ISSN:1687-1006

The Egyptian International Journal of Engineering Sciences and Technology

https://eijest.journals.ekb.eg/

Vol. 49 (2025) 41–55

DOI: 10.21608/EIJEST.2024.282505.1270

Hybrid Learning Prerequisites in Egyptian National Schools' Classrooms During Crisis

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ARTICLE INFO

Article history:

Received 11 April 2024
Received in revised form 24 July 2024
Accepted 24 July 2024
Available online 24 July 2024

Keywords:

1st Hybrid Learning.
2nd Egyptian Schools.
3rd Classrooms
4th Design criteria
5th Technological - Requirements.
6th Furniture - Requirements.
7th Climate - Requirements
8th COVID-19 Crisis.

ABSTRACT

Recent studies have shown that hybrid learning has become increasingly common in schools worldwide during the COVID-19 crisis. UNESCO has highlighted the impact of the crisis on the education process globally and revealed that school closures do not solve the crisis. In Egypt and other countries, schools were closed for 16 weeks, according to UNESCO reports. The World Bank has stated that the use of digital learning tools in Egyptian schools has become necessary after the crisis.

The research problem Although Egyptian schools are implementing hybrid learning under Education Development Fund guidelines, they confront many design challenges. The research gap is the lack of discussion on the design criteria for hybrid learning in previous studies.

The research aims to identify the design criteria for hybrid learning that must be available in Egyptian schools' classrooms and propose a matrix that includes three important design criteria for hybrid learning, such as technological requirements, furniture requirements, and climate requirements.

The research methodology consists of 1. A qualitative approach through analyzing previous studies and identifying the requirements of hybrid learning, and 2. An analytical approach by analyzing schools in and outside Egypt for different stages by using the design matrix.

Finally, the results include an assessment of the design criteria for hybrid learning in classrooms in and outside Egypt, and the research concluded guidelines for enhancing the design criteria for hybrid learning that must be fulfilled in Egyptian school classrooms.

1. INTRODUCTION:

Integrated learning environments that combine information and communication technology applications with face-to-face learning are often referred to as hybrid learning. Hybrid learning is an educational approach that combines face-to-face and computer-mediated instruction [1]. Hybrid learning is when students attend a synchronous session, with half of them in the classroom and the other half connected online, this may be the clearest definition. However, many problems arise when implementing hybrid learning, such as how to prepare the technology and how suitable the physical space is for that technology. Trainers, teachers, and supervisors all need support and training. Later research focuses on identifying the technological requirements of hybrid learning that must be considered in classrooms [2]. The coronavirus has resulted in one of the most educational disruptions in past periods, impacting 95% of the global pupil population [3]. According to [4], a correlation exists between the spread of viruses and the design criteria of educational spaces. By modifying the design criteria, such as incorporating natural ventilation and lighting, using surface materials with a short virus survival period, and controlling temperature and humidity, we can reduce the spread of viruses within these spaces. Both instructors and pupils had to change away from traditional face-to-face classroom environments to hybrid and E-learning environments [5]. As a result, video-conference software (like ZOOM, Google Meet, and Microsoft Teams) is becoming a common instrument for both hybrid and E-learning among individuals of all ages [6]. This type of technology allows pupils to communicate with educational resources, instructors, and peers in real-time, regardless of their location [7].

This paper focuses on the implementation of hybrid

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learning in Egyptian schools according to the Egyptian government's decisions at the end of 2020. The implementation of hybrid learning faces various problems. The research aims to identify the design criteria for hybrid learning in educational spaces. Therefore, the research questions are: What are the problems related to the implementation of hybrid education in schools? And what are the basic requirements that must be available to implement hybrid education in schools, especially in Egyptian schools? Finally, the research presents a matrix of the design criteria for hybrid learning in educational spaces, which will be used to analyze six government schools for different educational stages (primary, preparatory, and secondary) in and outside Egypt.

2. LITERATURE REVIEWS:

Previous studies have been divided into three major sections. The first section discusses the differences in learning methods (face-to-face, hybrid, and online) and why hybrid learning was prioritized. The second section addresses the first research question, which is: What are the challenges associated with implementing hybrid learning in schools? The difficulties that have arisen in various countries both outside and within Egypt will be discussed. The third section provides a solution to the second research question: What are the essential requirements for implementing hybrid learning in schools? By addressing the most critical classroom design criteria for implementing hybrid education.

2.1. Various Teaching Methods:

The following [Fig.1] illustrates the difference between learning methods (Face-to-face, hybrid, online).

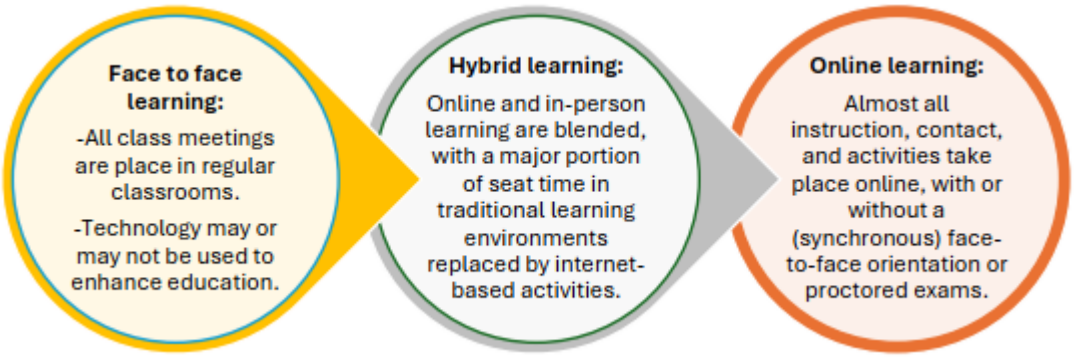


Fig.1 The Difference Between Various Teaching Methods [2]

The following [Table.1] shows the relevance of using hybrid learning during crises and why hybrid learning was prioritized.
Table.1 The benefits of hybrid learning [8]:

benefits	Face to face	Hybrid	Online
Extensive exchange of experiences	√	√	
Student Engagement	√	√	
Manual subject activities.	√	√	
Flexible learning		√	√
Content Personalization		√	√
Used on a vast scale		√	√
Maximize Media's Variety of Resources.		√	√

2.2. Hybrid learning challenges:

In this section, the first research question is, "What are the challenges associated with the implementation of hybrid learning in schools?" Will be answered, but before exploring the challenges that have delayed the implementation of hybrid learning in various countries, we need to understand all the basic elements that comprise the hybrid learning framework. According to [9], hybrid learning is built around four elements: learning management, learning environment, curriculum material, and learning experience. These elements make up the hybrid learning framework.

Considering the focus of the research in architecture, the third element of the hybrid education framework, learning environment, will be discussed, as well as the learning environment issues that hybrid education experiences when implemented. The learning environment was studied through a formula or principle to guide the allocation and management of time and resources for physical class and remote learning .Policy provision and systemic support from MOE/school administration: (1) to empower teachers to be 'curriculum makers'; (2) efficient online learning platform as shown in [Fig. 2]. However, there are crucial design criteria that must be addressed to provide the requirements for hybrid education within classrooms.

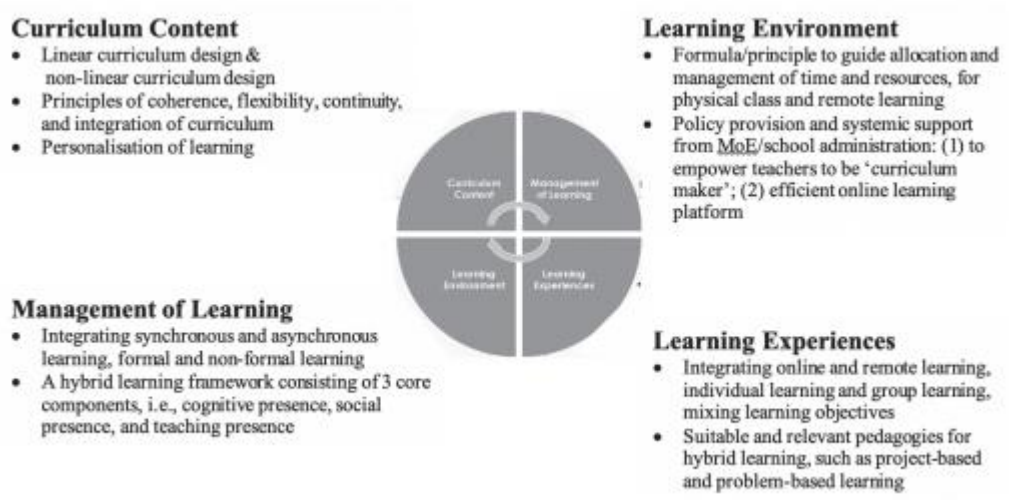


Fig.2 Hybrid learning frameworks [9]

During lockdowns in many developing nations, synchronous online classrooms were preferred and practiced, but uncertain internet connections and a shortage of digital equipment hampered interactions between teachers and pupils [10]. In such circumstances, lessons were supplied and reviewed asynchronously through digital devices to which homework assignments or recorded lessons were sent—via email, mobile phones, or even television channels.

Based on [11], here is a summary of the challenges faced in implementing hybrid learning in different countries:
Argentina: The biggest challenge was the lack of sufficient devices for all learners, especially during online lessons. Some school principals had to lend school computers to the most underprivileged students.
Lithuania: The main challenge was providing the necessary technological equipment within the classrooms to achieve the goals of hybrid learning. There was also a need to train teachers in using modern technologies for education.
Mozambique: The country has not yet entered the era of technological modernization in education. It can be said that the country is still technologically illiterate, with little mastery of the ability to access information available online and capable of modifying the direction of education.
Namibia: The key challenges identified were: (1) lack of digital competence among learners, teachers, and parents; (2) lack of a hybrid learning strategy; (3) lack of integration of hybrid learning in the curriculum; (4) lack of alignment between hybrid learning and core learning theories; (5) lack of quality standards for hybrid learning practices; and (6) lack of technical support for both learners and teachers.
Malaysia: There is a need to improve internet connectivity and provide sufficient devices to ensure equality. Some teachers and parents also needed support to effectively manage their classrooms in a hybrid setting. Reliable internet access and devices are essential for operating hybrid learning. To prevent widening learning gaps, the network and facilities must be available at times suitable for stakeholders.
Many studies in Egypt have identified impediments to the implementation of hybrid education in schools, the majority of which are related to classroom infrastructure [12, 13, 14].

In summary, the main challenges faced across these countries include lack of digital infrastructure and devices, inadequate teacher training on using technology, and the need for a comprehensive hybrid learning strategy integrated with the curriculum and learning theories. However, the infrastructure requirements that must be available within the classrooms were not mentioned, and this is what will be addressed in the third and final part of the previous studies.

2.3. Hybrid learning requirements:

In this section, the second research question will be answered, which is "What are the essential requirements for implementing hybrid learning in schools?

Studies focus on the services that should be available in the classrooms to facilitate the process of hybrid learning. Classrooms are spaces for teaching and learning. Typically, a general classroom contains a blackboard, a lectern, tables, and chairs. To make classroom activities more efficient, electronic devices such as a microphone, a projector, a video camera, and a computer have been increasingly used in the past few decades. Today, an internet-connected computer with a presentation system has become a fundamental requirement for classrooms [15]. To motivate and engage students during the learning process, interactive whiteboards

are utilized [16]. The interactive whiteboard is defined as a large touch-sensitive board connected to a digital projector and a computer [17]. Its main feature is the ability to control the computer by touching the screen [18]. It provides functions that facilitate teaching and learning, such as accessing the internet for additional educational resources, sending screen captures to learners, and magnifying images to improve readability [17, 19]. and allows for displaying texts, images, animations, and video clips [20]. However, we can't ignore the importance and existence of the traditional whiteboard inside the classroom.

Projectors have become one of the most important media in modern teaching [21], making teaching and learning more convenient than using traditional whiteboards [22]. The optical system is efficient, producing very strong light without turning off the room lights, allowing it to operate text and images that can be adequately projected onto the screen [23].

The existence and use of cameras are significant and interesting phenomena during hybrid learning in educational settings [24, 25]. Students can utilize the webcam to follow their instructors and classmates on the monitor, allowing them to communicate with one another, which is like traditional learning in the classroom. Instructors and pupils communicate via visual clues such as smiles, frowns, head movements, and displays of perplexity, weariness, and exhaustion that may assist pupils in learning [7].

Listening is an important part of the learning process [26], and it is linked to comprehension. The acoustics of classrooms and the effectiveness with which teachers transmit instructions to students have a significant impact on academic achievement. Academic failure might result from a student's inability to hear the teacher clearly and consistently [27]. According [28], understanding lessons in the classroom is the outcome of effectively receiving and hearing instructions. To improve the teaching process in classrooms, there must be speakers and microphones.

Over the last few years, the rapid growth of information and communication technology has resulted in the usage of computers, tablets, and smartphones in education [29, 30]. As a result, a new educational community has arisen in which learning using these types of mobile devices (known as mobile learning) has become an essential educational instrument at both the pre-university [31]. Students' use of interactive tools in the classroom, such as clickers and a clipboard, also helps to facilitate the teaching process.

Other requirements within classrooms for a comfortable educational environment include the presence of a podium or table for the teacher and a designated area for a computer connected to interactive screens or a projector. Desks and chairs for students should be flexible and can be rearranged according to individual or group activities [15]. To accommodate the emergency conditions of the COVID-19 pandemic, physical distance must be followed between student seats to limit the spread of the virus. Another requirement that must also be followed is the presence of shades to block light when operating both interactive boards and projectors. The visual environment in the classroom needs to provide visual comfort, a state in which students can see the whiteboard and their desks without any difficulty (such as direct sunlight or insufficient light) [32]. The building occupants' use of manual or sensor windows shades greatly affects the visual environment and comfort [33].

Several studies have shed light on the impact of lighting on students' progress in concentration and learning [34, 35]. One study indicated that concentration and comprehension improved significantly with the use of ventilation and lighting. [36] suggested that using daylight as the primary source of lighting in classrooms can provide an enjoyable visual environment and affect students' academic performance [37]. Industrial lighting and ventilation play a crucial role in classrooms, as students were more likely to turn on or request artificial lighting when the curtains were closed during the use of projectors or interactive whiteboards [38]. Additionally, closing the windows during the use of projectors leads to increased temperature and humidity levels [39], which can affect students' concentration [15]. Therefore, it is also necessary to use fans or HVAC systems in the classroom. To adapt to the conditions of the COVID-19 pandemic, it is preferable to add air purifiers [40] and use virus-resistant lighting [41] to reduce the spread of the virus inside the classroom.

2.4. Conclusion of Literature Reviews:

From previous studies, it can be inferred that there are three basic requirements for hybrid learning within learning spaces: technological requirements, furniture requirements, and environmental requirements, which are design criteria for classrooms in schools. This is illustrated in the following [Fig. 3].

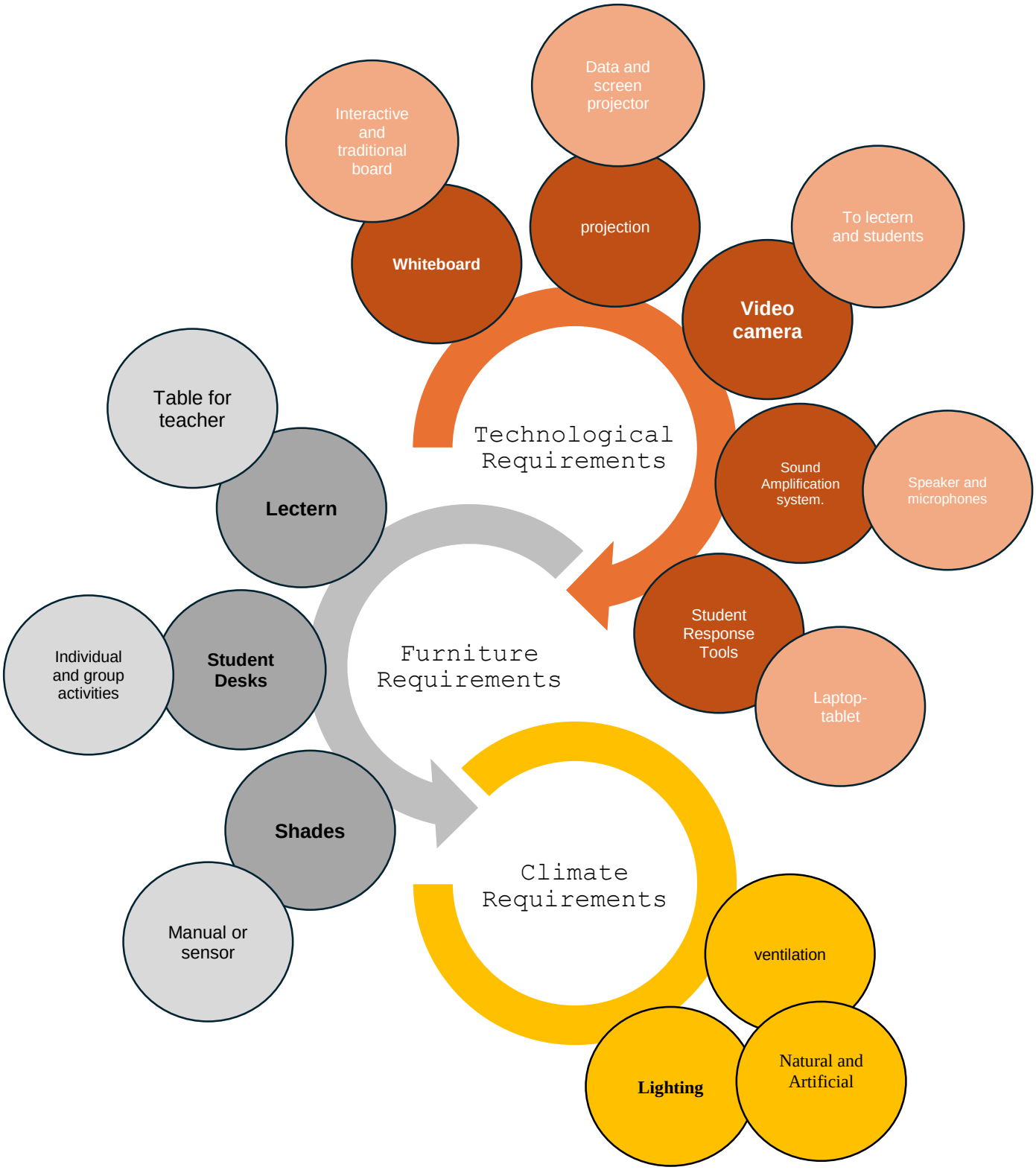


Fig.3 Design criteria for hybrid Learning in Educational Spaces. **[Source: Authors]**

3. METHODS AND MATERIALS:

3.1. The study methodology incorporates two approaches:

A. A qualitative approach based on a literature review to determine the design criteria of hybrid learning, as illustrated in [Fig. 3].

B: A comparative analysis of hybrid learning requirements in six government schools, three in Egypt and three outside Egypt, at various educational levels.

- First, the schools outside Egypt Several schools have been selected, and they are:

1. Rathbeggan National School (primary school) in the Growtown, Dunshaughlin, Co. Meath, Ireland, northwestern Europe.
2. The Chapin School (preparatory school) in New York, United States.
3. Woods Cross High School (secondary school) in Woods Cross, Utah, United States, as shown in [Fig. 4].

- Second, the schools inside Egypt, specifically in upper Egypt in Minya and New Minya city, are:

4. New Minya for Basic Education.
5. El Horeya Preparatory School for Boys.
6. Muhammad Wahid Habashi School (New Secondary School for Girls), as shown in [Fig. 4].

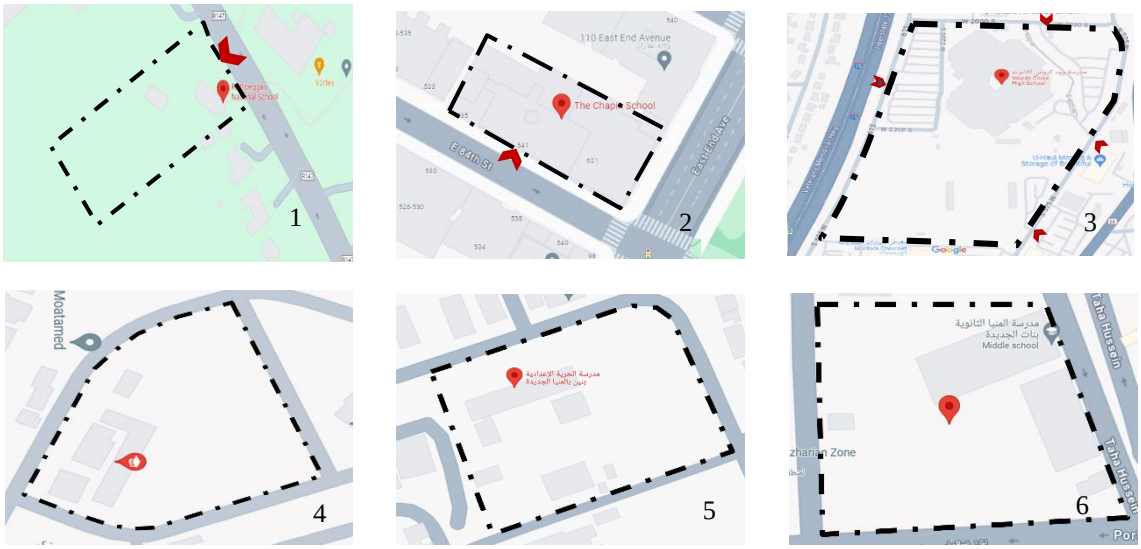


Fig.4 The Location of Schools. [Source: Authors by Google Maps]

3.2. Reasons for selecting schools:

- First, the constants reasons are that:

1. All the schools inside and outside Egypt are national.
2. According to UNESCO reports [42], the schools were closed for 16 weeks during the spread of the COVID-19 virus.

- Second, the variables reasons are that:

1. For schools inside all cities in Egypt, are all similar in design.
Schools were chosen specifically in Minya and New Minya city due to their nearness to the author's residence, ease of filming, and data collection.
Although the author obtained approval from the Education Directorate in Minya to take photos, some school headmasters refused to allow him to take photos, and the educational media in the schools gave the author the photos. Therefore, there were some limitations that the author faced during the analysis of images in the analytical study.

2. For schools outside Egypt, different design criteria were taken to prevent diseases, such as (the use of HEPA air filters [43], and antimicrobic lighting, and different Facilities and infrastructure were used which will be explained in the analytical part. The following figures illustrate what was used in all classrooms [Fig 5, 6, 7].
All the photos were available on the official websites of each school, so there are no limitations for the author in analyzing those images.

3.3. The technological requirements in the classrooms of Egyptian schools [Fig.5]:

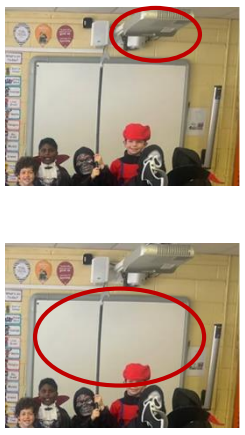
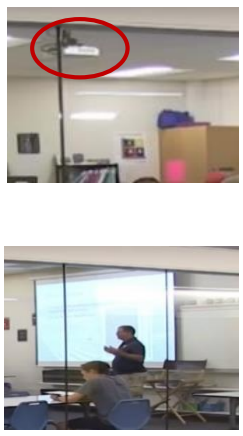
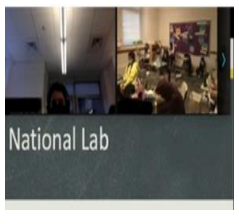
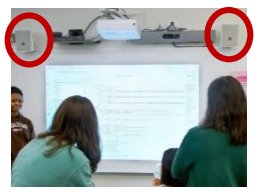
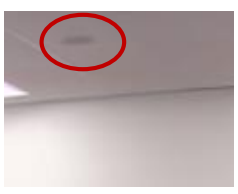
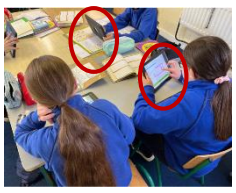
Schools / furniture requirements		National schools outside Egypt			National schools in Egypt		
		Rathbeggan National School (Primary school)	The Chapin School (Preparatory School)	Woods Cross High School (Secondary School)	New Minya School for Basic Education:	El Horeya Preparatory School for Boys new Minya	Muhammad Wahid Habashi School (New Secondary School for Girls):
3.1.1 whiteboard Board for different teaching methods:	Interactive board:		X	X	X	X	
	Traditional White – black board:						
3.1.2 Projection tools:	Data Projectors						X
	Projection screen						X
3.1.3 Video camera	Video camera to board or lectern	X		X	X		X
	Video camera to student	X		X	X	X	
3.1.4 Sound Amplification system	Speaker for (Student – teacher)				X	X	X
	Microphones for (Student – teacher)	X			X	X	X
3.1.4 Student Response Tools	Tablet		X	X	X	X	
	Laptop	X		X	X	X	X

Fig.5 The Technological Requirements in classrooms. [Source: Authors]

3.4. The furniture requirements inside the classrooms as shown, [Fig.6]

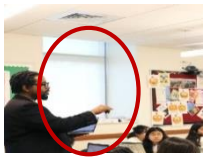
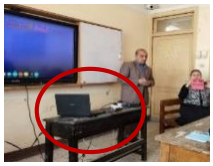
	Schools / furniture requirements	Lectern Table for teacher	Flexible Student desks For Individual activities	 For group activities	 social distancing between desks	Window Shades Manual or by sensors
National schools outside Egypt	Rathbeggan National School (Primary school)					
	The Chapin School (Preparatory School)					
	Woods Cross High School (Secondary School)					X
National schools in Egypt	New Minya School for Basic Education:	X				
	El Horeya Preparatory School for Boys new Minya					
	Muhammad Wahid Habashi School (New Secondary School for Girls):					X

Fig.6 The Furniture Requirements in classrooms. [Source: Authors]

3.5. *The Climatic requirements in the classrooms, as shown [Fig.7]*

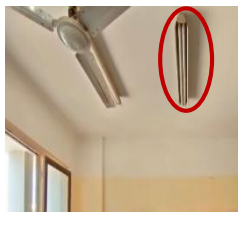
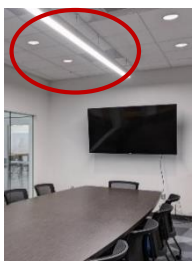
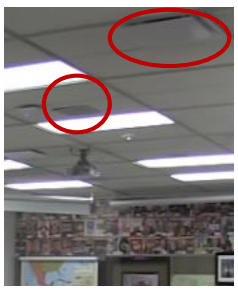
Schools / Climatic requirements		*National schools outside Egypt*			*National schools in Egypt*		
		Rathbeggan National School (Primary school)	***The Chapin School (Preparatory School)***	***Woods Cross High School (Secondary School)***	***New Minya School for Basic Education:***	***El Horeya Preparatory School for Boys new Minya***	***Muhammad Wahid Habashi School (New Secondary School for Girls):***
Lighting for different teaching methods	***Natural***			X			
	Artificial						
	Artificial lighting suitable for Pandemic	X	X		X	X	X
Ventilation for different teaching methods	***Natural***			X			
	Fans	X	X	X			
	Air conditioner for temperature and humidity				X	X	X
	Air purifier suitable for Pandemic		X	X	X	X	X

Fig.7 The Climatic requirements in classrooms. [Source: Authors]

The research presents a comparative analysis of design criteria for hybrid learning requirements in all schools, as shown in [Table 2].

Table 2: An analysis of design criteria for hybrid learning requirements in classrooms in and outside Egypt. [Source: Authors]

Schools / Hybrid Learning Requirements			*Icons*	*National schools outside Egypt*			*National schools in Egypt*		
				Rathbeggan National School (Primary school)	*The Chapin School (Preparatory School)*	*Woods Cross High School (Secondary School)*	*New Minya School for Basic Education:*	*El Horeya Preparatory School for Boys new Minya*	*Muhammad Wahid Habashi School (New Secondary School for Girls)*
Technological Requirements	*whiteboard for different teaching methods*	*Interactive whiteboard*		√					√
		Traditional Whiteboard		√	√	√	√	√	√
	projection tools	*Data Projectors*		√	√	√	√	√	
		Projection screen		√	√	√	√	√	
	Video camera for different teaching methods	*to board or lectern*			√			√	
		To Student			√				√
	Sound Amplification system	*Speaker for (Student – teacher)*		√	√	√			
		Microphones for (Student – teacher)			√	√			
	Student Response Tools	*Laptop*			√				
		tablet		√					√
Realized Points of Technological Requirements				*6/10*	*8/10*	*5/10*	*3/10*	*4/10*	*4/10*
Furniture Requirements	*Lectern*	*Table for teacher*		√	√	√		√	√
	Flexible Student desks	*For Individual activities*		√	√	√	√	√	√
		For group activities		√	√	√	√	√	√
		social distancing between desks		√	√	√	√	√	√
	Window Shades	*Manual or by sensors for different teaching methods*		√	√		√	√	
Realized Points of Furniture Requirements				*5/5*	*5/5*	*4/5*	*4/5*	*5/5*	*4/5*
Climatic Requirements	*Lighting for different teaching methods*	*Natural*		√	√		√	√	√
		artificial		√	√	√	√	√	√
		Artificial lighting suitable for Pandemic				√			
	Ventilation for different teaching methods	*Natural*		√	√		√	√	√
		Fans					√	√	√
		Air conditioner for temperature and humidity		√	√	√			
		Air purifier suitable for Pandemic		√					
Realized Points of Climatic Requirements				*5/7*	*4/7*	*3/7*	*4/7*	*4/7*	*4/7*
Total of Required Points				*22 Points*					
Total of Realized Points				*16/22*	*17/22*	*12/22*	*11/22*	*13/22*	*13/22*

Realized Points				**Unrealized Points**	
√	√	√			

4. RESULTS AND DISCUSSION:

This section covers the results of design criteria for hybrid learning and Similarities and differences between case studies.

4.1. *Technological Requirements:*

4.1.1. Traditional or smart whiteboards: In national schools in Egypt, interactive boards were only used in secondary school classrooms, while traditional whiteboards were used in all classrooms. In national schools outside Egypt, interactive boards were only used in primary school classrooms, while traditional whiteboards were used in all classrooms, as recommended [15, 16, 17, 18].

4.1.2. Projection Tools: In National Schools in Egypt, projectors and projection screens have been used in primary and preparatory school classrooms but have not been used in secondary school classrooms. In national schools outside Egypt, projectors and projection screens have been used in all classrooms, as recommended [20, 21, 22].

4.1.3. Video camera for different teaching methods: In national schools in Egypt, the video camera for Lectern was used in preparatory school classrooms to convey lessons during the COVID-19 pandemic, and the camera for students was used in secondary school classrooms. In national schools outside Egypt, the video camera for Lectern and students was used in preparatory school classrooms, as recommended [23, 24].

4.1.4. Sound Amplification System: In national schools in Egypt, speakers or microphones have not been used inside all classrooms. In national schools outside Egypt, speakers were used in all classrooms, while microphones were used in preparatory and secondary school classrooms, as recommended [25, 27].

4.1.5. Student Response Tools: In National Schools in Egypt, the tablet was only used in secondary school classrooms, and no interactive tools were used in all classrooms. In national schools outside Egypt, laptops were used in preparatory school classrooms, and the tablet was used in primary school classrooms, as recommended [28, 29].

Finally, national schools in Egypt covered 30 to 40% of the technology requirements in their classrooms, compared to 50 to 80% in national schools outside Egypt, as shown in [Fig 8, 9, 10].

4.2. *Furniture Requirements:*

4.2.1 Lectern: In national schools in Egypt, the lectern was used only in secondary and preparatory schools. In national schools outside Egypt, the lectern was used in all classrooms, as recommended [14].

4.2.2 Flexible Student Desks: In National Schools in and outside Egypt, the flexibility of the student desks has been considered to allow for individual or group work in all classrooms, while social distancing has been implemented between the students' desks during the spread of the COVID-19 pandemic in all three educational stages in national schools in and outside Egypt, as recommended [14].

4.2.3 Window Shades: In National Schools in and outside Egypt, manual shading for windows has been used in only primary and preparatory school classrooms, as recommended [31, 32].

Finally, national schools in and outside Egypt became similar in their classroom furniture requirements by a percentage ranging from 80 to 100%, as shown in [Fig 8, 9, 10].

4.3. *Climatic Requirements:*

4.3.1. Lighting for different teaching methods, as recommended [33, 34, 35, 36]:

Natural lighting: In national schools in Egypt, natural lighting was employed in all three school classrooms. In national schools outside Egypt, natural lighting was employed in only primary and preparatory school classrooms. Artificial lighting: In national schools in and outside Egypt, artificial lighting has been used in all classrooms. Artificial lighting for the pandemic: In national schools outside Egypt, antiviral lighting was only used in secondary schools.

4.3.2. Ventilation for different teaching methods, as recommended [37,38,39,40]:

Natural Ventilation: In national schools in Egypt, natural ventilation was employed in all three school classrooms. In national schools outside Egypt, natural ventilation was employed in only primary and preparatory school classrooms. Artificial ventilation (fans) was employed in all three school classrooms. In national schools in Egypt. Air conditioning: HVAC systems were used in all national schools outside Egypt. Air purifiers for the Pandemic: Air purifiers were used for epidemics within secondary schools outside Egypt.

Finally, national schools in Egypt covered 57 % of the Climatic requirements in their classrooms, compared to 43 to 71% in national schools outside Egypt, as shown in [Fig 8, 9, 10].

4.4. *Assessment of the hybrid learning requirements in schools:*

The following [Fig 8, 9, 10] shows an assessment of hybrid learning requirements for primary schools in and outside Egypt.

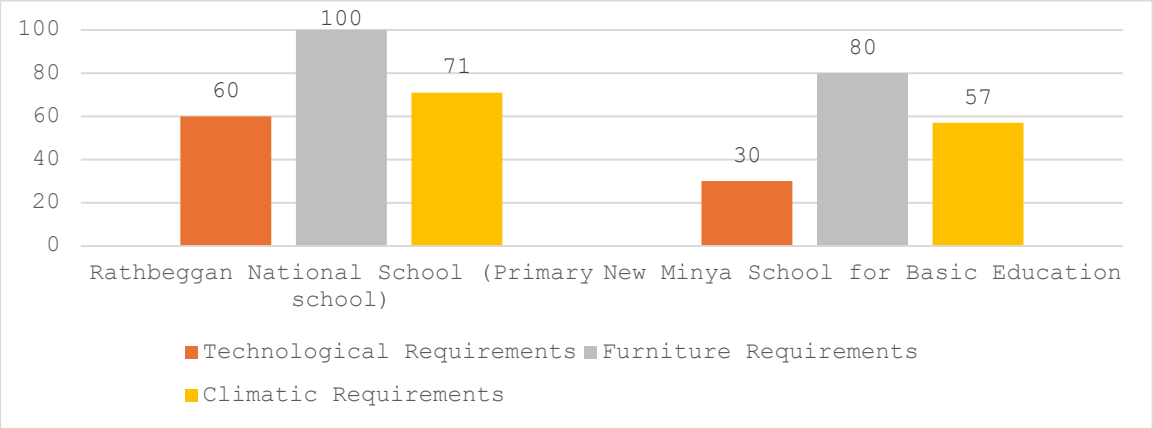


Fig. 8 Assessment of hybrid learning design criteria for primary schools in case studies. [Source: Authors]

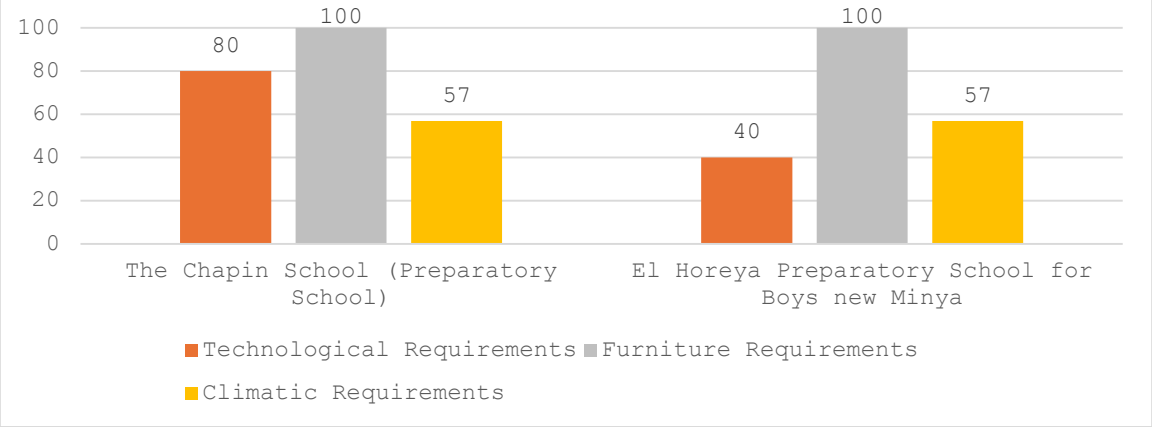


Fig. 9 Assessment of hybrid learning design criteria for Preparatory schools in case studies. [Source: Authors]

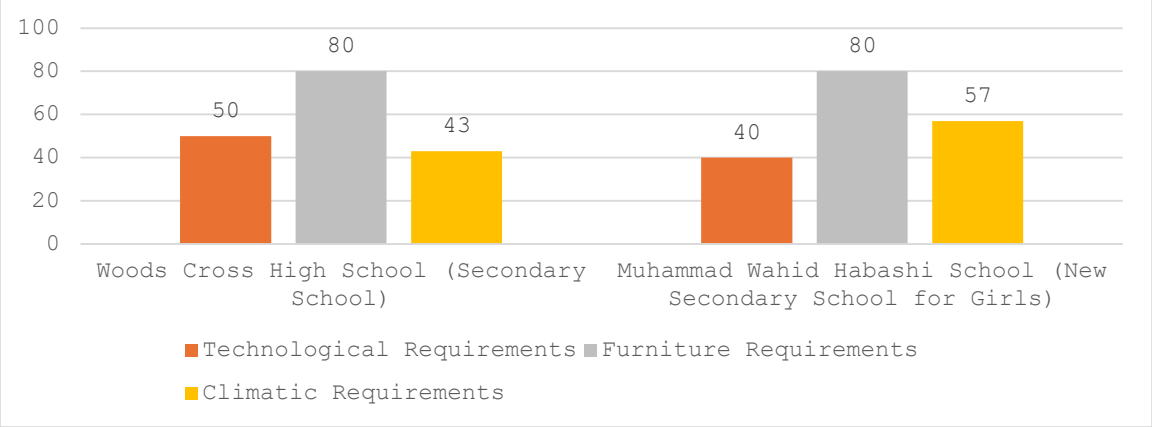


Fig. 10 Assessment of hybrid learning design criteria for Secondary schools in case studies. [Source: Authors]

Finally, the following [Fig 11]. show Comprehensive assessment of hybrid learning requirements in all school in and outside Egypt.

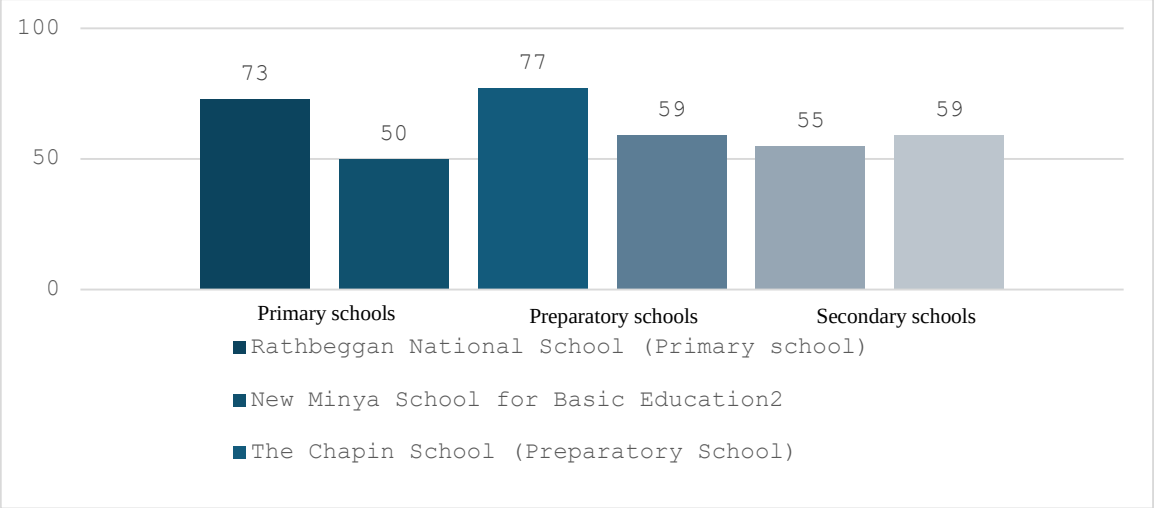


Fig. 11 Comprehensive assessment of hybrid learning design criteria in all case studies. [Source: Authors]

5. CONCLUSION:

The research focuses on the importance of implementing hybrid learning in Egyptian schools during crises. To achieve this, it is necessary to provide design criteria for hybrid learning inside the classrooms, which is the main aim of this research. The study provides guidelines that should be considered in classrooms to enhance hybrid learning, as follows:

- **For technological requirements:**

After analyzing the technological requirements in Egyptian classrooms at three levels (primary, preparatory, and secondary), it was shown that the technological requirements are deficient, with schools just conferring 30 to 40% of the criteria. To increase this rate, the following must be added: Interactive whiteboards inside the classrooms and ensure the availability of internet service inside the classrooms, Projectors and projection screens in the classrooms, and a video camera for students' desks and lecterns to be used at distance learning and connected to the internet, Speakers and microphones to enhance the educational process, and finally Providing students with computer devices, such as tablets and laptops, should be personal tools for each student.

- **For furniture requirements:**

Schools have achieved the requirements of classroom furniture by a high percentage. To keep or enhance that percentage, the following must be added:
Providing a lectern for the teacher equipped with a place for a laptop and internet. Adding manual or electronic shades, whether for use during presentations or with interactive whiteboards. For enhancing, regular maintenance for student desks and ensuring the flexibility of desk furniture to be used in various teaching methods.

- **For climatic requirements:**

Schools have achieved climatic requirements in classrooms by 57%. To enhance this percentage, the following must be added:
For Lighting: Adding disease-resistant lighting to classrooms and using it to combat the spread of diseases, such as what happened during the COVID-19 pandemic.
For artificial ventilation: Adding HVAC systems in classrooms and using them while using projectors or interactive boards, which may require closing windows, leads to increased levels of carbon dioxide, humidity, and temperatures, affecting the educational process. Adding air purifiers to classrooms and using them during crises such as the spread of a pandemic or others. Regular maintenance of artificial lighting in classrooms and regular maintenance of artificial ventilation (fans) inside classrooms.

6. CONFLICT OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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