

Challenges and Exit Strategies for Adapting Interactive Online Education Amid the Pandemic and its Aftermath

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Abstract—The COVID-19 pandemic has had a catastrophic effect on education across the world. The biggest compulsory disruption in the history of education has been caused by COVID-19, which is affecting about 1.6 billion students across 190 countries on all continents. This pandemic has forced a shift from traditional face-to-face class-based systems to online teaching and learning. Educational institutions are tackling unprecedented challenges to resume education. Many of them have already started education in partial (online) or blended (online and limited on campus) mode. In this article, we discuss the challenges faced by educational institutions, teachers, and students in resuming the teaching and learning process and the preventive measures taken to mitigate the current deteriorating situation. We analyze the overall institutional setup of re-opening the learning process from the perspectives of technology and logistics (smart educational tools), teachers' initiatives, teachers' competence, and the support (mental, financial, technological, etc.) provided to students. In order to continue with institutional education, we present strategies to exit from the worst situation during the pandemic. The results of this study can guide educational institutions, teachers, and students to take the necessary measures against disasters (earthquakes, tsunamis, COVID-19, etc.) and to continue educational activities both during the pandemic and in the post-pandemic period. The outcomes of this study can also help researchers and developers to create new technologies to deal with unprecedented situations to continue learning.

Index Terms—Online Education, Smart Education, Interactive Learning, Interactive Teaching, COVID-19, Pandemic, Post-pandemic

I. INTRODUCTION

The highly contagious COVID-19 disease has made life difficult around the world and affected almost every sector. The first case of COVID-19 was reported in December 2019 in Wuhan, Hubei, China [1]. Since then, COVID-19 has become a worldwide pandemic due to its range and severity [2]. The

devastating effects of the coronavirus have been felt in almost every aspect of life in the world, including the economy, business, education, and social activities [3]. As in other sectors, the impact of COVID-19 has hit the education system hard. The COVID-19 pandemic is preventing many students who live in poor or rural areas, refugee camps, and other places from accessing fundamental education [4]. A worrying picture provided by the United Nations (UN) is that about 23.7 million additional children and youths [from the highest level (tertiary) to the lowest level (pre-primary)] may drop out of school or not have access because of the economic impact of the pandemic in next year [4].

Many schools, colleges, and universities across the world are still closed due to the third/fourth waves of COVID-19 infection. Usually, every educational institution has a deadline for the end of their academic year. Due to COVID-19, the only option to end the academic year on time is to move to online education [5]. This adverse situation has exposed the flaws in our education system. Hence, it is time to think about the entire education system and how to deal with such a difficult situation in the future. The inclusion of smart education systems can be a convenient way of neutralizing this kind of unprecedented situation in the future. Conventional face-to-face learning has been almost entirely replaced by online or virtual learning. A few years ago, distance learning and e-learning were considered as an informal style of education but due to the pandemic, the times have changed and now these teaching methods are considered as part of mainstream education. Conventional face-to-face teaching and learning has now spread to various mediums, including social media, national television, Moodle, MOOCs, Zoom, Google Classroom, Coursera, ClassDojo, and Ted-Ed, among others [6].

The swift and unexpected compulsory transition from con-

ventional face-to-face learning to online, distance or virtual learning has highlighted a variety of barriers and challenges. Recent research has highlighted the challenges of education during the pandemic such as emergency remote teaching [7], emergency e-learning [8], poor virtual teaching infrastructures, limitations on sharing teaching materials with students, and unfavorable conditions at home [9]. Moreover, counseling and support for students, teachers' ability to adopt digital tools, and strategies for online teaching have been explored in various articles [10], [11]. The main stakeholders in online education are institutions, teachers, and students, so the concern is how teachers, students, and institutions can adapt to the new normal conditions caused by the COVID-19 pandemic [12]–[14]. The teaching strategies and technologies required to deal with the pandemic are discussed in article [15]. At the same time, it is important to know about digital tools for productive and effective virtual teaching and learning. Consequently, online teaching requires more improvements, and there is also a need to develop quality teaching materials, which will certainly help to deliver high-quality lectures [16]. The current situation actually helps educational institutions to understand institutional deficiencies and shortcomings and will hopefully help them to address such adverse situations in the future [17].

In this paper, we explore the challenges faced by educational institutions, teachers, and students during pandemic outbreaks and exit strategies to resume teaching and learning. Additionally, we explore smart technologies and logistics for smart education and learning. Based on the literature review, we present some recommendations and guidelines for educational institutions, teachers, and students to continue the teaching and learning process during both the pandemic and the post-pandemic situation. We also analyze teachers' competencies to teach online and the necessary support for the students' learning during the pandemic. We discuss what strategies and technologies have been adopted to manage online teaching and learning. The outcome of this study can be used by researchers and developers to generate new ideas and technologies.

II. TEACHING AND LEARNING SCENARIO DURING THE PANDEMIC

A. Impact of COVID-19 on Education Around the World

There have been many difficulties in every aspect of our daily lives since the first COVID case was reported. However, the damage to education is the most costly. The closure of schools and other educational outlets during the pandemic has affected about 94% of the world's total student population, which extends to 99% in middle- and low-income countries [4]. Closing schools is an effective strategy to prevent the spread of the infectious virus [18], [19], but this has had negative consequences [20] on the overall academic progress of students, especially those in rural areas. Tertiary-level students are the most affected among the world's total student population [21]. Many studies have noted that during this pandemic, students have concerns about their careers, economic problems, part-time jobs, health, and social interactions. The same also applies to academics [22], [23]. With more than 100

countries yet to announce the opening of schools, tensions are rising among all stakeholders as to how and when to enter the next phase of education in the pandemic [4]. Table I shows that Europe is one of the most successful regions where the effect on education is almost zero (0%) and the transition from face-to-face to online education is about 85% better than in other regions. On the other hand, 24% of education has been abandoned in Africa, which is the highest rate compared to other regions.

B. Transition from Face-to-Face to Online Teaching and Learning

Due to the proliferation of COVID-19 cases, on campus teaching and learning switched to online or virtual teaching and learning almost overnight. Online learning is a crucial medium to continue learning without disruption. In some countries, online education has grown exponentially amid the pandemic [25]. Online education can offer more attractive and advanced options for teaching and learning. Teachers can present their lectures in more innovative ways using digital tools, and students have the flexibility to join a class from anywhere. Fig. 1 shows the statistics of different education mediums used to ensure learning from pre-primary to high school in different regions during the pandemic. Online education has attracted the most attention among all the different methods of education during this pandemic.

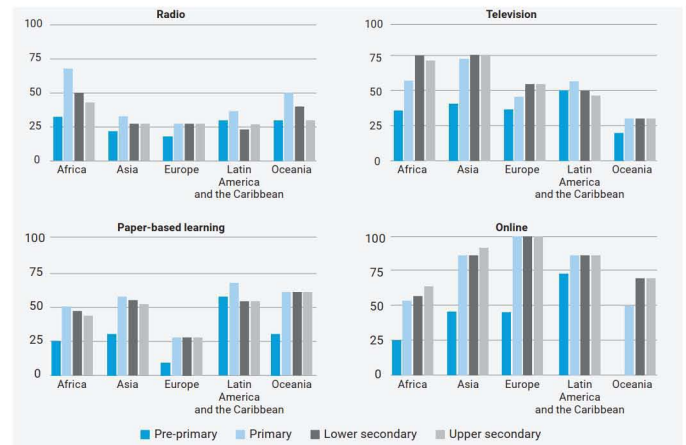


Fig. 1. Learning medium choice in different countries or regions [4]

C. Teachers' Competencies in Adopting New Teaching Methods

Teachers are playing a key role in conducting educational activities amid the pandemic and beyond. Online teaching differs in many ways from conventional classroom lectures. The transformation of information and communication technology (ICT) in the entire education system from primary to tertiary level has increased at a significant rate [26]. In addition to academic skills, teachers also need to be familiar with many digital tools and technologies to conduct online classes. Incorporating ICT skills is now a fundamental requirement for

TABLE I
IMPACT ON EDUCATION IN DIFFERENT CONTINENTS DURING THE COVID-19 PANDEMIC [24]

Continents	Not affected (%)	Face-to-face teaching replaced by distance or online (%)	Teaching postponed but institutions finding solutions (%)	Teaching abandoned (%)
America	3	72	22	3
Europe	Almost Zero	85	12	3
Asia & Pacific	1	60	36	3
Africa	3	29	43	24

increasing the technical knowledge that is strongly associated with online teaching and learning.

D. Learning Opportunities and Challenges for Students

Despite the inadequate preparation for teachers, students, and educational institutions, online teaching and learning has been forcibly activated due to the COVID-19 crisis. Students need family, teachers, and technical support to maximize their learning during online schooling [27]. Online teaching and learning is not an alternative to face-to-face learning but can be a partial replacement. Universal access to ICT infrastructure (smartphones, laptops, Internet, etc.) can be a major hindrance to students' learning [27]. Geographical location and economic status are also challenging concerns as regards equal learning opportunities for all students. Many studies have shown that students living in rural areas without an Internet connection are facing difficulties when learning online [6], [21], [28]. However, online teaching and learning is a better solution than completely shutting down schools.

E. Technology-equipped Smart Learning System

With the advancement of technology, educational institutions are adapting new technologies for better teaching and learning. The smart education system is equipped with the latest digital devices that enhance and diversify overall teaching and learning opportunities. The smart education system helps uninterrupted learning in any situation, especially in the time of natural calamities (i.e., the COVID-19 pandemic, earthquakes, etc.) [29]. Already, many countries have initiated smart education projects for different levels of education. Malaysia undertook a smart education project in 1997 with the aim of developing an education system to produce a quality workforce that meets the challenges of the 21st century [30]. Singapore has implemented a master plan called Intelligent Nation (iN2015) where technology-based education is a priority [31]. According to the plan, several future schools with diverse learning facilities have been established. A smart education program has been implemented by South Korea with the aim of renovating the education system, as well as developing the education infrastructure [32]. Integrating technology into the classroom is a priority of New York's smart school program [33]. Finland has also implemented a smart education system to improve learning [34].

III. CHALLENGES OF ONLINE EDUCATION IN THE PANDEMIC AND THE POST-PANDEMIC PERIOD

In this section, we discuss the challenges and problems in this immediate transition from the perspective of the main stakeholders such as institutions, teachers, and students.

A. Challenges for Educational Institutions

In the context of COVID-19, educational institutions have been expected to instantly transform to another way of learning. As a result, academic and administrative activities have been shifted online. Educational institutions have faced difficult times dealing with the pandemic and continuing administrative and academic activities. Based on the review of the literature, we present the challenges that educational institutions have faced so far.

1) *Lack of Preparation for a Pandemic or Other Natural Disasters:* Most educational institutions do not take pandemics or natural disasters seriously, which can disrupt education. Emergency management plan (EMP), education continuity plans in disasters (ECPD), and pandemic or biological risk management plan (RMP) are gaining importance in the face of the pandemic [35]. COVID-19 has shown that pre-planning in every educational institution is essential to continue teaching and learning activities in any challenging situation.

2) *Transition from Face-to-Face to Online Education:* The immediate transition from face-to-face learning to other forms of teaching and learning is always a difficult task for any institution. Adequate technology-equipped environments or classrooms are required to conduct online classes. Appropriate educational technologies can reduce the problem of learning during a pandemic, therefore, it is necessary to choose potential technologies that will be effective in the future (in the post-pandemic period) [26].

3) *Necessary Support for Teachers and Students:* Some basic items for online education are mandatory for teachers and students. Both teachers and students need PCs, laptops, smartphones, projectors, other digital equipment, and most importantly, the Internet. However, the availability of digital tools and the Internet is not the same for all students and teachers. It is a timely call for educational institutions to ensure such things before starting online education. In particular, access to the Internet in some rural areas is still a dream. At the same time, it is important to secure equal learning opportunities for all students. On the other hand, long-term attendance in online classes can lead to frustration and anxiety

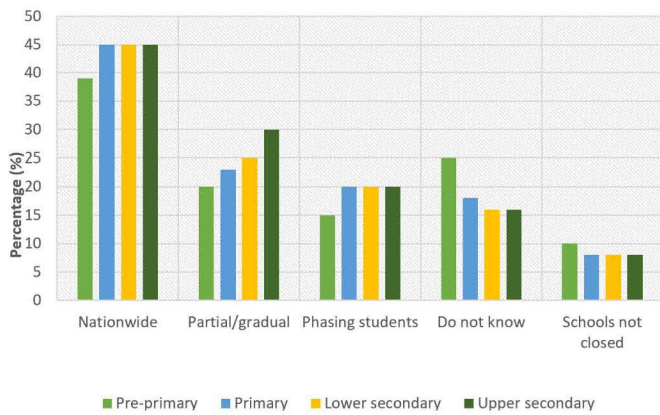


Fig. 2. Statistics on the school opening in different levels of education [4]

in many students, so they need psychological support as well as entertainment. The statistics regarding school opening plans at different levels of education around the world are shown in Fig. 2.

4) *Handling the Financial Crisis:* The negative impact of COVID-19 has affected the financial arm of educational institutions. The workforce's remuneration and employment are becoming more stringent than usual. Studies have shown that government educational institutes are facing less problems than other non-governmental institutes. It is noted that a significant number of schools have shut down due to an institutional financial crisis. Long-term school closures during the pandemic have a notable devastating effect on regular remuneration and employment, as shown in Fig. 3.



Fig. 3. Statistics regarding remuneration and employment in educational institutions [4]

B. Challenges for Teachers

Teachers are responsible for conducting academic activities in any circumstances. This pandemic has interrupted normal education, so teachers are giving lectures online. Teachers have had to immediately move to online teaching without proper preparation and this can be a barrier for teaching and learning. Based on a review of the literature, we have listed below the challenges that teachers are facing in resuming teaching.

1) *Institutional Guidelines for Online Teaching:* Most educational institutions suddenly moved to online learning and the teachers were unprepared for this unprecedented situation. This represents an unprecedented amount of work for teachers without institutional guidelines to conduct online classes. For

potential teaching in pandemic and after pandemic situations, it is necessary to follow institutional guidelines. An online learning curriculum can be different to face-to-face learning, in which case institutional guidance is essential. Most educational institutions do not have such guidelines for teachers and students in terms of online education as shown in various studies.

2) *Training and Workshops for Teachers :* Each training session and workshop can create opportunities to acquire new knowledge as well as developing skills. Digital technologies are heavily involved in online education, so teachers should have a high level of knowledge about technology. The technical knowledge of teachers in all levels of education (primary to tertiary) is not equal, so from the perspective of teachers, training is an important factor for online education. Studies related to online education during the pandemic have discovered that teachers' training as regards online education is one of the main obstacles to better and interactive learning. A large number of teachers are needed in different levels of education for distance and online teaching, as shown in Fig. 4.

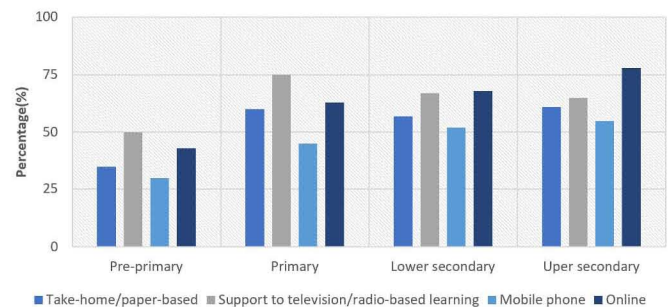


Fig. 4. Statistics regarding the teachers required at different levels of education [4]

3) *Insufficient Teaching Assistants for Online Classes:* The teaching assistant (TA) is an important part of regular teaching and learning. TAs help teachers to manage the class smoothly. Teachers can instruct TAs about class lectures before starting online classes and they must ensure the availability of TAs in online classes. Studies have shown that students concentrate less in online classes than in face-to-face ones. The number of questions asked by students in terms of understanding lectures is much more in online classes. So, the number of TAs for each online class needs to be increased to answer students' questions as well as providing better teaching. Otherwise, it could be an important concern for interactive online learning.

C. Challenges for Students

Students at every level of education (primary to tertiary) have been most affected by COVID-19. Regular classes, exams, internships, and other academic activities have been partially or fully cancelled around the world due to the coronavirus, but some academic functions are taking place in online. Various reports and surveys have identified student challenges related to education, social activities, mental and

physical health, and financial concerns during the COVID-19 pandemic.

1) *Adaptability to New Learning Trends:* The new normal situation has forced institutions to move away from conventional methods to online education. The opportunity for teachers and students to interact during online classes is more limited than in conventional classes. Although the learning is not synchronous, like usual. Also, maintaining concentration in online classes is a key concern for quality learning. Many students fail to understand online lectures due to a lack of interaction and concentration. The current situation may remain this way for a long time, so students need to adapt to these new learning trends as quickly as possible.

2) *Insufficient E-learning Competence, Internet, Tools and Software:* E-learning or online education is a different way of learning that incorporates many modern digital tools, software and the Internet is the backbone of online learning. A basic knowledge of e-learning platforms and related devices can widen learning opportunities for all students. In addition, a large number of students do not have the financial capability to buy such devices. Thus, to ensure equal learning opportunities in online education, every student must have such facilities. Unfortunately, the lack of this type of facility is a major obstacle to interactive online learning [25].

3) *Weak Economic Conditions:* Currently, the socio-economic situation of most students is as bad as it has ever been. So, the financial capability of students during this pandemic is getting worse day by day. Many students have lost their part-time jobs and other employment opportunities during the COVID-19 period. There are some job opportunities such as being a TA or a research assistant (RA) during face-to-face learning on campus. As a result of the school closures, these opportunities have been lost during the pandemic. Facing up to these difficult conditions coupled with the weak financial situation of many students are important factors in online education during the pandemic period.

4) *Mental and Physical Health Concerns:* During this pandemic, most students have refrained from sports, social gatherings, entertainment, and other co-curricular activities. Thus, the mental and physical health of students is a big concern. A famous quote "Health is Wealth" is most appropriate for students in this situation and beyond. This pandemic is having a long-term negative impact on mental health [36]. Thus, counseling services can be provided by universities to maintain students' mental health and well-being [37]. Quality learning is impossible alongside mental and physical stress.

IV. INSTRUCTIVE EXIT STRATEGIES

The emergency transition from class-based face-to-face learning to online learning has created many challenges in the field of education. The nature of these challenges varies among educational institutions, teachers, and students. We have discussed these key challenges in the previous section. The key goal of this research is uninterrupted learning where the educational institution integrates modern educational technology to tackle a very difficult situation. Based on the

discussion and review of the literature, we recommend some exit strategies for sustainable education in adverse situations, such as pandemic or natural hazards, which can be applicable in the post-pandemic period.

A. Institutional Future Disaster Management Plans

At present, most educational institutions are struggling to make the right decisions to handle the pandemic and its aftermath. It is very difficult for an institution to prepare a quick and effective recovery plan without proper evaluation of the parameters. So, pre-planning (with a backup plan B, C, and so on) is now mandatory for each institution. According to institutional future disaster management plans, all support and logistics should be prepared in advance and implemented. Therefore, future plans can ensure uninterrupted learning in any adverse situation.

B. Pre-service Training for Teachers

Teaching during the COVID-19 pandemic is completely different from normal conditions, with teachers having limited access to traditional teaching materials for online lectures. Instead, the involvement of teachers with digital tools and software for conducting online classes has increased notably. Technical knowledge and skills can help teachers to search for teaching materials, create new materials, prepare online lectures, and interact with students during class, so those skills create the best opportunities for interactive learning. Teachers' pre-service training can enhance online teaching skills as well as technological competencies. For the first time, many teachers are taking online classes without hands-on training or knowledge, which puts pressure on them to provide their best lectures online. Furthermore, a survey regarding the pre-service training of teachers indicated that trained teachers have better ideas, innovation, interaction, management, feedback, lecture delivery, and competencies than other non-trained teachers [38].

C. Innovative and Interactive Approaches to Online Teaching

Online teaching is a kind of one-way teaching and learning where teachers give lectures and students are on the receiving end. Normally, teachers cannot control students' attention during online classes. Paying attention to students inside and outside the classroom is a big concern for online education. Thus, teachers can experiment with new methods or techniques for interactive online classes that maximize student learning. For example, if a scheduled two credit course has 20 classes and four (04) class tests (QTs), and each QT has five (05) marks, then teachers can distribute QT marks in 20 classes. The correct answers to some simple questions at the end of each class carry the QT marks. This can ensure higher concentration of students in the class as well as better attendance. Similarly, other innovative ideas can be applied when conducting interactive classes to attract students' attention.

D. Importance of Vocal and Physical Gestures Utilization in Online Classes

In the conventional classroom, teachers use eye contact, facial expressions, body language, body and hand gestures, and vocal methods as teaching tools that are essential in interactive classes. At the same time, it is easy to obtain feedback from students during class, and teachers can respond accordingly. However, once we move to online classes, the only way to communicate with students is through voice. Studies show the importance of voice or vocal methods for effective and interactive online classes [12], [28]. Thus, maintaining voice or vocal functions during online teaching allows students better learning opportunities [28].

E. Quality of Lecture Contents and Splitting Large Content into Smaller Modules

To keep students' attention and focus during online classes, it is essential to divide larger lecture content into smaller modules. In many aspects, online learning is completely different; one of the important aspects is the quality of the lecture content, and other is the volume of content. For example, figures, relevant mathematical examples, and statistics can be presented (where appropriate) with theories that attract more attention than simple theory lectures. The duration of the online class can be shorter to make it more interactive. Various studies have suggested that the duration of online lectures should be limited to 20–30 minutes [12], [28]. So, the quality of the lecture content and small-sized lecture modules can be useful to attract students' attention more frequently.

F. Management of Lecture Materials and Discussion Sessions

Lecture materials can be provided to students before an online class to make them aware of the lecture topic. Teachers can arrange a discussion session with students about the topic during an online class. As a result, interaction between teachers and students will improve, and students will be able to answer questions during the class. Certainly, some students will have some questions related to the class lecture for the teacher if they have read the lecture materials properly. Thus, interesting question and answer (QA) sessions between teachers and students can happen during each online class. Additionally, recordings of each online class can be provided to students [28]. Students can repeat lectures offline to review the learning and solve their problems.

G. Flexibility Policies for Teaching and Assessment

Not all students have the same facilities (financial, technical, logistics, etc.) for online education. Many students live in remote areas (villages/regions) where there is no Internet connection to download lecture materials and attend online classes. In a real-world situation described in [39], students traveled two hours from their village to connect to the Internet and attend online classes. Online teaching and assessment can be flexible during a pandemic or any natural disasters. Many unavoidable circumstances (technical or non-technical) may arise during online classes or when submitting assignments.

So, students can be allowed late access to online class lectures and late assignment of submissions.

H. Different Strategies and Technologies for Lectures and Exercises

At present, it has become a challenging task to adopt appropriate strategies and choose the right technologies for lectures and exercises. Some educational software is performing well when conducting lectures as well as assessments. Practical classes are completely different from theory lectures due to many issues such as technical questions, error detection and correction, and the use of tools created by students. Solving these questions and queries effectively during a practical class is the most challenging task for teachers and instructors. However, the evaluation of exercises, including computer programming, SQL, circuit design, digital logic design, and algorithms is quite different to the evaluation of theory assignments and exams. To the best of our knowledge, the software does not exist to properly evaluate exercises automatically. Evaluating online exercises (programming, SQL, circuit design, digital logic design, algorithms, etc.) and lectures are equally important. So, selecting the appropriate technology for lectures and exercise assessments is vital for online education.

I. Intelligent Assessment Tools for Programming and Programming-related Courses

1) *Automated Programming Assessment:* Automated programming assessment systems (Online Judges) are playing an important role in advancing programming education [40]. These systems are being used as academic tools for evaluating program solutions. Also, automated assessment systems provide a useful platform for students (programmers) where they can practice and participate in programming competitions to develop programming skill sets. These systems evaluate solutions with predefined test datasets rather than using AI.

2) *Automated Programming Assessment with Intelligence:* Sometimes conventional online automated assessment systems are not sufficient for evaluating computer programming or programming-related tasks. While most conventional programming evaluation tools are not supported by AI, AI-based tools can improve programming evaluation and feedback. Logical error detection, correction prediction, and error location detection are just a few examples that AI-based tools can provide. AI-based models have a significant impact on evaluating programming tasks [41]–[43]. Educational institutions can focus on integrating AI-based tools to promote programming and programming-related education.

J. Smart Education System

Equipped with digital tools, a smart education system (SES) can help educational institutions migrate faster from face-to-face to online education. An SES system automatically activates and functions in any adverse conditions (pandemics, natural hazards, tsunamis, etc.). An SES can be helpful for uninterrupted learning and can create more opportunities. The

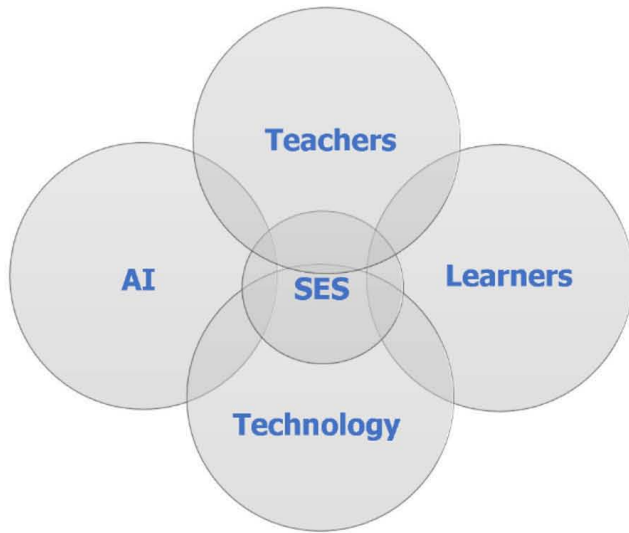


Fig. 5. Components of a SES

main components of SES are teachers, learners, technology, and AI, as shown in Fig. 5.

Many countries, including Malaysia, Singapore, the UAE, Finland, the USA, and South Korea, have introduced an SES at different levels of education and are receiving good results as discussed in the earlier section. In addition to an SES, the integration of the following technologies and strategies can improve learning, research, and development facilities.

- **Cloud Computing:** Cloud computing is essential for storing and accessing data due to the increasing level of learning materials. Global access to educational resources can be effective for research and development purposes.
- **Streaming Techniques:** Transmitting high-quality videos to learners with limited resources is a challenging task for online education. Thus, streaming techniques can be effective for high-quality video streaming.
- **Service Composition:** Online learning relies on many services like video streaming, educational tools, and software simultaneously during exercise classes or lectures. Integration and customization of various essential services is provided by the service composition. So, service composition can be one of the most important features of online education.
- **Educational Data Mining (EDM):** Educational data mining is a technique that helps researchers and developers to generate new knowledge and technologies to improve educational services [45], [46].
- **Ecosystem for Smart Learning:** This systematically represents the activities of all agents in a SES.

K. Strategies and Policies in the Post-COVID World

The reality is that we will not return to the world as it was before COVID-19. Ongoing educational activities during the COVID-19 pandemic may continue for the next few years or

decades. UNESCO has shared a number of important concepts for public activities that are needed for sustainable education after the COVID-19 period [44]. Strengthening education is a key concern both during and after the pandemic. Determining appropriate technology-based strategies helps to keep educational activities on the right track. Also, the long-term sustainability of the current educational approach is challenging for all stakeholders (institutions, teachers, students, parents, staff, etc.), so a set of educational policies is required.

V. CONCLUSION

This research article presents the challenges and exit strategies for educational activities in the time of the pandemic and beyond. During the COVID-19 pandemic, most teaching and learning activities have shifted to an online environment. We have identified challenges for educational institutions, teachers, and students to continue education during natural hazards or pandemics. Factors hindering online education have been identified, such as inadequate smart educational infrastructures, lack of technical adaptation of both teachers and students, poor financial situations of many students, availability of the Internet to students, health (mental and physical) concerns of students, and so on. These identified challenges can open up opportunities for research and development. Also, we have provided exit strategies for institutions, teachers, and students to continue education during a pandemic and beyond based on these identified challenges. In particular, this study assesses the challenges for each stakeholder when managing the rapid transition from face-to-face learning to online education. The outcome of our research can be useful for making decisions about future educational strategies. Finally, our instructive strategies can be effective for overall education.

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