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Online chemical engineering education during COVID-19 pandemic: Lessons learned from Pakistan

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ABSTRACT

The development of Covid-19 epidemic into a pandemic led to great changes in education delivery modes around the globe. Online education (OE) began after the closure of education buildings. The unprepared start of OE led to access barriers, challenges, and opportunities for improvement. This work explores the scope of OE during COVID-19 in Pakistani institutions offering the degree of Chemical Engineering. A mixed-method approach was followed with a sample of 10 teachers and 1200 students from public and private sector universities. Teacher data came from semi-structured interviews by email, while students’ views of their learning experiences were collected through an online survey. The learners’ responses showed that the unprecedented and unprepared shift to online course delivery lowered their motivation and interest in learning and they do not perceive the present practice as useful for several reasons. However, the teachers believed that the transition to OE helped the continuity of education, though they had to face technical, personal, social, learning-management-related, and other barriers they were not adequately equipped to deal with effectively. The results imply the need for a rapid preparation phase to enhance the effectiveness of OE during a crisis. The results may assist academics and policymakers in revising decisions regarding the great education migration to OE.

1. Introduction

Within weeks of its outbreak in Wuhan, China, in December 2019, Covid-19 swept across the world causing an unprecedented impact on almost all aspects of human life. By the second week of April, 2020, Covid-19 infection rates rose in most areas of the world, particularly in America, Europe, Africa and South Asia, with 129,000 mortalities overall (Dadax, 2021). Covid-19 disease spread linearly from January to April 2020 and exponentially from May to November 2021 with 269.65 million confirmed cases. Covid-19 variants, including currently the 5th variant (OMICRON), still posed a serious threat to the continuity of education. To contain the spread of the highly infectious virus through non-pharmaceutical interventions, most affected countries have enforced lockdowns or partial curfews and closure of educational campuses, which affected the continuity of education of millions of tertiary education students across the world. However, the degree of education disruption caused by the pandemic varies across countries and regions, depending upon their level of development, and their comfort and training in the use of technology in their education systems.

The transition to online education always depends on the availability and training of high-speed, sophisticated Information and Computer Technologies (ICTs). Though Pakistan is rich in natural resources, it lags far behind in technological and energy resources (Butt, Dilshad, Abas, Rauf, & Saleem, 2021). The transition to the online mode of education without adequate training, together with cultural issues and several others reasons has made OE delivery very difficult during the full and partial closure of academic institutions from March 2020 to September 2021, keeping in view the virus trajectory and its variants (HED, 2021). The Higher Education Commission of Pakistan (HEC) urged universities across the country to resume their educational operations through Learning Management Systems (LMS) along with other internet resources, like Zoom, Microsoft Teams and Google Meet. The Pakistan Engineering Council (PEC), the regulatory body of engineering education in Pakistan, drew up policy guidelines for online education and suggested online education for the cognitive domain and, that simulations might be conducted through e-labs for psychomotor learning. Where lab education could not be conducted online, students were asked to attend physical labs when their institutes reopened (PEC, 2020). Some universities restarted their educational activities by transiting to online delivery very quickly, while others took 5–6 months. A sudden forced transition in education mode could prove to have unforeseen long-term implications for the future of online higher education in
Pandemic Impact on Education

| Black Plague | Small Pox | Spanish Flu | Tuberculosis | SARS | COVID-19 |
|--------------|-----------|-------------|--------------|------|---------|
| Rise in medical education | Awareness of disease / Immunization | Distance Education | Open Air Schools | Classroom on the air | Transition to Virtual Education |
| 1347 | 1796 | 1918 | 1908 | 2002-2004 | 2020 |

Fig. 1. Major pandemics influence on the emergence of new education systems.

1.1. Pandemics and Online Education

Technology driven learning can be classified as blended, online, hybrid, e-learning, digital learning and/or distance-learning/teaching based on the level of dependence on technology. With the exception of a few disciplines like engineering, where material labs and workshops are required, developments in web and internet technologies have proved transformative for education provision. Recognizing the exponential growth in the transition from the traditional education systems to online delivery over the last two decades, increasing numbers of studies have explored this new mode of education from different perspectives. A critical review by Kinash, Knight, and McLean (2015) showed how online content can develop constructive learning. Online education can also stimulate learner engagement through promoting self-efficacy (Chyr, Shen, Chiang, Lin, & Tsia, 2017). Research has also revealed that prior experience of online gaming reduces learner anxiety about failure (Yang & Quadir, 2018).

Several infectious diseases have altered the course of human history. A review of pandemics reveals that some aspects of education have been shaped and modified from earlier pandemics as illustrated in Fig. 1. Leprosy influenced religious education as it was considered the visible manifestation of sin and separate church services started for lepers (Spielman & Sunavala-Dossabhow, 2021). The Black Plague and Smallpox led to the opening of medical schools in the most affected countries. Tuberculosis introduced social distancing in 1908 in open air schools (Korr, 2016). In 1918, the Spanish Flu triggered the rise in distance education by mail (Florida National University, 2019). Severe Acute Respiratory Syndrome (SARS) which struck many countries in 2002–2004, caused the closure of many education institutions and to fill the void, China Educational TV, through ‘Classroom on the Air’, attempted to provide a short-term alternative to continue the education of those confined to their homes. The outbreak of Ebola in 2014–2016 in West Africa resulted in months of school closure (e.g. in Sierra Leone for 8 months). These countries’ education systems were not technologically able to support education, hence, the pandemic wreaked havoc for young boys and girls (Farmer, 2014). The government of Sierra Leone, with the help of international donors, launched an educational radio program which was not successful (Powers & Azzi-Huck, 2016). Then, Covid-19 catapulted virtual education as a target worldwide.

A review of previous pandemics and educational transitions reveals that countries with adequate technology capacity were able to deal with disease outbreaks that disrupted the normal modes of education delivery. Chemical Engineering education is dynamically changing to adopt new tools and innovative techniques to address the latest challenges (Glassey, 2019). Practical skills learning, an aspect of chemical engineering education, has become challenging with limited physical delivery. Glassey and Magalhães (2020) suggested using virtual lab experiments to address this challenge. Though virtual labs cannot replace learners’ physical interaction with equipment, he argues that virtual experiments could provide students with an opportunity to become familiar with the equipment and procedures. Kumar et al. (2021) also suggested the benefits of incorporating virtual reality-based training and education for chemical engineering students instead of simulation-based models where students cannot experience unexpected and hazardous scenarios. Martin-Somer, Moreira, and Casado (2021) experimented with another tool. Their survey of chemical engineering students on a theoretical course had revealed a decrease in student motivation due to the transition from face-to-face to remote learning. However, when ‘Kahoot! Platform’ and ‘Kahoot! Games’ were employed, greater participation and better results in some topics reduced earlier concerns about student interests and motivation. Students also found Kahoot! useful and suggested using it for other subjects as well. Lapitan, Tiangco, Sumaling, Sabarillo, and Diaz (2021) investigated the effectiveness of a blended learning strategy for teaching chemical engineering students enrolled in a chemistry course in the Philippines. The ‘discover, learn, practice, collaborate and assess’ (DLPCA) strategy was employed in online learning and students’ responses gathered at the end of term by survey. The results showed that students were positive about this learning strategy. Another study in Spain by Ripoll, Godino-Ojer, and Calzada, (2021) investigated undergraduate students of Biotechnology’s adaptation to technology. They were enrolled in a biochemical Engineering course during the Covid-19 outbreak. Their response to the course was assessed through a mixed method- student survey, observation, and their performance in mid-term exams. The results showed that more students passed the online course exams than the conventional exams. It was also concluded that this new methodology could help expand the competencies of learners easily. However, students complained about lack of time for conceptual questions and difficulty in submitting video-recorded assignment.

Other research also uncovered several challenges to successful online education. Lapitan et al. (2021) highlighted that stable internet connections and instructor’s familiarity with teaching tools and software were major challenges. The researchers also pointed out that countries with fewer technical resources must consider the socio-technical challenges when designing course content and delivery, while Ghassem and Ghanam (2021) found that technical obstacles like the availability of devices and internet connectivity were not significant problems for students in technologically advanced countries. The researchers surveyed students of chemical engineering in UAE and found concentration during the online sessions with limited student-instructor interactions was difficult, and technical discussions with advisor online were challenging, particularly for student projects.

Developing countries, like Pakistan, lag far behind in transforming their educational structures to bring them into line with e-learning. The educational system has been badly disrupted by Covid-19 in Pakistan with schools, colleges and universities left stranded. Like other disciplines, engineering teaching and learning has also been interrupted. The Pakistan Engineering Council (PEC) is the regulatory body of engineering education in the country, a signatory to the Washington Accord since 2017. Chemical Engineering education is delivered in 23 institutions across the country with level I and II accreditation status, as shown in Fig. 2. Of them, Punjab University is the oldest institution, having offered 2-year courses from 1917, which were subsequently replaced by a three-year-degree in 1925.

Universities in Pakistan within the PEC system envisaged policies to shift to online education, but at the start of the pandemic, chemical
engineering education institutions had little preparation. This has raised several critical concerns about how this sudden, forced and unplanned education transition to online has influenced teachers’ and students’ views and adoption of online learning for engineering education. By exploring and analysing the current online experiences of teachers and learners in chemical engineering department during the Covid-19 pandemic, this study suggests the possible future of online education in the field of the chemical engineering.

1.2. Research Questions

1. How do Pakistani university chemical engineering teachers view the emergency transition of learning mode during the Covid-19 pandemic?
2. How far do teachers perceive the present shift as boon or bane for chemical engineering education?
3. What are students’ perceptions of their online learning experience during Covid-19 pandemic?

2. Methodology

2.1. Process

A pragmatic, research-question driven, mixed-methods approach was followed to gather teachers’ and students’ perceptions and experiences of the recent shift to online learning as instructors and students are two important stakeholders of any instructional process, and may have different attitudes to online learning. The data were triangulated to offer a more comprehensive understanding, as suggested by Creswell (2014). An initial review of all Pakistani Higher Educational Institutes (HEIs) offering Chemical Engineering revealed that less than 50% of public and private HEIs made the transition from traditional teaching to online education, as shown in Fig. 1. Despite growing numbers of Covid-19 cases in all provinces, most universities showed no interest in adopting the change suggested by the country’s foremost Higher Education Commission.

Therefore, the sample was limited to 10, with an equal number of public and private universities to examine views and experience of the transition to the online delivery of education. The distribution of universities is as follows: 5 Public (1 from each province and 1 from federal territory), 5 private (3 from Punjab, 2 from Sindh, according to available data). Teachers’ opinions were collected through semi-structured interviews from 10 volunteer faculty members from the participating universities. Interviews took place by email once consent had been given. Initials were used as pseudonyms to preserve the participants’ privacy (AP, FL, MB, FA, SS, SZ, RU, SB, AS, and HN). Students’ responses were gathered from the same universities through an online administered survey. Using purposive sampling, 1200 student participants were selected and contacted, and 1144 agreed to participate, an ample response rate of 95.3%.

2.2. Instruments

Research questions 1 and 2 as related to teachers were addressed through interview questions which were formulated and administered via email. Interview items included questions about teachers’ perceptions of the engineering transition to online education, the effectiveness of online education delivery, and problems teachers faced in the new environment. Thematic analysis was applied to the teacher participants’ responses (Creswell, 2014). Thorough reading and re-reading of responses helped to break down the interview text into codes, which were further collated to identify major themes.

For the students, an online survey was developed to collect their responses concerning their Covid-19 driven OE experiences in response to research question 3, as stated in Section 1.2 above. The quantitative questionnaire consisted of 4 sections. The first section dealt with demographic information and the other sections were based on four concerns related to OE experiences: learner attitudes, advantages and disadvantages of online distance education, class management (student engagement and teacher-student interaction), and availability of resources. The questionnaire had 17 items with two types of questions on the Likert scale: 15 items were yes/no, and 2 were multiple-choice questions (MCQs). The confidentiality of the collected data was maintained. Students’ responses were analysed using descriptive statistics. Quantitative parametric data were presented in percentages.

3. Results

3.1. Lack of coherence between universities

The data collection process also revealed a few facts; for instance, the Higher education Commission of Pakistan (HEC) had envisioned that universities would plan and start online classes. However, there was a lack of synchronization between and among the universities about...
finding alternative ways to continue the education process. The number of universities offering online access is quite low, as many of the HEIs are reluctant to adopt new modes of education. Furthermore, the HEIs offering OE were only partially functional, with much confusion about semester length, evaluation, and assessment methods, and adoption of the Learning Management System. The inconsistency in the academic calendar of HEI’s is another key issue highlighted during the transition to OE.

The answers to the demographic question showed that of 1144 respondents, 67% were male, and 33% were female students, as shown in Fig. 3. Higher education is recognized as capital investment for the social and economic development of any country. The ratio of male and female students in the chemical engineering program was found to be 74:26 in the public sector, and 58:42 in the private, showing that male students outnumber female students in both public and private sector institutes, which supports the observation that certain domains tend to be stereotyped on a gender basis (Yasmin, Naseem, & Raza, 2018).

The analysis of the data gathered from teachers and students identified 4 major themes: the impact of transition in education mode on academia, availability of resources, advantages and disadvantages of OE, barriers (personal, technical, social, institutional, learning management). The responses of both sets of stakeholders- teacher and student - were analysed and interpreted separately.

3.2. Teachers’ Experiences

From 28 February 2020, all Pakistani teachers found themselves as education front-line workers. When they were asked about the impact of the Covid-19 driven education transition on their teaching routine, they articulated it as a sudden paradigm shift aiming to help continue their activities, but also demanding a new set of skills. New skills build confidence once users have mastered them, and they foster autonomy in teachers, and learners alike, and accelerates the technology-enabled teaching/learning shift.

3.2.1. Effectiveness of Technology-enabled Learning

The present shift in learning mechanisms occurred because of the unexpected and emergency changes imposed by an unprecedented and abnormal situation; most teachers accepted the situation as a challenge. All the participants appreciated that education had been nudged into the transition, as participant SB put it, “the teacher and the learner alike have been accustomed to traditional, face-to-face classroom interactions, rather than online virtual interactions. The situation they’re in right now is not one in which they’re in willingly, after a properly planned strategy. Instead, they’ve been just pushed into that to adapt to it”. The context of Covid-19 meant that distance learning was the only choice, if educational institutes and students were to sustain their academic activities, “to keep them in touch with the courses and subjects’ (SZ) and ‘to save student’s time’ (FA).

Many teachers were very excited about participating in synchronous online teaching after becoming familiar with various online tools; it clearly takes a lot of work to adjust course design to suit the new context and a lot of time was spent exploring online technology. Some participants termed the transition as learning exposure to new skills. SZ believed that the new mode of learning ultimately benefit as, ‘for teachers, it may be a good chance to learn from this online-classes/sessions and afterward create their own online videos for the course and upload to some course website like Coursera, Edx, Udacity, etc. for their exposure and even for financial benefits’. Participant FA, referring to learners, said:

…as they are home, they can convert this time to quality time by getting confident about online learning. Usually, teachers think that they have sufficient knowledge and lack of time means creating more courses is not viable. The sense of responsibility developed during this transitional emergency period is driving/ pushing us to enter a new era… For students, it may be a good exercise in self-learning and searching websites helps them believe in their own capabilities.

It is interesting to note that the teachers, who were found to be highly responsible, put enormous efforts into making the unfamiliar easier. Most of the participants emphasized that the transition boosted their confidence in technology-enabled learning. Participant FA pointed out teachers “have taken an involuntary jump caused by (Covid-19 shock). Personally, it put a pressure on me to learn how to make slides for online lectures for students. So, I think it will boost confidence in Technology-enabled learning”. They also believed that the sudden shift not only geared up the teachers but could promote autonomy and self-sufficiency in both teachers and learners as it would help them learn independently, as research has shown (Yap & Tan, 2022; Yasmin & Sohail, 2017; Yasmin, Naseem, & Abas, 2020; Yasmin & Sohail, 2018). Participant AS stated that it “could bring revolutionary change to make teachers and students more efficient in the teaching-learning process. It would give students a chance to think more productively and depend more on themselves in learning by doing things in their own ways”.

It was also observed by some teachers that the shift to OE was not well received at first; however, teachers and students were found to be adapting to the new scenario, as SB stated, suggesting optimism for the future:

However, I also feel that teachers and learners are gradually adjusting themselves and their experiences are getting better. If this improvement is happening in such conditions where there is an extreme dearth of the required facilities, resources, and training, then it can be said that the current experiences are going to expand the space and opportunities for the acceptance of online education in the future.

Another participant, RU, observed that initially the process appeared “to be artificial and it was felt it was simply to cover the loss of a semester of physical attendance, but once it started practically, I didn’t feel much difference in the teaching”. However, on the students’ side, adjustment over time was only observed in an active student and she had a concern about the shy students being left behind.

Similarly, the present mode shift has accelerated the advance that was expected to happen over a much longer period, as one teacher said, “I, personally was not ready to teach online classes, but, I think, the university’s immediate response was to move us from a period of gradual progress to the advanced state that we [would have] had to meet in many years” (FA). Covid-19 proved to be a crisis-cum-opportunity. An unprecedented natural experiment offered educators a great opportunity to
collect evidence and address important questions that have not been answered or often, even asked before. This has been recognized worldwide. Blumenstyk (2020) feels that the ‘black swan’ is upon us as she views the pandemic as “more of a catalyst for online education and other ed-tech tools than decades of expertise-gathering along with self-serving corporate exhortations.”.

3.2.2. OE Related Barriers

Though institutions, teachers, and students are trying hard to adjust to the abrupt closure of physical facilities and the resulting dependence on OE, technical, pedagogical and resource unpreparedness blur the future prospects and potential of e-learning. An analysis of participants’ data revealed major possible impediments; personal, learning management-related, technical, social, and institutional, as illustrated in Table 1.

3.2.2.1. Personal Barriers. The major personal barriers all the participants faced was their lack of background knowledge and experience in OE. Secondly, the teachers do not have the relevant pedagogical skills for the new medium. According to FA, despite her energy and efforts to learn and adjust, she needed “help at certain stages which, the university did not provide” and she had to find and manage using outer resources. Such an unprepared and hasty transition can damage the effectiveness of OE as SB pointed out:

The situation they’ve been in right now is not one they’ve entered willingly with a proper, planned strategy. Instead, they’ve been just pushed into it, to adapt to it without any technical training, proper lesson planning, pedagogical training, technological facilities and many other relevant things. So, definitely, this is impinging upon the effectiveness on the online classes.

The teachers’ current teaching and learning experience cannot be said to be very positive for reasons ranging from unavailability of infrastructure to lack of training, interest, and ability to adopt the new technology. This is why the current unplanned and hasty transition to online education may seem a negative experience to the many, rather than the new and interesting experience it was to the few. Faculty members aged over 50 were observed to resist the transition not because of their years of experience of and preference for face-to-face traditional teaching in brick-and-mortar buildings, but for their being resistant to modify their methods or learn new pedagogies. Recent research also supports this finding. Englund, Olofsson, and Price (2017) found that teachers who were novices in the use of educational technology exhibited a greater readiness to acclimatise to change than their more experienced colleagues. The present study results are in line with recent research by Lapitan, Tiantco, Sumalinog, Sabarillo, and Díaz (2021) who found instructors’ lack of familiarity with teaching tools and software to be a major challenge.

More damaging was the mental stress many teachers underwent trying to steer the OE wheel without any technology education experience. Many teachers shared their emotional, physical and mental state during the first month of this endeavour. Preparation and delivery of online lectures was taking them approximately twice the time needed for their traditional class. This stress was found heightened in private-sector faculty members, AS explained:

I felt abnormally bio-mentally stretched due to the heightened health concerns for my family and continuity of my job as an employee of a private organization. Having no training to teach online, feeling the threat of a looming financial crisis in the case of job loss, no financial savings to fall back on, no proper technological facilities and lack of interest in online classes on the part of students, with these problems I started feeling psychological issues through the first four weeks of online classes.

3.2.2.2. Learning Management. The second major OE transition barrier was learner management in online classes; specifically, difficulty in class control and student engagement. In a video-off digital environment, knowing with certainty the person on the other end is the student enrolled in the class remains a challenge for online instructors (Sithole, Mupinga, Kibirige, Manyanga, & Bucklein, 2019). The participant teachers found that online class discipline was out of their control, as expressed by respondent SB,

Sometimes, even students [sic] irritate teacher[s] by deliberately making noise or creating distractions through music, ridiculous voices and annotations on the shared screen. Controlling class and maintaining discipline in traditional classroom is easier as compared to this online mode. Maintaining discipline by not losing my temper has become another problem for me in large classes.

As a technology-mediated online platform means loss of face-to-face interaction between instructor and student, and for students, it produced a drop in learner-teacher motivation. The majority of the teacher respondents reported a lack of interest and due attention from students during online sessions. They complained about students’ inattentiveness during online class and there being no way to check on their activities. Other participants complained that they were unable to engage with students. FA said, ‘Concentration levels on the students’ part are not so good. I would say ‘we are saving time but we are not providing quality education.’

Perhaps, the problem is our expectations of excellence from our regular university teachers for doing what they were never educated or trained for. A traditional class had a teacher conducting a 50–60 min face-to-face lecture and s/he never imagined that the attention span of a viewer (2 min in general) could be an issue. Expecting them to craft videos with even a 15 min-attention span and a comparison of his/her video with the material developed by experts in a Virtual University is just like a one day international played with T20 cricketers. From the students’ point of view, it has been found that though it is possible to learn as effectively in an online context as in face-to-face context, self-motivated learners are more likely to succeed in the OE system (Muuro, Wagacha, Kihoro, & Oboko, 2014).

3.2.2.3. Technical barriers. The third constraint, most apparent in developing countries and a large part of the world, was related to technology. Like in other developing and underdeveloped countries, not all Pakistani teachers have access to technological devices, software, and internet connections. Of these, the issue of internet connectivity was the biggest problem cited by almost every respondent as it meant interruptions not only for the teachers but also for the students. The required access to high-speed internet connections for successful sessions affected most teachers and students, particularly those living in rural areas, as it did in other remote areas of the world also (Jones, 2015).

### Table 1

Teachers’ perceived barriers in Covid-19 driven GET.

| Sr. No. | Barrier       | Description                                           |
|---------|---------------|-------------------------------------------------------|
| 1       | Personal      | Lack of background knowledge and experience           |
|         |               | Resistance to change                                  |
|         |               | Excessive workload causing mental stress             |
| 2       | Learning Management | Lack of class control                          |
|         |               | Lack of student engagement                         |
| 3       | Technical     | Lack of tech. devices                                |
|         |               | Lack of software                                     |
|         |               | Lack of access to internet                          |
|         |               | Connectivity failure                                 |
| 4       | Social        | Lack of student-student interaction                  |
|         |               | Lack of student-teacher interaction                  |
| 5       | Institutional | Lack of teacher/student training                     |
3.2.2.4. Institutional barriers. The fourth major constraint on the delivery of university classes was lack of institutional support. The central reliance on technology increased the need for and value of its technological infrastructure, effective LMS, guidelines for pedagogical design, and appropriate training. Every teacher interviewee stressed the need for an IT training program for teachers as the following excerpt from ML illustrates: “There are technological hurdles while using the software. Teachers should be given training on the usage of software”. This lack of training and dearth of IT knowledge results in an inability to express ideas well. According to respondent SB, “In such situation when I’m not well trained and do not have a purpose-built online education platform, and when my students are facing multiple problems and showing lack of interest, I cannot deliver what I want to.” During a worldwide crisis, while teachers are ready to be on the front line, they need to be equipped with the appropriate, relevant skills so that education can continue.

3.2.2.5. Social barriers. Key features of a traditional classroom include the teacher making eye contact, and reading students’ body language, which are mostly absent in OE. Teachers showed their frustration with their inability to predict their learners’ immediate needs and actions, particularly when video resources became hard, as FA said, “Online education can never be the substitute of a traditional classroom, because, in online classes, one to one relation becomes a little bit weaker. Lack of association and low level of concentration can hinder in the learning process.” The absence of discussion boards in a limited and poorly created and maintained online system puts the students at a disadvantage and teachers at a distance. Both suffer due to fewer opportunities for involvement in discussions, asking questions to deepen their understanding, for correcting misconceptions, and sharing examples from real-world experiences. It is natural for face-to-face interactions to be more spontaneous than asynchronous interaction. Participants found that real-time discussion brought a livelier character to interactions.

3.3. Students’ Online Education Experiences

Students’ learning experiences and outcomes are the most significant factors in evaluating OE quality and prospects. Overall, the students’ responses indicated that they found it very hard to get into the spirit of completing online learning activities in a non-classroom environment which can also be the result of depression and isolation because of the pandemic.

3.3.1. Availability of resources

This situational transition led institutions to experiment with the most user-friendly, freely available learning tools. Zoom emerged as one of the leading tools all over the world. The CEO of Zoom, Eric Yuan, removed the limit of meeting minutes for schools in Japan, Italy, and the United States. However, in Pakistan, most online teachers could access the free version of Zoom, but with a time limit 45 min. Only one private institute from the sample of 10 universities purchased a license for extended time use. The other teachers had to log in twice in one class session. Despite this limitation, the results show that Zoom was the most in-demand software tool among public and private sector students.

The results showed that 42% and 51% of students of public and private universities respectively, used Zoom. However, as Zoom is far from the only tool required to benefit the students and teachers, teachers had to combine it with other tools for document sharing. A limited number of students used LMS and WhatsApp, while 31% of private and 33% of public sector students did not use any software. Students were also asked to rate the effectiveness of these learning tools. Their responses showed that Zoom was considered comparatively more effective learning software compared to LMS, WhatsApp, or other available tools.

Students were asked to rate the availability of resources for seven items and about three problems they may have faced during their online classes. The responses revealed that an acute lack or minimal access to resources were major challenges as illustrated in Fig. 4. The study revealed that the majority of the student respondents (82%) perceived lack of university support as the biggest challenge followed by an absence of technical training (78%). The only readily available devices were enabled 3 G/4 G mobile phone (58%).

A comparison of public and private-sector students’ responses showed that private-sector students had more deficiency of resources as compared to public sector students particularly in lack of training (81%:74%), institutional support against their queries (84%:77%), connectivity issues (82%:72%) as shown in Fig. 5.

The level and quality of digital access determined the quality of education received. While virtual classes on personal tablets may be the norm in China and Hong Kong, for instance, students from other countries have to rely on WhatsApp for academic communication.

3.3.2. Covid-19 Driven OE Economic Impact

When students in Pakistan were asked how much they spent on internet data packages costing between 1000 and 5000 PKR (5–28 USD), 1144 students responded that 2.6 million PKR (14,690 USD) was spent on buying internet packages in one month alone, an average of 2282 rupees (12.9 USD) per student as shown in Fig. 6. According to Ministry of Finance data, total enrolment in Pakistani public and private universities was 1.6 million students. Under a ‘business as usual’ scenario, the students would pay more than 2.9 billion rupees (16.38 million USD) on internet data purchases alone. The lock down has already cost the jobs of a large number of daily waged workers, who find it difficult to provide the basic necessities of life. For many students (61%), who do not have laptop or 3 G/4 G enabled mobile phones, the cost is even greater. These extra costs could prevent some learners having access to OE at all, as Debrah et al., (2021) study indicated higher cost affected e-learning.

A comparison of students from both sectors showed that public sector students are more inclined to use 1000-rupee packages while private sector students spend more money on expensive packages, as shown in Fig. 7. Their economic background controls and determines students’ access to OE.

3.3.3. Student Attitudes to OE

Students’ attitudes were recorded using five items enquiring about the novelty of OE transition, nature of the experience - enjoyable or unpleasant - their comfort level while studying from home, and whether they wanted to continue doing or not. The results showed a negative attitude towards OE as 80% did not want to continue the OE post-Covid-19, 79% did not enjoy the learning experience, and 68% found it a bad experience; their opinion on the novelty of the experience was divided. It should be noted here that their responses were based on their lack of prior OE experience.

3.3.4. Advantages & Disadvantages of Online Education

The questionnaire items on the perceived features of OE referred to 12 key advantages and disadvantages which respondents rated according to their level of agreement or disagreement. The analysis showed the majority of students were dissatisfied with their OE experience, as shown in Fig. 8. They were not convinced there were any obvious and tangible benefits of online learning as 90% disagreed with the idea that students can learn better through OE. By contrast, all the participant teachers (100%) believed that OE was the only solution to semester interruptions, but 71% of students disagreed that OE had benefits where face-to-face learning is impossible. Other researchers found that OE saves the time and energy invested in travelling and the added difficulties of architectural and mobility barriers found in cities (Vilaverde, 2020), but the result showed that 70% and 67% of students denied OE had benefits in terms of time, and comfort, respectively, while the students had mixed opinion about travel cost. Their low rating showed that
students did not agree it was a time-gaining opportunity. Another benefit found by earlier researchers is that OE promotes learner autonomy (Vilaverde, 2020); however, this study showed that 80% of students rejected the viability of learner autonomy through OE system.

Likewise, when students were asked about their learning experiences, they regarded the OE class as non-interactive (68%), with little opportunity for group study (74%). Online classes produced psychological pressure (58%), frustration (80%), and poor grades (83%). It can be argued here that if teachers and students had been provided with better training, they might be in a better mental and psychological position to handle the frustrations of OE. This is how a teacher SS put it; “This transition has boosted the confidence of many but has made some depressed as well. Students who cannot afford the online arrangements are particularly suffering.” Fig. 9 shows the distribution of responses on the six perceived disadvantages from 1144 respondents.

When student responses were compared based on their association with public or private sector universities, an interesting finding emerged. Despite the overall similar response rate, closer examination of the data showed that private sector students had stronger views as a higher number choose ‘strongly agree or disagree. Their stronger opinions were highlighted in agreeing that OE was frustrating, not interactive, made them anticipate poor exam grades and in disagreeing...
that the expected OE had time and energy-saving benefits and helped semester continuity during the Covid crisis.

3.3.5. Student Engagement in Online Classes

Student engagement and teacher-student interaction were the main concerns of the teacher participants. When the learners were asked about their interest in online classes, they exhibited low motivation; 23% found their lectures uninteresting as there was limited use of relevant explanatory visuals. However, interestingly, students rated their teachers’ efforts to engage students a little higher. Teachers were reported engaging their students by asking questions (57%), responding to student queries (67%) and encouraging students to ask questions (59%) as illustrated in Fig. 10. The mismatch between teachers’ and students’ perceptions about the lack of student engagement in OE recalls a recent finding by Joshi et al. (2020) that lack of social interaction was considered a weakness by teachers twice as much as by students.

It is also worth noting that students from public universities were found to be more positive about their bond with teachers than students from the private sector. Public-sector students reported more efforts to engage them through asking questions (63%: 54%), responding to them (77%:62%) and by encouraging learner inquiry (69%: 54%).

4. Discussion and Recommendations

The results showed that the education transition from traditional classrooms to virtual learning in Pakistan proved to be a pandemic-driven hasty, and unprepared paradigm shift. The researcher’s preliminary survey showed that HEIs took individual decisions about how OE would fit into HEC, despite the advice at national level. The survey and interview results from this research showed a difference of view between teachers and students about the effectiveness of the transition of educational mode to OE. The unprepared shift was problematic for both stakeholder groups; however, the teachers’ responses showed that they accepted the transition as a challenge, while the learners showed more of a reactive response. The students’ reactions can be linked to the general unavailability of digital devices, lack of basic access to the internet, electricity failure, and lack of information technology support from their university. The expected benefits of technological advances had, by virtue of their changing the status quo turned into barriers. Present finding reflects students’ reaction in early lockdown days through their campaign on social media and their demand to consider the closure as a semester break. As a result of mounting pressure, HEC officials held brainstorming sessions with VCs and drafted the first OE policy on 17 April 2020, after OE had been running for a month without any new and relevant standard operating procedures or quality assurance standards (HEC, 2020). It is inferred from the findings that the first month would have been better spent on preparation including teacher and student training, setting up an online academic council, establishing an Information Technology support office, and purchasing the necessary LMS.

Teachers’ responses showed that they feel overburdened and mentally strained due to the un-prepared, and short notice of the shift to OE which involves various tools, software, and modes of communication quite different from face-to-face classroom interaction (Roddy et al., 2017). The teachers in both public and private HEI sectors had to extend their work hours to learn new technologies for OE delivery, and to respond to students’ queries. The extra burden caused mental stress and disrupted family life. The lockdown in the country further augmented the problems. The situation was worse for private-sector teachers as they also faced job insecurity in case of non-compliance or slow response time due to the high expectations of corporate educationists.

The present transition to OE has starkly exposed technological deficiencies, absence of planning for contingencies and deep inequalities within higher education system in Pakistan. According to questionnaire results, only 57% of students have 3 G enabled mobile phones, probably those from a privileged background leaving a quarter of those from disadvantaged rural backgrounds. Schools and universities are in a difficult situation as if they do not opt for OE, all their students will miss out on classes for particular semesters/terms. If they do, a sizable number of disadvantaged students will fall even farther behind. If the decision-makers do not act appropriately, the existing vast inequality of opportunities will be amplified. If educational access is dictated by access to the latest technologies and tangible steps were not taken, the situation may have a negative effect on poverty-stricken students and would certainly worsen the digital divide.

Previous research established that clarity about assessment methods affects student engagement (Ripoll et al., 2021), and also places new demands on teachers’ digital technology competence. Without these skills, teachers were unable to motivate and engage students or resolve technology-related issues during their live classes; the results showed that students’ frustration was because they were unable to grasp concepts completely. The present study highlighted that training teachers for OE would not only benefit them and their students but also expand their skills to build confidence in OE through experience. Hence teacher training courses need to cover a range of skills, with technology and pedagogy in their content.
The results of the study prompted the researcher to propose a teacher-centred training framework for the new teaching media brought about by the pandemic, reflecting four interconnected components, as illustrated in Fig. 11. The proposed framework covers all the required components without leaving any grey area. It should also be noted that the needs and modes of training for new teachers and those who are unfamiliar with the required inputs will differ from those with prior online teaching experience, as suggested by Vilaverde (2020). Furthermore, the nature and content of the training will also be affected by individual disciplines; as for instance, a faculty of science might already have better computer skills than arts and humanities faculties, which may need a more comprehensive understanding of technology use. Once the COVID-19 crisis is over, on the positive side, it is expected that more teachers are likely to be able to use technology due to their increased experience and confidence in using the necessary tools (Vilaverde, 2020). Those who had a positive experience are not expected to enrol in online education but in case of any emergency, they may be more likely to consider online programmes in the future.

5. Conclusion

Due to the exponentially growth of Covid-19, the government of Pakistan announced the closure of educational institutions, with directions to start OE immediately. Many public and private HEIs started OE without being ready for it, so there was wide resistance of it by students; individual departments showed severe concerns about the unprepared start. The present study investigated the Covid-19 driven educational transition from traditional face-to-face classrooms to OE by

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Fig. 8. Learners’ perceptions of the advantages of Covid-19 driven online education.

Fig. 9. Learners’ perceptions of disadvantages of Covid-19 driven online education.

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recording the response of learners and teachers of chemical engineering in Pakistan. The results of the quantitative survey showed high dissatisfaction and frustration among students due to the lack of LMS, an IT support office, and adequate training from HEIs. Students had low motivation due to the non-availability of broadband services, inadequate electronic devices, and poor internet connectivity. The teachers’ responses showed a dismal picture of OE prospects in chemical engineering in Pakistan due to institutional, social, personal, technical, and learning management-related barriers. Private sector teachers were worried about job security if they were unable to meet the expectations of corporate educationists. If teachers are pressurized to work with existing resources, the quality of education will be seriously compromised. The author suggests a comprehensive learning environment that includes a framework for teacher training, HEIs and the Pakistan Engineering Council. Teacher training should focus on technological knowledge, development of online content, and instructional and assessment techniques. The proposed model can assist the policymakers and executives responsible for decision-making. It will also help teachers to develop pedagogical innovations to match OE teaching requirements instead of carrying traditional methods to online classes.

Declaration of Competing Interest

The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix-A

Survey for students.
University ____________________________
Class Level/semester ____________________________
Part-A. Choose the response by ticking one option.
Name of universities.
Semester/Level.
Gendera. Maleb. Female.
1. What is the type of classroom learning tool being used by your institutions to conduct online class? (You can choose more than one option).
   a. Google classroom
   b. university learning management system (LMS)
   c. WhatsApp
   d. ZOOM
   e. Any other ————

2. Which learning tool do you feel more effective? (You can choose a combination of two)
   a. Zoom
   b. WhatsApp
   c. LMS
   d. Google Classroom

3. What is the amount of money you spend on internet data packages every month?
   a. 1000
   b. 2000
   c. 3000
   d. 4000
   e. 5000

**Part-B.** Read the statements and tick the option you like. Options are: Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A), Strongly Agree (SA).

| No. | Statement | SD | D | N | A | SA |
|-----|-----------|----|---|---|---|----|
| Attitude | During covid-19 closure, online learning was a new experience. | 1 | 2 | 3 | 4 | 5 |
| | I enjoy online learning during university closure due to covid-19. |  | | | | |
| | Online learning during covid-19 closure was a bad experience. |  | | | | |
| | I do not want to continue online education after the control on Covid-19 crisis. |  | | | | |
| Advantages | I am learning better in online education than in traditional classroom. |  | | | | |
| | During covid-19 closure, online learning can help to continue semester. |  | | | | |
| | Online education saves time. |  | | | | |
| | Online education saves travelling expenses. |  | | | | |
| | Studying from home is more comfortable. |  | | | | |
| | Online education encourages me for self-study. |  | | | | |
| Disadvantages | I do not understand concepts clearly in online class. |  | | | | |
| | I feel more psychological pressure in online class. |  | | | | |
| | In online education, group study is not possible. |  | | | | |
| | I think that online classes can negatively affect the grades of students. |  | | | | |
| | I cannot raise questions or debate in online class. |  | | | | |
| | Online class make me frustrated when I do not understand the concept. |  | | | | |
Appendix-B

Questionnaire for teachers.

With due respect, it is hereby requested to answer the following questions in detail with reference to the current COVID-19 pandemic. It can take about 10–15 min.

1. How do you view the emergency transition of learning mode from traditional classroom to online education during Covid-19 in Pakistan?
2. How far do you find your online classes effective?
3. What problems do you face while delivering online lecture? (for example, availability of laptop/computer and internet, connectivity issue, your knowledge of online class room software)
4. What problems being a teacher you face during online lecture regarding student-engagement, their participation and interaction?
5. Please enlist/suggest the tangible actions your university can take up keeping in view the budgetary constraints and available resources.
6. What impact do you think this emergency transition into online learning might have on teacher’s and student’s confidence in technology-enabled learning?

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