online medical education	Data collection: The online teaching module has been organised, and the survey was given after the module have been done. Outcome: satisfaction	The results show the students were satisfied with the online module since all the score given is more than half – Practical skills (3.28), Technical issue (3.60), Time (3.77), Assessment (3.35) and Overall content coverage (3.97). The results show a lower score for practical skills since practical usually need skills that required f2f.
(Coffey et al., 2020)	During the COVID-19, students' perceptions of remote learning	Cross-sectional study	N = 132 Undergraduate medical students from	Online medical education	Data collection: The online survey was distributed to all the participants via software	The results show student perception toward online learning application – 25% believed that they are prepared for the upcoming exam while 40% vote for (somewhat prepare).

	curricula used by clinical clerkships at a single US medical school were evaluated.		the School of Medicine at UC San Diego		platform – Qualtrics, Provo, UT Outcome: perception	The students also reported getting enough internet connectivity to support online learning, while 11% reported not getting adequate space. Students also provide little feedback on what is good and bad of online application – Good: Flexibility of online learning, Increase engagement Bad: Difficulties in time management, Lacking clinical experience, anxiety
(Martinez et al., 2020)	Its purpose is to investigate telemedicine education among medical students.	Cross-sectional study	N = 47 Undergraduate medical students from Florida Atlantic University	Online medical education	Data collection: All medical students undergo three sessions on telemedicine. Then, after the telemedicine session is done, the survey is conducted. Likert scale is used. Outcome: perception and learning outcome	The results show the students felt the telemedicine application was relevant to their medical education 4.68/5. Students also scored 2.89/5 regarding these sessions actually help them in their exam. They also agreed this platform helps them increase interaction between the patients even though it is online, but some technical problems are reported. Virtual OSCE has been conducted, and the results show the students performed during virtual OSCE (93%) is almost similar to the in-person exam (93.5%).
(Co et al., 2021)	A study of surgical education among final-year medical students was conducted.	Cross-sectional study	N = 30 Undergraduate medical students from the University of Hong Kong	Online medical education - WSSL (Web-based surgical learning)	Data collection: Basic surgical skills was conducted face to face before the pandemic. Due to pandemic, these groups of students then join WSSL via zoom. After that, a survey was distributed, and a Likert scale is used. Outcome: satisfaction	The results show that 90% of the students feel that WSSL implementation was very good and easy to understand, and most of them also did not have problems with technical problems. More than half of the students feel like WSSL learning is almost the same as conventional learning; 10% of student agreed WSSL is easier to follow, while 26.7% are having difficulty with WSSL. Overall, 40% of the students recommend WSSL implementation, which is 50% slightly recommended, while 10% is not recommended.

(Jiménez-Rodríguez et al., 2020)	The purpose of this study was to look into nursing students' satisfaction and perceptions of simulated nursing video consultations.	Cross-sectional study	N = 48 Undergraduate nursing students from the University of Spain	Online nursing education	Data collection: After the simulation finished, the survey was distributed to all the participants. Likert scale was used. Outcome: satisfaction and learning outcome	The results show that 97.6% agreed that they had learned the simulation's mistakes, 97.6% the simulation is related to the theory. Overall satisfaction shows 95.8% felt that the simulation video was helpful. Some of them are having a problem with calm during simulation 14.6%, and this simulation also makes them worried about their clinical training 60.3%. Lastly, 62.5% have agreed that they have improved their clinical skills. Some feedback from students, which includes good and bad: Good: Reality of the simulation, Nontechnical skills development, Transfer to clinical practice Bad: Technical issues, Technical skill development
(Fischbeck et al., 2020)	To assess the effectiveness of a digitised physician-patient communication course.	Cross-sectional study	N = 203 Undergraduate medical psychology and medical sociology from university in Mainz	Online medical education	Data collection: Th questionnaire was distributed to all the participants after the all the exercise was done. Likert scale is used. Outcome: satisfaction and learning outcome	The results show that 91% agreed that video-based situations help them become more familiar with medical conservation practice. 76% agreed that the exercise has given (Enlightenment Conversation/SPIKES Protocol) helped develop communication skills. 83% agreed that all the exercises given could promote patient orientation, and 70% believed it helps increase psychological knowledge. Overall, most of the students agreed that all the exercise given online was very helpful while only 24% did not agree that online courses can replace f2f.
(Anwar et al., 2020)	During the Covid-19 shutdown, it intends to assess the perspectives of medical and dental undergraduates on E-learning.	Cross-sectional study	N =283 Undergraduate medical and dental from CMH Lahore Medical College	Online medical and dental education	Data collection: The online questionnaire has been created via google forms and was sent to all the participants. Likert scale is used. Outcome: perception	The results show, 79% of students agreed that they have enough access to technological equipment while 83.8% feel the online learning application is encouraging, especially during this pandemic. 43.1% of the students feel the lecturers were very helpful, 37.5% of the students feel the online video provided is related to their courses, and 39,2% agreed the presentation by the lecturer was very clear, while 28.6% disagrees.

						Lastly, 38.2% believed that online learning could provide flexibility in learning and 31.4% believed that it could save time. There are also few students 33.2% disagreed that online can improve communication between students and lecturers.
(Amer & Nemenqani, 2020)	The goal of this study was to see if utilising VM to assess student learning in practical Histology during distance education programmes has an impact on students' grades.	Online survey	N = 166 Undergraduate medical students from College of Medicine, Taif University	Online medical education – Virtual microscopy	Data collection: Students feedback regarding the application of virtual microscopy was conducted via an online survey which was sent to all the participants at the end of the course. Likert scale is used. Outcome: perception and learning outcome	The results show that 72% of the students preferred the VM application, 61.5% believed that VM was very helpful, especially during pandemic situations, and 72% agreed that VM could help them imagine the structure and help them apply it. The students also agreed that the virtual microscopy application was very helpful because students can access the image at any time and place. The only problems that arise during the application were technical problems, especially during the setup of the program. (not available on iOS)
(Alqurshi, 2020)	To look at the impact of emergency remote teaching on pharmacy education in Saudi Arabia and make recommendations that could aid in the development of a backup plan.	Cross-sectional study	N = 703 Undergraduate pharmacy students from institutions in Saudi Arabia	Online pharmacy education	Data collection: The online questionnaire was created via google forms, and then it was distributed to all the participants. Likert scale is used. Outcome: perception	The results show that more than 20% of the students were having problems with an internet connection, and due to this, they cannot maintain their presence online compared to f2f. 35% of the students agreed that student-instructor interaction was very limited, making them have difficulties understanding the lecture. 35% of the students agreed that it was hard for them to concentrate in the online class compared to f2f teaching. Due to their inability to attend the laboratory, 35% of the students reported having problems gaining knowledge and laboratory skills.
(B. Shahrvini et al., 2021)	The goal of this study was to analyse pre-clinical medical students' perspectives of remote learning, as	Cross-sectional study	N =268 Undergraduate medical students from the University of	Online medical education	Data collection: Online survey was distributed to all the participants, and it was conducted via an online software platform – Qualtrics/Provo/UT.	The results show most of the students 64.4% feel like the online learning give flexibility, 18% of the students feel like online learning can cause digital fatigue which leads to exhaustion, cannot focus and also disengagement, 16.7% agreed that they ore problem with PBL learning and 50.8% feel problems in obtaining

	well as to identify the benefits and drawbacks of remote learning, as well as to identify gaps that need to be addressed in future curricular development.		California San Diego		Outcome: perception	clinical skills (lacking clinical skills lead them to become unprepared for any clinical assessment). Lastly,16.7% reported a feeling of loneliness and isolation in their mental health, which led to their hard focus on their academic.
(Yoo et al., 2021b)	The objective of the questionnaire was to learn about: 1) student' chosen learning techniques between virtual and head classes; 2) the reasons for students' chosen learning style; and 3) the impact of online classes on learning.	Online survey	N = 108 (2020) N = 104 (2019) Undergraduate medical students from Korea University College of Medicine (KUCM)	Online medical education - anatomy	Data collection: Online questionnaire was distributed to all the participants to access the objectives mentioned. Outcome: perceptions and satisfaction	The results show the majority of the students, 78.6%, preferred online learning compared to f2f learning 21.2%. They agreed that online learning could save more time, 89.5%, and use that free time to self-study 75%. The students' few benefits, which includes they can repeatedly watch the recorded video 76.3% and more available time 60.5%. There are also problems arise during online learning application 61.9% reported having a problem with their internet, and 50% reported having problems with the interaction between students and lecturer.
(Kumar et al., 2020)	During the COVID-19 pandemic, the goal of this article was to share the key aspects of evaluation using staff and student input on curricular adjustments implemented through digital transformation in a medical school in the Arabian Gulf.	Cross-sectional study via Online survey	Undergraduate medical students from Medical School in Arabian	Online medical education	Data collection: The feedback from the students is taken after getting the informed consent by using a validated questionnaire. Outcome: perception	The results show that 96% of the students agreed that the communication online was very clear, 85% feel they can maintain the online interactivity, and 92% of the students interested to continue with the online learning application even though after the pandemic. 74% of the students agreed that all the software use in online learning is very user friendly and very easy to use, 77% believed that the online platform used was very appropriate which consist of good video which helps them a lot in this pandemic, 77% is happy on technical support provided during online. Overall, 71% did agree that the application of online learning was very helpful and enjoyable. There are also few problems mentioned by students, which include limited interaction and clinical training problems.

(Bączek et al., 2021a)	The purpose of this study was to find out how medical students felt about this form of learning.	Cross-sectional study	N = 804 Undergraduate medical students from Polish	Online medical education	Data collection: The online questionnaire was distributed to all the students after eight weeks of using online learning via social media. Likert-scale is used. Outcome: perceptions and satisfaction	The results show students perception towards online learning, 69% of the students they like online learning application due to ability to stay at home, 69% agreed that they have continuous access to online learning material and 64% agreed that online learning provides the opportunity to self-study. The major problems that arise mentioned by students 54% reported having a problem with the technological equipment, and 70% believed that there is less interaction between medical students and patients. The results also show that online learning application was not that effectively compares to f2f learning in term of increasing knowledge ($P < .001$) and also social competencies ($P < .001$). Students also mentioned that they are having problems keeping themselves active during online class compared to f2f learning. Overall, 73% of students enjoyed online learning, while 27% did not enjoy the online learning application.
(Dutta et al., 2021a)	To determine the level of satisfaction among undergraduate medical and nursing students in India with regard to remote preclinical and clinical teaching during COVID-19.	Cross-sectional study	N = 1068 Undergraduate medical and nursing students across India	Online medical and nursing education	Data collection: The questionnaire has been administered via emails and also messaging to all the participants. Outcome: satisfaction	The results show that 37.76% of the students were very satisfied with online learning, while 42% did not feel satisfied with the online learning application. The overall satisfaction of 1st, 2nd, 3rd and 4th-year students was compared, and the results show the first-year students show a higher dissatisfaction rate compared to another year ($p = 0.005$). There is also negative feedback from students mentioned by students, which is associated with interaction and focus, practical learning, technologies, and learning content.
(Suppan et al., 2021)	We wanted to see if an e-learning module, compared to a typical didactic	RCT	N = 158 Undergraduate medical students	Online medical education	Data collection: Online learning module has been done, and the data was collected and will be	The results show that the students who participated in the online learning module (38 correct answers) performed very well compared to traditional (35 correct answers). 40% of students are also very

	film, could increase asynchronous distance knowledge acquisition in senior medical students.		University of Geneva Faculty of Medicine		compared with the control, which is a traditional didactic video. Outcome: learning outcome and satisfaction	satisfied with the online learning module compared to 15% of traditional didactic videos. There are no significant differences that we can see in searching for any difficulties, but the student, 84%, agreed that the online learning module is very easy to use compared to 53% of the traditional didactic video. 66% of the students believed that they would recommend this type of learning to another colleague.
(Liu et al., 2021)	During the COVID-19 pandemic, this project sought to investigate a new teaching approach for Histology, Embryology, and Pathology courses, as well as demonstrate its practicality and acceptance.	Cross-sectional study	N = 512 Undergraduate medical students from Shandong First Medical University	Online medical education	Data collection: The online questionnaire was created and was distributed to all the students. Outcome: satisfaction	The results show that 71.3% and 82.5% of the Histology and Embryology and Pathology course students are very satisfied with the new teaching method. About 18.4% of students from the Histology and Embryology course and 23.3% of Pathology students rated that web-based course is better than a usual traditional class. Then, 82.4% and 84.1% of students from Histology and Embryology and Pathology score above 60% in their course. Only 37% want to return to traditional teaching from Pathology course while 52.1% from Histology and Embryology. 50.4% of the students from pathology preferred online teaching while 56.4% from Histology and Embryology.
(Tuma et al., 2021b)	The problems and outcomes of a recently adopted online education curriculum are investigated in this study in order to share findings and make recommendations.	Cross-sectional study	N = 636 Undergraduate medical students from Wasit University College of Medicine in Iraq	Online medical education	Data collection: The online questionnaire was created, and it was distributed to all the participants via email and the data collected anonymously. Outcome: perception	The results show that 67% of the students feel like online learning is very difficult to use compared to online learning. Even though there are many difficulties, 27% still report that online learning meets their expectation, while 67% reported not interested and having fatigue while participating in online learning. About 33% of the students feel like online learning is almost the same or more superior compared to f2f. Students have few challenges: a poor internet connection, unfamiliar with the online learning platform, and audio-visual media quality.

(Langegård et al., 2021)	The goal of this study was to describe and evaluate nursing students' experiences transitioning from traditional campus-based learning to remote learning utilising digital resources.	Cross-sectional study (quantitative) and qualitative study	N = 132 Undergraduate nursing students from Gothenburg University	Online nursing education	Data collection: The online questionnaire was constructed, and then it was distributed to all the participants. Outcome: perception	The results show, 2/3 students did prefer f2f teaching compared to online and the most rated type of learning is pre-recorded lecture, while self-study rated the lowest. 18% of the students reported having technical difficulties to continue online learning. 2/3 students also reported having a problem with communication between students and instructors, leading to deterioration in learning. The student also reported online learning impacts their motivation in learning. This might be due to the students feeling like the interaction during f2f teaching with the classmates can boost their motivation. More than 50% did report having a problem with their study discipline (hard for them to track everything, especially when you are at home). Lastly, most of the students agreed that online teaching helps them improve responsibility since all the assignments required their own effort.
(Elsalem et al., 2021b)	To assess students' experiences with distant E-exam preferences and academic dishonesty during the pandemic.	Cross-sectional study	N = 730 Undergraduate students from Jordan University of Science and Technology	Online medical sciences education	Data collection: After the final exam, the online questionnaire was prepared via google form and then it was distributed to all the participants. Outcome: perception	The results show that 68.22% of the students preferred the f2f exam, and only 1/3 did the preferred online exam. 49.86% agreed that more hard work and time required in preparation for online exam compared to f2f teaching. Most of the students, 40.95%, preferred the online exam compared to the f2f exam, while 57.03% preferred the f2f exam because they said that more time was required to prepare for an online exam. The students also reported that the question asked during online learning is not appropriate for student study material. The results also show the students' GPA, which 30.41% has a higher GPA, 36.71% no GPA change, while 32.88% reported lower GPA scores during the online exam. Overall, about 62.33% of the students reported they did not achieve their objectives in their study.

(Jaap et al., 2021a)	To see how remote online exam delivery affects students' experience and performance.	Cross-sectional study - Online survey	N = 447 Undergraduate medical students from UK medical school	Online medical education	Data collection: The online questionnaire about the online exam was conducted online, and also the exam results obtained will be compared with campus-based teaching. Outcome: perception and learning outcome	The results show students' perception towards the online exam, 18.5% of students having problems finding a good environment to sit for their exam, and 84% of the students having a very good internet connection. Regarding anxiety results, about 51.3% reported feeling anxious before the exam because they were afraid about their internet connection issues. Overall, most of the student preferred the traditional approach exam, which is at the computer lab at the faculty. Regarding exam performance, it can be seen that Year 4 students performed better during the online exam 76.53% [SD 6.57] compared to traditional exam 72.81% [6.64], while for Year 5, the students' performance 76.02% [8.41] is almost the same to traditional exam 77.25 [9.43].
(Schoenfeld-Tacher & Dorman, 2021a)	In Spring 2020, students in a pre-planned online second-year veterinary toxicology course at North Carolina State University were polled about their viewpoints and academic achievement.	Online survey	N = 103 Undergraduate medical veterinary students from North Carolina State University	Online veterinary education	Data collection: The online survey was created via a web-based survey (Qualtrics), and it will then be distributed to all students via email. Outcome: Learning outcome, perception	The results show students academic performance online compared to f2f learning; overall, students scored higher in diagnostic toxicology quiz online (2020) compared to f2f learning (2019). According to the survey, only 87.6% of students have experience with online courses, and at the end of the course, the students agreed that the online class performs 52.6% almost the same, and 15.8% think it is better. Students' few benefits, which include online learning, increase their motivation and flexibility of time and place. Students also stated few challenges that include a problem with internet connectivity and lack of instructor-student interaction.
(Guiter et al., 2021)	To evaluate the implementation of a new curriculum at Weill Cornell Medicine-Qatar.	Online survey	N = 29 Undergraduate Medical students from Weill Cornell Medicine-Qatar	Online medical education	Data collection: After the elective program was done, the survey was distributed to all the participants. Likert scale is used.	The results show students' perception of online learning; the students feel like the online learning application provides an easier ability to communicate, which leads them to engage more easily than online. The environment at home is more relaxing and saves time. There only problems stated by students regarding this elective is internet connectivity problems.

					Outcome: perception	Overall, the results obtained show the student satisfied with the elective organised with only a small problem arise.
(Gupta et al., 2021)	The goal of this study was to gather faculty and student perspectives on e-learning at medical colleges during COVID-19, as well as to analyse the likely perceived benefits and challenges of choosing blended learning activities after the COVID crisis.	Cross-sectional study	N = 248 Undergraduate medical students from the Delhi-NCR region	Online medical education	Data collection: The online survey was created via a google form, and it was distributed to all the participants. Likert scale is used. Outcome: perception and satisfaction	The results show that about 88.3% students agreed that online learning application is very useful during this situation. The students also stated that there is enough interaction between students and instructors 43.5%, 29.8% was neutral, and 27.8% felt insufficient. 35.4% of students preferred online learning while 43.1% are more into traditional teaching, and 21.4% remained neutral. 41.2% of students agreed that online learning could provide flexibility in time and place, which increases their understanding and good presentation. It is also one factor that can boost their understanding of 42.7%. Few challenges associated with online learning include 35.9% internet connectivity problem, 29.8% reduce interaction, 27.1% problem with the sound and lack of clinical skills.
(Co et al., 2021)	The surgical skills competency of medical students trained by the WSSL is assessed in this case-control research.	Case–control study	N = 62 Undergraduate medical students in Hong Kong university	Online medical education – Web-based surgical skill learning session (WSSL)	Data collection: The case-control study was compared to the WSSL method. Then, the independent blinded assessment was done to compare those two. Outcome: learning outcome, perception	The results show, 33 students are in the control group while 29 students in the case groups. Overall, the result concludes that students are able to do a proper surgical knot via instrumental tie. The mean score obtained for the control groups was 4.8 out of 5, while for case groups were 4.7 out of 5. Obstacles stated includes: - Lack face to face interaction - Internet connectivity - Different time zone (overseas students) Benefits reported includes: - Can demonstrate the skill easily - Affordable

(Tigaa & Sonawane, 2020)	To get a better understanding of student learning and engagement in two similar-sized schools in Dhule, India, and St. Cloud, Minnesota.	Cross-sectional study – online survey	N = 150 (46-St. cloud, 104-Dhule) Undergraduate students who are taking chemistry courses at St. Cloud USA and College in Dhule in India	Online education – chemistry courses	Data collection: The online survey was created, and it was distributed to all the participants. Outcome: perception and satisfaction	The results show that up to 60% of the students from both universities are affected by this pandemic. According to the survey, about 49% and 19% of Dhule students did mention having problems with internet connectivity and also a financial problem, while 63% and 11% from St. Cloud. Then they also reported on not having enough electric supply to continue online learning 15% from Dhule and 57% from St. Cloud. Overall, only 24% from Dhule and 15% from St. Cloud that satisfied with the online learning application, while most of them, 36% from Dhule and 22% from St. Cloud, only partially agree with the online learning practices.
(Ibrahim et al., 2021)	During the Covid-19 closure period in Jeddah, the study's goal was to examine medical students' acceptance and perceptions of e-learning.	Cross-sectional study	N = 340 Undergraduate medical students from King Abdul Aziz University	Online medical education	Data collection: Online form was created via a google form, and it was distributed to all the participants via email and WhatsApp. Likert scale is used. Outcome: perception	The results show, 59.7% agreed that online learning could replace face to face learning. The students, 59.2%, also feel like online learning was less time consuming compared to f2f teaching. 74.6% of students agreed that interaction during online class was present between instructors and students. Next, 54.1% of students were agreed with the online learning application can make them motivated. Regarding the problems includes 84.2% agreed online learning would affect the clinical skill. 72.1% of students also agreed that their exam could be affected due to internet connectivity problems. Then, 57% agreed that there are limited resources, and 32.2% agreed they have a technology training problem.
(Khan et al., 2021)	To discuss our experience with building and executing a framework for quickly transitioning practical lab instruction of pre-	Mixed method study	N = 103 Undergraduate medical students from North India	Online medical education - Demonstrate-Engage-Assess framework for Practical online	Data collection: The online questionnaire was created to receive feedback from the participants via google forms. Outcome: satisfaction and perception	The results show, majority of the students, 62%-80%, shows satisfaction toward online learning practices. The students reported that the online learning application was very enjoyable, engaging, and motivating them to learn while the disadvantageous was lacking practical skill classes, technical issues such as internet connectivity, lacking interaction, and hard to learn how to adapt to the new online stuff.

	clinical subjects to an online format.			teaching of Pre-clinical subjects (DEAPP)		
(Menon et al., 2021)	To learn what undergraduate medical students think about the institution's online teaching-learning platform.	Questionnaire survey	N = 370 Undergraduate medical students from college hospital in South India	Online medical education	Data collection: Online questionnaire was created via a google form, and it will then be distributed to all the participants. Outcome: satisfaction and perception	The results show that most of the students satisfied with the online learning application (31% scored high satisfaction, 53.6% scored moderate satisfaction), while only 15.4% were not satisfied. About 49.8% of students did not satisfy by attending the class online, while 15.7% think it is better. The barriers of online learning reported by students were connectivity problems, 44.8% and lack of peer interaction since clinical classes cannot be replaced with online classes.
(Sindiani et al., 2020a)	This research looked at the classroom experience, student-lecturer interaction, and the benefits and drawbacks of online learning.	Cross-sectional study	N = 3700 An undergraduate medical student from Jordan university	Online medical education	Data collection: Online survey was created via a google form, and it was distributed to all the participants. Outcome: perception and satisfaction	The results show that 48.7% of the students feel less interaction between the instructors than traditional teaching. Students' benefits include saving money and energy in terms of transportation 48.7% and reducing social contact reduce spreading of the virus 58.3%. The barriers include no interaction between lecturers 45.6%, technical problem 57.7%, no clinical practices 43.9% and distraction at home 36.4%. Overall, about 75% of the students were not satisfied with the online learning application and did not wish to use it even in the future.
(Zhang et al., 2020b)	The purpose of this study was to find out how MBBS overseas students felt about taking an online TCM course and to evaluate the effectiveness of online learning.	Online questionnaire -	N = 48 Undergraduate medical students from Zhejiang University	Online medical education	Data collection: The online questionnaire was distributed to all students before the live broadcast class and after the broadcast class via WeChat groups. Liker scale was used. Outcome: satisfaction	The results show that most of the students, 54.17% preferred f2f teaching compared to the online application. Students felt that online learning could provide many advantages (mean 3.83 and SD 0.95), but still, they do not think it can replace traditional learning (mean 3.87 and SD 0.94). The student knowledge on TCM and also behaviours to learn more about TCM also improved via online learning TCM with $P < 0.001$. Lack of clinical practices and lacking of interaction are the major problems that have been reported.

Suliman et al., 2021	To learn more about undergraduate nursing students' initial experiences with OL, and to gain a better grasp of the opportunities and obstacles they faced.	Qualitative study	N = 18 Undergraduate nursing students from 2 universities at Jordan	Online nursing education	Data collection: An interview based on an extensive literature review was created, and the students were invited to participate via the school website. Outcome: perception	The results show that students show several emotions towards online learning; some expressed fear and worries regarding their education. The students also did report not having good skills, especially with the most important technology in implementing online learning. There is more time required for them to adapt to online technology and how to manage their time well. Financial burdens also have been reported by students who have a problem with internet issues. Distraction at home is also one of the major problems students reported and lack of interaction between teachers and students. Lack of clinical skills also has been mentioned by the students. Students' few benefits include watching the recorded lecture as many times as they want, spending more time with their families, saving time, and getting more relaxed.
(Atli et al., 2020)	To assess the effectiveness of an interactive VR platform as a key teaching aid for neuroanatomy and neurosurgical operations in a year-long neurosurgery elective course.	Prospective survey	N = 12 Undergraduate medical students at University Hospitals Cleveland Medical Center in Cleveland, Ohio, USA	Online medical education – Virtual reality in Neurosurgical Course	Data collection: The pre and post-survey was emailed to all the participants. Pre survey administered on the first day of the course, and the post-survey administered at the end of the course. Outcome: learning outcome (skills)	The results show that most of the students 100% reported increased confidence in analysing patients' cases and interpreting lab results. 50% of students also agreed that VR helps them understand according to neuroanatomy and neurosurgery, and 66% agreed that VR helps them retain surgical skills throughout this course. 100% of the students agreed that the VR application was a very valuable learning experience.
(Elsalem et al., 2020b)	To assess Medical Sciences students in Jordan's experience with remote E-exams during the	Cross-sectional study	N = 1019 Undergraduate medical sciences students from Jordan University of	Online medical Science education	Data collection: The online survey was created via google forms, and it was distributed to all the participants	The results show that the majority of the students 91% that online exam is most stressful when compared to f2f teaching while 23.55% against the statement. The major problems stated by students include technical problems and also internet connectivity problem, which led to stress >60%. Online learning exam also led to

	COVID-19 pandemic.		Sciences and Technology		through their learning account. Outcome: perception	behavioral changes in students, including changes in dietary habits, sleep cycle, and reduction of physical activity.

Table 1: Details of 64 included studies