Cost Effective DIY OBS based Smart Hybrid Mode Classroom

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\textbf{ABSTRACT}

The pandemic of COronaVirus Disease (COVID)-19 has resulted in schools and universities shut all across the world. Globally, around 1.6 billion children are out of the classroom [1]. It causes significant disruption to the provision of education, training, and mobility opportunities for students, learners, instructors, faculty members, and educators. Online digital tools should serve different educational purposes [1]. They should support the following basic requirements of teaching and learning methods: connecting educators and learners with each other when in separate locations, accessing information and environments not usually available in every home or institution and supporting continued professional development of educators in a flexible way [1].

While some solutions, for instance, using expensive components like electronic smart boards, real time tracker like Pan-Tilt-Zoom (PTZ) cameras, smart markers, and interactive projector cannot be afforded by everyone. Especially, in this kind of crisis, careful consideration of all expenses is necessary. Therefore, in this white paper we propose an efficient Do-It-Yourself (DIY) teaching system implemented from an existing classroom and a free software Open Broadcaster Software (OBS) studio with very low additional cost. The system can support both live virtual and physical face-to-face classrooms with full interaction and user-friendliness yielding an online user experience that is similar to an actual classroom. The idea is very useful for any schools and universities without financial obstacle. In addition, it will not be only a fixing solution for the COVID-19 pandemic, but also a flexible mode of education that can attract people who are working in companies and do not want to or cannot leave their jobs or people who cannot be all the time on campus to study.

\textbf{KEYWORDS}

Open Broadcaster Software (OBS) studio, Hybrid Mode Instruction, Snap Camera, Virtual Machine

\textbf{1 Introduction}

Due to the widespread of CORonaVirus Disease (COVID-19) across the world, following the requirements of “nonstop teaching and learning,” most schools and universities have started online education. In a short time period, millions of teachers, instructors, faculty members, and educators started to teach in front of a computer screen, and their students have to stay at home and take the courses through the Internet [2]. A hybrid of in-person or face-to-face lesson and online distance learning is one of the many proposed models for the future of the technology-assisted classroom [3].

While an expensive system upgrading a classroom for such a blended learning might be proposed as a solution of some schools or universities, which have no financial problems, not everyone (school or university) can afford that. Electronic smart boards, real time tracker like Pan-Tilt-Zoom (PTZ) cameras, smart markers, and interactive projector may be the answer to help them make lessons relatable to their students and to help students stay connected to what they need for their future. The costs of these devices are very high, for instance, an electronic smart board can cost up to around US Dollar (USD) 10,000 or Thai Baht (THB) 300,000 or a Pan-Tilt-Zoom (PTZ) camera can cost up to USD 1,000 or THB 30,000 or and interactive whiteboard with projector for interactive presentations can cost around USD 1,400 or THB 44,000-USD 16,000 or THB 499,000 dependent of their specifications [4]-[7]. Of course, not only one classroom that we will plan to have. Basically, we should upgrade all existing classrooms or as many classrooms as possible. Thus, the total cost will be the cost of one set multiplied by the number of classrooms.

Therefore, this white paper proposes an cost effective Do-It-Yourself (DIY) smart hybrid mode instruction system upgraded from an existing classroom with very low cost. The system can support both live online and physical face-to-face classrooms with full interaction and user-friendliness. The proposed system consists of the Hardware (HW) components and the Software (SW) components. The HW part consists of the traditional classroom components, i.e., 1 existing computer with the additional Graphics Processing Unit (GPU) card, 1 existing projector, 2 existing Microphones (Mics) for instructor and students with 1 loudspeaker and the additional components, i.e., 3 Webcams (USB cameras). The SW part consists of a video-conferencing application and a free SW called “Open Broadcaster
Software (OBS) studio,” and another optional free SW “Snap Camera.” The whiteboard camera, the classroom camera, and the shared screen (the screen capture of the projector) are controlled by the OBS studio. The online students can experience a class similar to the students in the physical classroom. They can switch their view to watch the slides or the whiteboard by themselves whereas a system with just a computer cannot fulfill this requirement.

The idea is very useful for any schools and universities. As a result, education can be continued to persist post-pandemic whereby teaching is undertaken both remotely on digital platforms and in physically classrooms. Such a shift would impact the worldwide education market since this flexible mode of education can attract people who are working in companies and do not want to or cannot leave their jobs or people who cannot be all the time on campus, for example, housewives taking care of their babies to join our academic programs.

2 System Components

Our proposed cost effective Do-It-Yourself (DIY) smart hybrid mode classroom consists of the Hardware (HW) components and the Software (SW) components.

The HW part consists of the traditional classroom components, i.e., 1 existing computer with the additional Graphics Processing Unit (GPU) card, 1 existing projector, 2 existing Microphones (Mics) for instructor and students with 1 loudspeaker and the additional components, i.e., 3 cameras or more (They can be either Webcam (USB camera), Digital Single-Lens Reflex (DSLR) camera or Mobile phone) and 1 additional computer display. The HW interface or each port of the Central Processing Unit (CPU) of the computer is shown in Figure 1. The additional GPU card is required to support three displays, i.e., the computer’s own display, the projector, and the additional computer display showing the online students’ faces.

![Figure 1 HW interface of Central Processing Unit (CPU)](image1)

As shown in Figure 2 the SW part consists of a video-conferencing application or software, e.g., Zoom, Google Meet, Skype, Microsoft Teams or Cisco Webex. The Zoom SW running on the computer is used for explanation in the white paper since we are using it. A free SW called “Open Broadcaster Software (OBS) studio,” and another optional free SW “Snap Camera” are used in the proposed system. The whiteboard camera, the classroom camera, and the shared screen (the screen capture of the projector) are controlled by the OBS studio.

![Figure 2 SW integration](image2)

**What is OBS Studio [8]?**

OBS studio is a free and open-source software suite for recording and live streaming. Written in C, C++ and Qt it provides real-time source and device capture, scene composition, encoding, recording, and broadcasting. Transmission of data is primarily done via the Real Time Messaging Protocol (RTMP) and can be sent to any RTMP supporting destination, including many presets for streaming websites, such as YouTube, Twitch, Instagram and Facebook [8]. It can help manage multiple screens, scenes, very well. There are versions of OBS studio available for Microsoft Windows (both version 7 and 10), MacOS, and Linux distributions, i.e., compatible with Windows, Mac, and Linux AMD FX series or Intel i5 2000-series processor (dual or 4-core preferable) or higher DirectX 10 capable graphics card. At least 4 GB of RAM is recommended, but not necessary. The bandwidth requirements are as follows:

- 2.0 Mbps up and down for single screen,
- 2.0 Mbps up 4.0 Mbps down for dual screen,
- 2.0 Mbps up 6.0 Mbps down for triple screen,
- For screen sharing only: 150-300 kbps, and
- For audio Voice over Internet Protocol (VoIP): 60-80 kbps.

**What is Snap Camera [9],[10]?**

Snap Camera is a free SW that can let us apply lenses to our face while using our computer’s webcam. Snap Camera creates a virtual webcam on our computer. When Snap Camera is open, it takes the input of a physical webcam and then augments it with the selected lens. This augmented video is then output to the Snap Camera virtual webcam [9],[10]. In our application, we use Snap Camera for the green screen purpose.

3 Methodology

The system requirement is as follows. Both students in the physical classroom and online students can see the documents,
e.g., slide, video, from the projector and from the shared screen on the video-conferencing application, which is a Zoom SW as earlier mentioned. This can be easily switched to the whiteboard view. Online students can see the face of the instructor clearly.

As can be seen in Figure 3 the proposed systems are done by setting 3 Webcams (USB cameras) which are pointed to the instructor’s face, the whiteboard, and the classroom environment (students in the classroom). It is to note that the number of Webcams can be more if we want to show more views to the online students and is limited by the possible connections, i.e., USB ports and Wi-Fi connection of the computer. The classroom or instructor microphone (Mic.) is set up. Of course, it is attached with the instructor during teaching and known as clip microphone. The classroom views seen by the online students and the instructor are shown in Figures 4 (a) and (b), respectively.

The step-by-step setup procedure is explained as follows: 1.) installing the Zoom, the OBS studio and the Snap Camera on the computer, 2.) connecting Webcams to the computer, and 3.) connect the all display devices (Projector/computer display/additional computer display for showing the online students’ faces) to the computer’s VGA output. Then, we open the OBS studio.

The instructor’s face can be shown overlaying on the slide or document without the real background is done by the Snap Camera with a green screen lens. Then, we call it as a “Video Capture Device” and adjust the green screen using the “Chroma Key filter” in the OBS studio as can be seen in Figure 6. Now the instructor can be smoothly overlaid on any document’s screen as can be seen in Figure 7. Now we can add the Zoom window as another source by using either “Window Capture” or “Display Capture.” It is to note that the SW setting is just one-time setting, which gives the user-friendliness to instructors. Figures 8 (a) and (b) show the online students’ views, i.e., the whiteboard and the (shared document) slide with the overlaid instructor’s face and classroom view.

Audio System

The OBS studio can be used to connect multiple audio inputs. Our proposed system uses two microphones (Mics.). The one is the instructor’s clip microphone and the other is for the students. The
radio frequency receiver of the instructor’s clip microphone is connected to the microphone slot in the computer. The students’ microphone is connected to the LINE IN slot in the computer. Both microphones are added to the OBS studio and adjusted each volume/gain as suitable to the classroom. A trial and error method can be used to adjust the volumes of the microphone and audio amplifier system to avoid feedback effects. As a final step, a feature in the Zoom SW is selected to broadcast the voice online. It can also be used with the Webcam (USB camera) microphone by configuring through the OBS studio.

Figure 5 Using Snap Camera with a green screen lens

Figure 6 Instructor’s face with the green screen and the Chroma Key filtering in the OBS studio

Figure 7 Instructor smoothly overlaid on any document’s screen

Figure 8 Online students’ views (a) whiteboard and (b) shared document (slide)

**Flexibility for Online Students**

Another requirement is to allow the online students selecting the screen by themselves. They have flexibility in switching from the shared document screen to the whiteboard screen and vice versa anytime they want. This can be done by connecting to the Zoom with another account. However, to avoid the extra expense from using the second computer, the concept of Virtual Machines (VMs) or Virtual Personal Computers (VPCs) is a software computer that provides the same functionality as a physical computer is used here [12].

Although VMs have the advantages that they are simply managed, maintained, and are widely available their drawbacks, which can cause unstable performance, e.g., running slower than a physical computer or creating latency of sharing a video, are needed to be taken into account. We solve this problem by using a USB3 Wi-Fi dongle, which costs 29 USD or THB 890, for connecting with the VM. Our computer is Lenovo i5 (7th generation) processor, 8 cores, 8 GB RAM, 180-Watt power. Everything satisfies the Zoom’s recommendation in both VM and physical machine, i.e., the packet loss is 0, the jitters are in average (avg) equal or less than 2 ms, and the latency is in avg about 70 ms. The detailed information about the performance of the test of using the VM is reported along with the Zoom recommendation in Table I [11].
The system can support both live multiple computer displays and recorded videos, which is a huge advantage over other options, such as Zoom or Teams. The proposed system is a great idea for schools and universities, and it will not be only a fixing solution for the COVID-19 condition. As a result, it will not be only a fixing solution for the COVID-19 condition. Consequently, the total minimum additional cost for implementing our system with a 55" computer display is about THB 42,000 or USD 1,350 which is much cheaper than spending money for the expensive solution addressed earlier.

6 Conclusion

We proposed a cost effective DIY smart hybrid mode instruction system implemented from an existing classroom based on the free softwares, “OBS studio” and “Snap Camera” with very low cost. The system can support both live virtual and physical face-to-face classrooms with full interaction and user-friendliness. The VM was applied instead of using another computer to give flexibility to online students in switching from the shared document screen to the whiteboard screen and vice versa anytime they want. This would seem to make for an online user experience that is similar to an actual classroom. The proposed system is a great idea for any schools and universities without financial obstacle. In addition, it will not be only a fixing solution for the COVID-19 pandemic.

Table I Detailed Information of the test of using the VM

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<thead>
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<th>Network physical interface</th>
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<tr>
<td>Network Bandwidth</td>
<td>&gt; 2.5 Mbps up, 4.0 Mbps down</td>
<td>avg: 20 Mbps up, 40 Mbps down</td>
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<tr>
<td>Latency (Sharing, Receiving)</td>
<td>&lt; 150 ms</td>
<td>avg: 70 ms</td>
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<tr>
<td>Jitters (Sharing, Receiving)</td>
<td>&lt; 25 ms</td>
<td>avg: 0 - 2 ms</td>
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<td>Packet Loss (Sharing, Receiving)</td>
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<tr>
<td>Frames Per Second (FPS)</td>
<td>20 &lt; FPS &lt; 30</td>
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<table>
<thead>
<tr>
<th>Operating System</th>
<th>Win7 / Win10/ Mac</th>
<th>Win 10 Edu</th>
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<tr>
<td>Network Bandwidth</td>
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<td>avg: 15 Mbps up, 15 Mbps down</td>
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<tr>
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<tr>
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<td></td>
</tr>
<tr>
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<td>0.0%</td>
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<td></td>
</tr>
<tr>
<td>Frames Per Second (FPS)</td>
<td>22 fps</td>
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<tr>
<td>Frames Per Second (FPS)</td>
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<td>N/A</td>
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Note that: *We tested for the most extreme condition of the Zoom recommendation. We turned on the optimized sharing video in the Zoom SW to address that the video will automatically resize and run with more than 20 frame per second (fps).

4 Comparison between Instructor’s View and Online Students’ View

In the OBS setup the instructor has full attention of the online students since the instructor controls the screen of the online students. On the other hand using the VM setup the online students have more flexibility in switching from the shared document screen to the whiteboard screen and vice versa anytime they want as earlier described.

5 Budget Plan

Our propose system uses only 1 computer which can be a Personal Computer (PC) with a GPU card. An example of the cost of each component is shown as follows:

1. PC: CPU i5: THB 7,000 or CPU i7: THB 12,000, Motherboard: THB 5,500, Hard disk: THB 1,000, Casing: THB 5,500, Power Supply: THB 3,000, and RAM 16 GB media 4: THB 4,000. The total cost of a PC is about THB 26,000-31,000.

2. 1 GPU card: GDDR5 AMD RX570 POWER COLOR RED DRAGON OC, 4GB: THB 3,990 supporting 3 display ports (minimum criteria) or GTX1660, 6GB: THB 7,000 supporting 3 display ports or GTX1070, 6GB: THB 9,000 supporting 4 display ports or Workstation Graphic card: Quadro P2000, 8GB: THB 20,000 supporting 4 display ports, supporting share with many machines.

3. 3 Webcams (USB cameras): THB 1,500-4,400.

4. 1 additional computer display: The prices is dependent of how large, resolution, response time, refresh rate (60Hz, 120 Hz, 144 Hz, 240 Hz), and the brand. Some Examples are 24", 1080, 75Hz In-Plane Switching (IPS) Monitor: THB 3289, 34", Curved Gaming 144 Hz: THB 12,900, 49": 32:9 Curved 120 Hz FreeSync LCD Gaming Monitor: 29,000 THB, possible 55" THB 10,000-28,000.

Consequently, the total minimum additional cost for implementing our system with a 55" computer display is about THB 42,000 or USD 1,350 which is much cheaper than spending money for the expensive solution addressed earlier.
pandemic, but also a flexible mode of education that can attract people who are working in companies and do not want to or cannot leave their jobs or people who cannot be all the time on campus to study. This can support the new trend of educations.

REFERENCES