Lightboard and Chinese Language Instruction
("光板"与对外汉语教学)

Weibing Ye
(叶为兵)
University of Notre Dame
(圣母大学)
wye@nd.edu

Abstract: The Lightboard, which consists of a specialized glass board, a video camera, and a real-time presenter monitor, is a novel tool that creates instructional videos for hybrid and online courses. It allows an instructor to face viewers through the glass board while simultaneously drawing highly visible sketches or writing notes. Powerpoint slides can also be merged into the Lightboard video, seemingly projected onto the glass board, so that the instructor can annotate and interact with the slides in real time as the video is recorded. Moreover, the final video has much higher quality than traditionally filmed lectures. All these features render the Lightboard a desirable tool for making pedagogical media that can "flip" language classrooms. For example, the Lightboard will serve instructors and students alike through improving the ease of filming short tutorial videos regarding teaching Chinese characters, explaining difficult grammar patterns, correcting common pronunciation errors, while likewise offering homework feedback and review. This article first introduces the Lightboard, including its component parts, working mechanism, and its development history. The paper then analyzes the major advantages and limitations of using Lightboard followed by addressing its implications for Chinese language instruction. Finally, the article provides an example and tips on how to create instructional videos for Chinese courses with the Lightboard system and introduces two ways for installation of a Lightboard studio.

摘要："光板"系统主要由一块可供书写板书的透明玻璃板，摄像机以及实时的视频合成与显示设备而构成，是一款为在线及混合课程打造的新型教学视频制作工具，亦可为传统课堂制作补充教学视频。与传统教学视频相比，"光板"视频的优势在于它将授课者清晰可见的荧光笔板书与幻灯片巧妙地融合到了一块特殊制作的玻璃板上，摄像机透过该玻璃板可以同时捕捉到授课者以及玻璃板上的板书，使得授课者在板书时仍可面向观众，并与板书及幻灯片互动。其优点还在于操作简便，以及最终生成的视频非常高清。因此"光板"是"翻转"语言课堂的理想工具，特别适用于制作辅导短片来教授汉字，解释语法难点，纠正常见的语音错误，提供作业反馈及复习辅导。本文首先介绍了光板的构成部件及工作机制，回顾了其发展历史，随后分析了使用"光

板"的优势和限制，并讨论了其对对外汉语教学的启示。最后本文通过实例演示了如何操作"光板"制作教学视频，并介绍了建立"光板"工作室的两种方式。

Keywords: Lightboard, instructional video, tutorial video, online course, hybrid course, educational technology

关键词：光板，教学视频， 网络课程，混合课程，教育技术

1. Introduction

A Lightboard is a specialized glass board internally illuminated by bright LED strips around its edges. The Lightboard is placed between a presenter and a video camera (Figure 1). The camera captures, through the glass, the presenter who speaks while writing notes on the glass with fluorescent markers. The writing glows brightly with illumination from LED lighting. PowerPoint images and texts can also be overlaid onto the glass simultaneously so that the presenter can annotate and interact with them during recording. The overlaid PowerPoint slides and the glowing handwritten notes are highly visible and seemingly float in the air in front of the presenter (Figure 2). Once filming is complete, the Lightboard generates a high-quality video and saves it instantly to a flash drive attached to the system. The video is ready-to-upload and can be shared with students via Sakai, Google Drive, YouTube or other hosting websites.
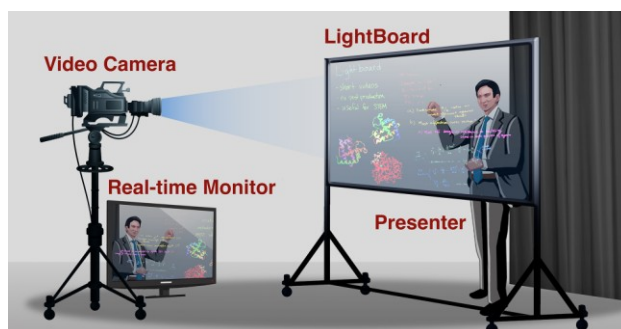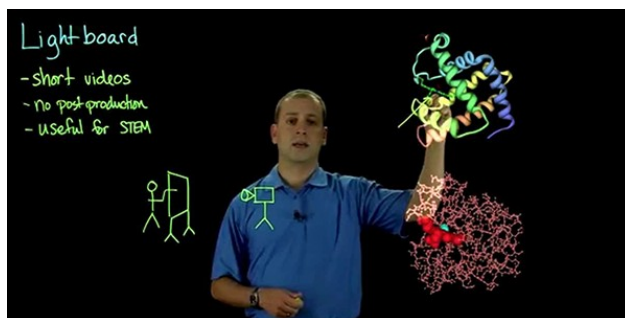

Figure 1: The Lightboard system

Figure 2: Powerpoint superimposed for demonstration with hand-written annotations
(Photo courtesy of Jim Parise, University of Notre Dame)

Therefore, the Lightboard gives a low technology solution for non tech-savvy instructors to create stunning and engaging instructional videos that allows them to visually explain the content and to write lecture notes without turning their back to the viewers or obstructing the writing with their body. Facing viewers while teaching and writing allows instructors to communicate with more richness and immediacy and enhances the non-verbal communication and personal connection with students. However, here comes one problem: the handwritten text, viewed through the glass, is backward. So the text orientation must be flipped. This mirror-flipping can be done by pointing the camera at a right angle toward a mirror reflecting the Lightboard and the presenter, or digitally by a videocamera with a "mirror-flip" function (Figure 3).

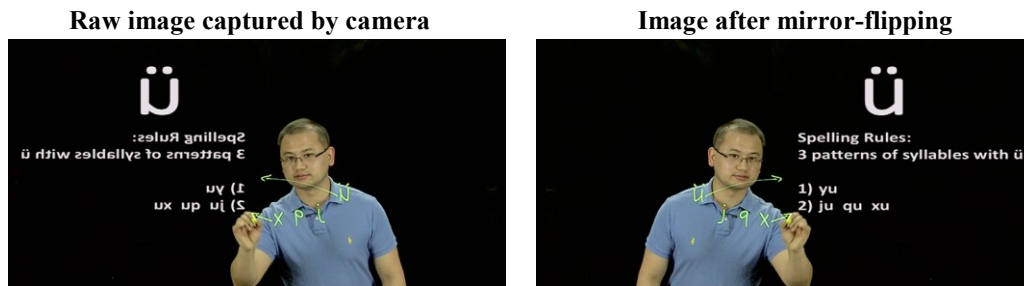**Raw image captured by camera**   **Image after mirror-flipping**

Figure 3: Mirroring the video

1.1 Lightboard component parts and working mechanism

A Lightboard consists of six major component parts (Figures 4 & 5): (1) a sheet of heat-tempered glass board for writing notes; (2) a lighting system for illuminating the glass board and the presenter; (3) a video camera to film the lectures; (4) a black background curtain; (5) a control desk to operate the Lightboard system; and (6) a presenter's monitor to see the real-time video during filming.
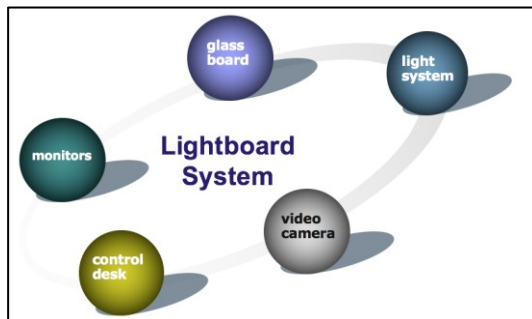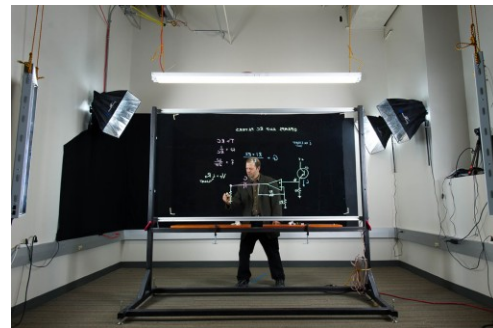

Figure 4: The Lightboard System

Figure 5: A Lightboard studio
(Photo courtesy of Michael Peshkin)

Most Lightboards use a 4x8 foot sheet of low iron architectural glass which is mounted on a metal frame so that the glass board will not vibrate or move when the presenter writes on it.

The lighting system, along with the video camera, plays an important role for the video image quality. It consists of three parts: (1) the LED strips along the upper and bottom edges of the Lightboard to illuminate the writings on the board; (2) back overhead

lights with a mylar reflector curtain to illuminate the presenter from top (Figure 5 & Figure 6, left photo); (3) key and fill lights (i.e., main and supplementary lights) that are placed on the right and left sides of the Lightboard to illuminate the presenter and the writings. These lights should be placed far enough from the glass board so that their reflection in the glass is not visible to the camera (Figure 5 & Figure 6, right photo).

Figure 6: Back and front lights in the Lightboard studio at Notre Dame

The video camera significantly determines the video image quality so a semi-professional or better camera is always preferred if it is within the project budget. You also want to use a scan-reverse camera which has a mirror-flipping option built in to produce a mirrored video stream. Otherwise, you will need to use a mirror in front of the camera (Figure 7) or a video editing software to reserve the video image so that the final video shows the handwritten texts in the right way.
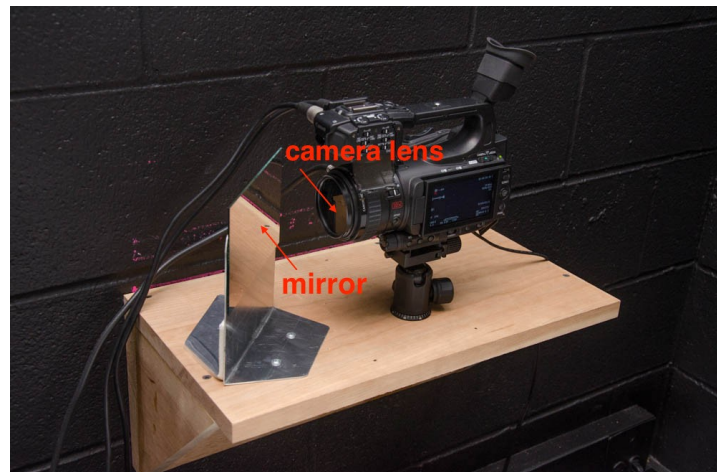
Figure 7: Using a mirror for image reversal

The control desk usually has a computer such as a Mac mini with a monitor. On this computer, you can operate the video switcher (e.g. Blackmagic Design ATEM software, Figure 8). The video switcher combines signals from the video camera and other video resources such as a laptop computer with prepared PowerPoint slides which you can incorporate onto the live image from the video camera.
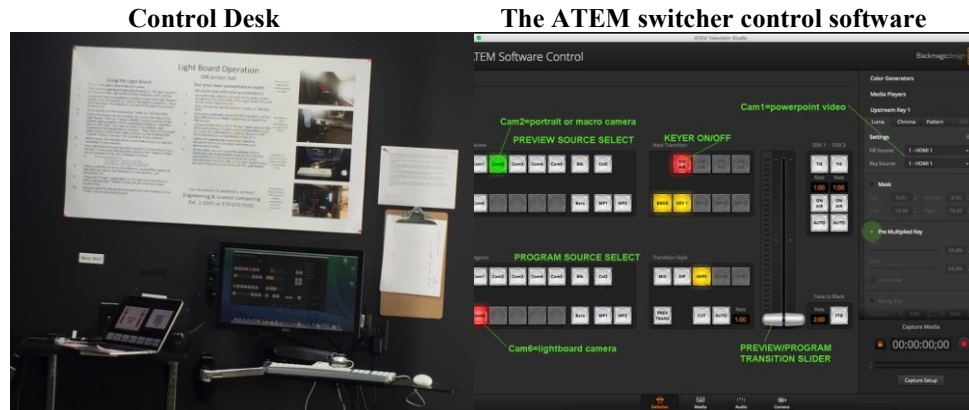
Figure 8: the control desk and the interface of the video mixing control software

A presenter's monitor is usually positioned near the video camera so that the presenter can see it through the glass board (Figures 1 & 9). This enables him or her to monitor the mixed live video image and to interact with the PowerPoint graphics. With this monitor, the presenter can perceive where the marker tip is relative to the graphics.

Other major Lightboard component parts include a black muslin backdrop curtain, sound absorbing foam behind backdrop, wireless microphones, liquid chalk and optionally, an additional monitor as a teleprompter (Figure 9).
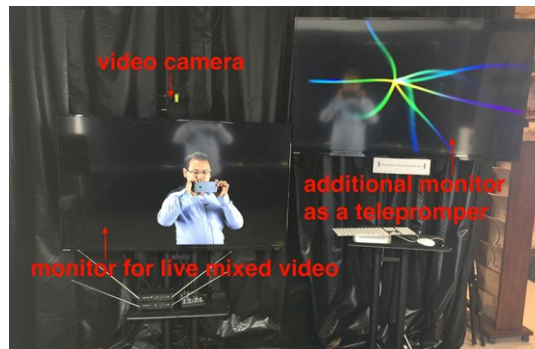

Figure 9: Real-time and Additional Monitors

1.2 Development history

The Lightboard was originally developed around 2011 by Michael Peshkin, a mechanical engineering professor at Northwestern University (Peshkin, 2013; Peshkin，2014). He invented the Lightboard to create visually stimulating video lectures for his students and inspired other faculty members and students at Northwestern to produce their own videos with the Lightboard.

Peshkin also developed the Lightboard as Open Source Hardware allowing for innovation across different institutes and even built a website in 2013 to share step-by-step instructions on how to build a Lightboard (Peshkin, 2013). Many other institutes, including Penn State's One Button Studio team and Duke University, have adopted the technology and modified it to suit their own purposes.

Duke's similar system was designed to be portable so that it can be easily set in place for filming and then returned to storage. Their lighting system has also been simplified for quick setup, and the glass board is switched to lightweight materials (Wells, 2014). At Pennsylvania State University, technicians have successfully integrated the Lightboard into the school's One Button Studio, a studio-control software that provides a simple way for instructors to produce videos in a studio session (Oberdick, 2015). According to Northwestern University's report, over 30 institutes worldwide have installed Lightboards on their campuses. In many cases, the Lightboard has been deployed to enhance their existing One Button Studio (OBS) and other video facilities (Northwestern University's Digital Learning site, 2016).

At around the same time that Michael Peshkin invented his Lightboard (around 2011-2012), some individuals developed their own Lightboard systems independently and nearly simultaneously. Among them was Matt Anderson, a physics professor at San Diego State University who named his Lightboard as "Learning Glass" and used it for his physics classes (Skibinski, 2015). His Learning Glass (Lightboard) uses a smaller glass sheet, 3.5x5 feet (Peshkin's is 4x8 feet). He also shared online an instruction video and detailed written documentation for constructing his "Learning Glass". Anderson and his colleagues later founded a company, Learning Glass Solutions, which markets complete packages. Matt Anderson also has experimented with live audiences in his "Learning Glass" studio at SDSU (Jacobs, 2014; Figure 10). He presented a live mirror-reversed image on a couple of projection screens for studio audience to view.

Figure 10: Matt Anderson with his Table-Top "Learning Glass (Lightboard)": the center image was not mirror-flipped while the ones on both sides were flipped.
(Michael Peshkin. *Learning Glass* [digital image]. Retrieved from
https://sites.google.com/site/northwesternlightboard/buy-or-build)

The majority of current Lightboard users are professors from science and engineering subjects. They have been using it for various purposes, from demonstrating a biochemical reaction to teaching electronic circuit design. However, it's not limited to STEM faculty. At Northwestern, Russian language faculty also uses it for flipped courses and for creating short videos to answer student questions. Moreover, students also use it to create videos for course assignments and presentations (Birdwell, 2015).

2. Advantages and Limitations of Lightboard

2.1 Advantages

The Lightboard has many advantages when being used to create instructional videos for online or flipped courses. First and foremost, as a replacement for traditional whiteboard or blackboard video, the presenter always faces the camera even during writing notes. So she or he can maintain face-to-face contact with audience (i.e., the camera) and her or his body never obstructs the hand-written notes since the presenter doesn't have to turn her or his back to the camera. In this way, the presenter is able to give a smoother and more natural presentation. The constant eye contact with the audience and the writing that glows in high contrast in front of the presenter make the video more engaging and intimate.

Second, effective use of Lightboard videos can support learning in a range of ways. Effective working memory capacity can be increased by using auditory and visual working memory together rather than using one or the other alone (Mayer, 2001; Sorden, 2005). The combination of narration and gestures from the presenter can support learning. According to Kelly, Manning & Rodak (2008), hand gestures were "a natural, ubiquitous and meaningful part of spoken language" and "[g]esture and speech form a tightly integrated system during language production and comprehension"(p.569). Additionally, better learning transfer occurs when learners can choose their own pace. In this case, learners can control the pace of presentation by stopping or replaying the video. (Plassa, 2003; Sorden, 2005).

Third, compared to regular online course videos, the Lightboard video is more interactive and engaging. Guo, Kim & Rubin (2014) classified the videos used on the edX or MOOC platform into four types: (1) a recorded classroom lecture; (2) an instructor's talking head; (3) a Khan-style digital tablet drawing (popularized by Khan Academy); and (4) a PowerPoint slideshow with voice-over. The videos created with the Lightboard excels these aforementioned videos in the following ways: it combines both PowerPoint slides and hand-written annotations as well as the presenter's gestures and facial expression; additionally, it allows the presenter to convey more information through annotating specific parts of the slides on the glass board with neon markers.

Fourth, owing to the easiness of using Lightboard, very little training is required for an instructor to create instructional videos. In its simplest form, the instructor simply turns on the Lightboard system by clicking the start button on the control desk computer, gives a lecture and finishes it up by clicking the stop button. Then the final video is immediately generated and saved to a flash drive, ready for uploading. Since the lecture is recorded in real-time and little or no post-production is required, it is much less time-consuming than many other methods for producing videos. The quickness and easiness of operating Lightboard definitely helps overcome the reservations of some instructors who feel uncomfortable with video production. Similarly, the lighting system and the semi-professional videocamera (or better ones) help produce very high quality videos. This also makes the Lightboard especially appeal to those instructors who are not tech-savvy but want to engage their students with videos of decent quality.

2.2 Limitations

Although it can produce high-quality videos as easily as the Penn State University's One Button Studio (OBS), the Lightboard is not intended for deployment in classrooms. First, the live audience in a classroom will see the presenter's writing in reverse unless the Lightboard is viewed in reflection. Matt Anderson has experimented with live viewers by putting mirror-reversed image on projection screens for the live (Jacobs, 2014), but this practice is not cost-effective enough for extensive implementation in classrooms. Second, a complete set of the Lightboard system costs about $10,000 (Peshkin, 2013). The high cost renders it impossible to equip many classrooms with the Lightboard. Third, it is inconvenient and even hazardous to move between classrooms the whiteboard-size sheet of glass which is fragile and cumbersome.

Furthermore, while the Lightboard can be used to produce long videos technically as long as the storage space for videos is adequate, it works better for making brief videos. The principle reasons are that the space on the glass board for writing is relatively limited and that wiping the glass surface is more difficult than erasing a blackboard or whiteboard. In other words, no further writing can be done in the recording session once the glass board is all filled, which makes the Lightboard not ideal for creating long videos.

Additionally, one small tricky thing to note about Lightboard is that nearly all of the writing seen in Lightboard videos are left-handed. This is the result of mirror reflection which mirror-reserves the handwritten notes as well as the image of the instructor, so right-handers appear as left-handers, and vice versa.

3. Implications and Applications of Lightboard for Chinese Language Instruction

Given that Lightboard is originally developed by engineering professors as a desirable tool for explaining equations and diagrams, most of its current users are not surprisingly STEM faculty. Instructors use it to develop tutorial videos for solving difficult problems, providing homework feedback and explanations of more complex topics, and review sessions. Videos created with Lightboard can also be used as the major way to deliver content for online courses, such as distance learning offerings and MOOCs, for professional programs, and for remotely attended conferences. Additionally, undergraduate and graduate students have used Lightboard to create videos for class presentations and student organizations. Graduate TAs for STEM courses have also recorded demonstrations for their classes.

Hybrid courses have been well adopted in education with its multimedia features, interactivity, and ability to support cooperative and autonomous learning (Reinders, 2011). This module of integrating classroom and online communicative learning has become very popular in European language instruction, but just begun to emerge in the field of teaching Chinese to English speakers (Lin & Huang, 2011; Wang, 2014). The completely online MOOCs are also expanding in Chinese language education (Lin & Zhang, 2014). According to Liu and Luo (2016), a beginning Chinese course titled "Chinese for Beginners" developed by Peking University on the platform of Coursera

has attracted more than 730,000 users across the world with over 330,000 active learners.

As a growing number of Chinese language instructors are exploring ways of flipping courses or moving them completely online, proportional demands are increasing for an easy and quick tool to create high quality engaging videos to deliver the course contents. Lightboard can satisfactorily fit that need for many of those language instructors.

Just as STEM faculty, Chinese language instructors will find that Lightboard is a simple yet powerful tool for recording tutorial videos to complement their traditional and flipped courses. You can illustrate and write lecture notes on the glass board (see Figure 11-a) or annotate a PowerPoint slide (see Figure 11-b) while maintaining your face-to-face contact to the camera to facilitate your teaching of Chinese characters, pronunciation and grammar patterns. Specifically, you can incorporate hand-written demonstrations, stroke order animations, and other multimedia resources as well as your oral instructions into one single video simultaneously to visualize and enhance learning of characters. It can also be used to develop short video tutorials to teach key and difficult new words and grammar patterns. Its versatile features make Lightboard video tutorials more intelligible than a conventional lecture and helps conserve classroom time for drills and communicative activities. Additionally, it also offers chances and flexibility for language students to go back to the videos to review and consolidate their learning.
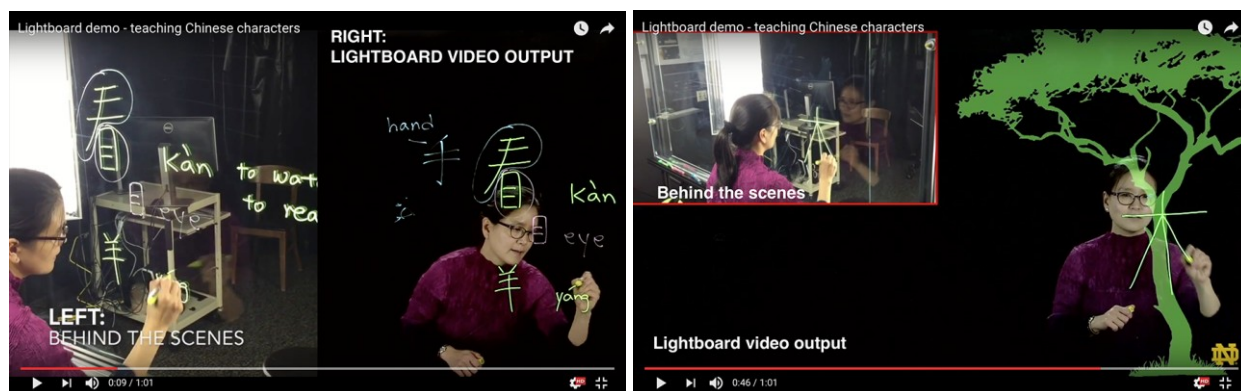
Figure 11-a: Writing & drawing on Lightboard
(Photo courtesy of Hanna Kang, Notre Dame)

Figure 11-b: Annotating a Powerpoint
(Photo courtesy of Hanna Kang, Notre Dame)

Lightboard videos' nature of brevity also makes them easier for language students to find time to watch and better fits their attention span. Studies show with substantive evidences that shorter videos are much more engaging. Engagement drops sharply after 6 minutes (Guo, Kim & Rubin, 2014). These results can be bolstered by the cognitive load theory which views the limitations of working memory capacity and duration as a major barrier to learning. The theory also encourages learners to lessen working memory load during new information processing (Sweller, 1988). Therefore, a lengthy lecture should be segmented into small chunks. For example, we can deliberately select difficult vowels (such as ü, u, ui, iu, üe, ian), consonants (such as j/q/x, z/c/s), and other pronunciation issues (such as tone sandhi and the complex pinyin spelling rules), and produce individual Lightboard videos to address each item. In many beginning Chinese textbooks and courses, the teaching of pinyin seems too intensive for students to absorb and master.

However, short Lightboard tutorial videos seem more effective than a traditional lecture, as the latter usually seems too daunting for students based on the feedbacks from students on the pronunciation tutorial videos that I created.

Additionally, you can deploy Lightboard to record short videos to give students timely homework or exam feedbacks. For some common errors, such as those grammatical or pronunciational ones, these short videos will be a very effective and efficient way to correct mistakes since you can share the videos with different sections of students and even future students so that you don't have to repeatedly deliver the same content to different students again and again.

4. How to Use Lightboard and Install a Lightboard Studio

4.1 Step by step: Create a tutorial video using Lightboard

Next I will illustrate how to use the Lightboard to create tutorial videos step by step through a sample video I produced for pronouncing "ü" (Figure 12 shows a screenshot of the video, and the video link is listed in the Appendix).
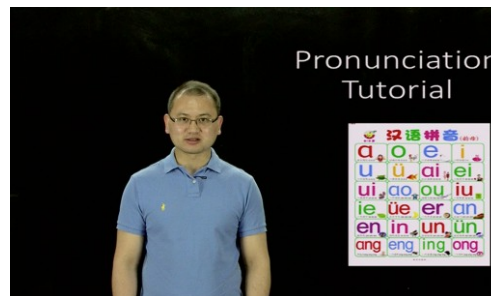

Figure 12: Pronunciation tutorial video for "ü"

Step 1: Preparation

Write down lecture notes including the knack of pronouncing "ü", its spelling rules, common errors with their solutions, and examples for drill. Just as you would for a class, it always helps to prepare an outline or script for each presentation topic. You can also display the outline on an additional monitor and use it as a teleprompter (Figure 10). Considering this type of video needs to be short, I personally prefer to rehearse adequately so that I can give the lecture in a more natural and smoother way without referring to any notes.

Create PowerPoint slides to be overlaid onto the Lightboard. Make sure the PowerPoint background is black and all texts are white to stand out in contrast to the background (see the comparison from Figure 13). You also want to leave space on your PowerPoint slides for your hand writing and for your appearance on the screen (Figure 14). Upon your arrival at the Lightboard studio, connect your laptop, which plays the PowerPoint file, to the Control Desk computer and also insert a flash drive stick to the computer for video storage.
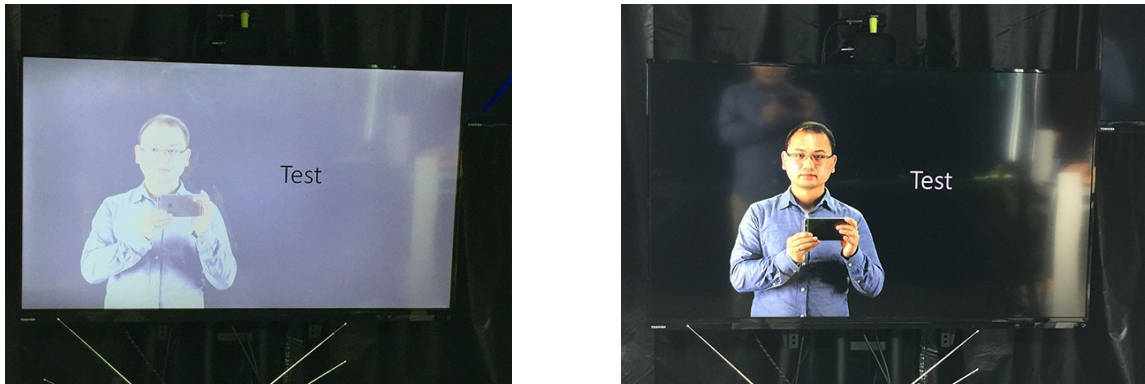
Figure 13: PowerPoint background comparison: left, white background; right, black background

Figure 14: Leave space for you and your writing when making PowerPoint

Step 2: Turn on the Lightboard Switcher and Film

Turn on the studio lights. Put on the wireless microphone and check its battery level to make sure it's not too low.

The "switcher" panel, which controls the recording and mixes the camera video with the PowerPoint slides, may seem too intimidating to operate, but actually you can keep all default settings and simply click the "unlock" icon and then the start button to film (Figure 15).
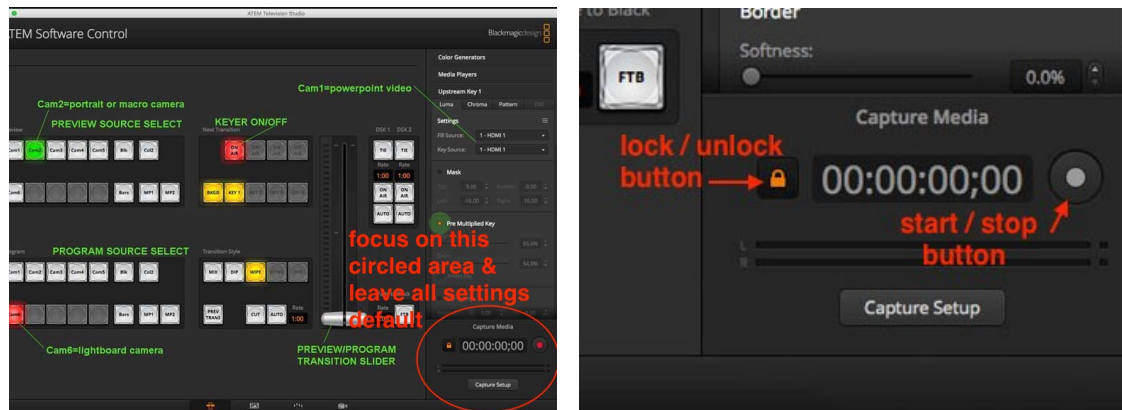

Figure 15: Switcher panel (the Blackmagic Design ATEM software) which controls the recording and mixes videos from different sources

It's recommended to record a short "screen test" snippet and then play it on the Control Desk computer. This helps check if any technical details need to be corrected or refined, such as a malfunctioning microphone. Then it's your show time: click the start button, walk to the Lightboard and start your talk. Stand and face the camera for a few seconds at the beginning and end of each video. This will help you in post-production to find a clean cut point to edit out your walk-in and walk-out.

Step 3: Finish up Your Lecture and Turn off the Switcher

After finishing up your lecture, walk to the Control Desk again and just click the stop button. Your video then will be automatically saved right into your flash drive and ready to be watched and uploaded. In most cases, you just need to cut off the part of your walks in the video between the control desk and the Lightboard. Some instructors also feel comfortable to leave their walk-in and walk-out there. So usually little or no post-production is needed. The final video can be shared with your students via Sakai, YouTube, Vimeo, Google Drive or other platforms you use for your courses.

Figure 16: Flow diagram: use the Lightboard to create instructional videos

4.2 Tips for producing Lightboard videos

Below are a few valuable tips for produce decent videos with the Lightboard. For more detailed best practices, you can refer to Peshkin's website (Peshkin, 2013).

- Make it short! A 3-6 minutes video may be the best. Short videos fit better students' attention span and enhance the likelihood of their watching.

- Don't wear clothes whose color is too dark or too bright. Black clothes make you appear like a floating head on the black backdrop while bright clothes, such as a white shirt, make your writing on the Lightboard hard to read. Light blue shirt seems to work decently.

- Your wear must not have any logos or text on the front side as they will

appear mirror-reversed in the final video.

4.3 Installation of a Lightboard Studio

If the aforementioned features of the Lightboard fit your needs to make instructional videos for your Chinese courses, you may want to check first if your home institute has already built one. If not, joining up with STEM faculty at your school will certainly renders it easier to secure funds for building a Lightboard studio. Candidly, your colleagues teaching science or engineering subjects probably find the Lightboard ideas even more tempting for them.

Michael Peshkin, the pioneer of the Lightboard, has built the open-source project website that technicians or other supporting staff from your school will find very helpful. The site contains a detailed parts list and thorough instructions on how to construct a Lightboard studio. The estimated cost for the whole system is around $10,000. Recently it was reported that Kent State University has built a Lightboard system with a budget of under $1,000, of course not including labor cost since it was built by school-employed technicians (Earley, 2016). The cost was dramatically economized by switching to cheaper materials. For instance, the video camera on Peshkin's list, Canon XF-105, is a semi-professional camcorder with a "mirror revere" function and costs about $3,000, while the Kent State uses a $200 video camera with which they have to mirror-flip the output video with a software.

If your institute prefers to purchase a complete package, you can consider products provided by Learning Glass Solutions. Matt Anderson, who independently developed their Lightboard that he named as "Learning Glass", and his team from their company, Learning Glass Solutions, offer complete packages for sale (Figure 10). For more information about their two types of products, Learning Glass Studio Package and smaller Table-Top Studio Package, you can refer to their website listed in the Appendix. For ambitious DIY technicians, the company also provides the complete build instructions for these products at its website.

5. Conclusion

The Lightboard is an innovative and powerful tool to deliver content to students, for both hybrid and completely online courses. It allows instructors to directly interact with their glowing handwritten notes in front of them and to vividly annotate PowerPoint slides superimposed onto the board. In contrast to a blackboard or whiteboard, the Lightboard allows instructors to maintain their face-to-face interaction with viewers even while writing notes on the glass board. Despite its high-quality final video, little training is required for the Lightboard instructions since its operation is pretty simple. All these features render the Lightboard a powerful tool to make short tutorial videos to complement hybrid and fully online courses including teaching of Chinese pronunciation, characters, new words and grammar patterns. As more and more institutes are adopting

the Lightboard, this article hopes to provide a general overview of the Lightboard for those interested in exploration of using the Lightboard for their Chinese courses.

References

Birdwell, A., & Peshkin, M. (2015). Capturing technical lectures on Lightboard. *ASEE Annual Conference & Exposition Proceedings, 2015*, 1-9.

Earley, C. (2016). A personal site of Clarke Earley from Kent State University. Retrieved from http://delta.stark.kent.edu/lightboard/construction

Guo, P., Kim, J., & Rubin, R. (2014). How video production affects student engagement: An empirical study of MOOC videos. *Proceedings of the First ACM Conference on Learning at Scale, March 2014*, 41-50. doi:10.1145/2556325.2566239

Jacobs, H. (2014). Illumination in Education. Retrieved from http://newscenter.sdsu.edu/sdsu_newscenter/news_story.aspx?sid=75004

Kelly, S., Manning, S., & Rodak, S. (2008). Gesture gives a hand to language and learning: Perspectives from cognitive neuroscience, developmental psychology and education. *Language and Linguistics Compass, 2/4* (2008), 569–588. doi:10.1111/j.1749-818X.2008.00067.x

Lin, C., & Huang, C. (2011). Chinese course design and evaluation via web-supported blended learning: A study of users view. *Journal of Chinese Language Teachers Association*, *46*(3), 85–115.

Lin, C. H., & Zhang, Y. (2014). MOOCs and Chinese Language Education. *Journal of Technology and Chinese Language Teaching, 5*(2), 49-65.

Liu, X., & Luo, Y. (2016). MOOC: Chinese for Beginners. Retrieved from http://mp.weixin.qq.com/s/a_WMb2B-Ko-6uHcEWloKIw [刘晓雨, 罗雨晴. (2016). 对外汉语界的"网红课": 零起点基础汉语 Chinese for Beginners. "汉语在线"微信公众号, 2016-12-27]

Mayer, R., Heiser, J., & Lonn, S. (2001). Cognitive Constraints on Multimedia Learning: When Presenting More Material Results in Less Understanding. *Journal Of Educational Psychology, 93*(1), 187-198. doi:10.1037//0022-0663.93.1.187

Northwestern University's Digital Learning (2016). Lightboard Studio. Retrieved from https://digitallearning.northwestern.edu/article/2016/04/12/lightboard-studio

Oberdick, J. (2015). Lightboard integrates with One Button Studio to enable more engaging teaching videos. Retrieved from http://tlt.psu.edu/2015/03/11/lightboard-integrates-with-one-button-studio-to-enable-more-engaging-teaching-videos/

Peshkin, M. (2013). An open source project website built by Michael Peshkin. Retrieved from http://lightboard.info

Peshkin, M., Birdwell A., Inzko, H., Bobbert C., & Evans, E. (2014). 7 things you should know about Lightboard. Retrieved from https://library.educause.edu/~/media/files/library/2014/8/eli7111-pdf.pdf

Plassa, J., Chun, D., Mayer, R., & Leutner, D. (2003). Cognitive load in reading a foreign language text with multimedia aids and the influence of verbal and spatial abilities. *Computers in Human Behavior, 19*(2), 221–243. doi:10.1016/S0747-5632(02)00015-8

Reinders, H., & White, C. (2011). Learner autonomy and new learning environments. *Language Learning & Technology, 15*(3), 1–3.

Skibinski, E., DeBenedetti, W., Ortoll-Bloch, A., & Hines, M. (2015). A Blackboard for the 21st century: An inexpensive Light Board Projection system for classroom use. *Journal of Chemical Education, 2015, 92,* 1754−1756. doi:10.1021/acs.jchemed.5b00155

Sorden, S. (2005). A cognitive approach to instructional design for multimedia learning. *Informing Science Journal, 2005*(8), 263-279.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science. 12*(2), 257-285. doi:10.1016/0364-0213(88)90023-7

Wang, H. (2014). Toward Deepening Cultural and Language Understanding: The Design and Practice of a Hybrid Business Chinese Course. *Journal of Teaching in International Business*, *25*(3), 250-262. doi: 10.1080/08975930.2014.925750

Wells, S. (2014). The LightBoard is done! Retrieved from https://sites.duke.edu/ddmc/2014/06/04/the-lightboard-is-done/

Appendix

Sample Lightboard Videos
- Pronunciation tutorial video for "ü": https://www.youtube.com/watch?v=x78hjsjJWfY
- Lightboard demo - teaching Chinese characters: https://www.youtube.com/watch?v=RAXva4jbM5c
- Sample Videos Using Lightboard by University of Florida: https://mediasite.video.ufl.edu/Mediasite/Play/7c44307b942f424c8bdde637b716dd021d
- EMC ProtectPoint Lightboard Overview: https://www.youtube.com/watch?v=98y5-qa6nYs&list=PL0dcjleaDomqUk8C9JTMyQFzEY2uE2fYh&index=9
- Stanford Online's Lightboard Demo: https://www.youtube.com/watch?v=eRuDGbTuuqo
- UNC-TV Lightboard Demo: https://www.youtube.com/watch?v=ea2VQ0OAFyc
- University of Illinois Demo Video: https://citl.illinois.edu/services/for-instructors/instructional-resources/studios/lightboard

Introduction and How-to-do
- Northwestern "Lightboard": https://www.youtube.com/watch?v=N1I4Afti6XE&index=8&list=PL0dcjleaDomqUk8C9JTMyQFzEY2uE2fYh
- FIRST Lightboard Challenge & What You'll Need by Humber College, Toronto https://www.youtube.com/watch?v=x74rUXki_bk&t=1m13s
- Lightboard Basics | Part 1 of 5: It's Easy! https://www.youtube.com/watch?v=g8UpAuBdy9M

- Introducing the Lightboard:
  https://www.youtube.com/watch?v=Rmqeakjllu4&t=8s
- One Button Lightboard Studio Introduction
  https://www.youtube.com/watch?v=TFF3MEqRE-s&t=29s
- Digital Learning - active classroom & lightboard
  https://www.youtube.com/watch?v=jhA0gnTO4-w
- Lightboard Tips #1:
  https://www.youtube.com/watch?v=29X8oPrqm4w
- Lightboard Tips for Recording Preparation:
  https://www.youtube.com/watch?v=KyhCiOhASBA
- How to Make a Lightboard for Shooting Videos
  https://www.youtube.com/watch?v=wNnsU1e8uoM
- Tech in Teaching: Using A Light Board in Educational Videos
  https://www.youtube.com/watch?v=x7cpffO-mys&index=7&list=PL0dcjleaDomqUk8C9JTMyQFzEY2uE2fYh&t=1s
- Learning Glass Solutions:
  https://www.youtube.com/watch?v=GJKNR_zb0BY
- FlipCon 2016: How to make and use a lightboard:
  https://www.youtube.com/watch?v=c79lrxj0pks
- User Forum: https://groups.google.com/forum/#!forum/lightboard

Lightboard Construction and Purchase:
- Peshkin's Parts List:
  https://sites.google.com/site/northwesternlightboard/home/parts
- Peshkin's Typical Bill of Materials
  https://docs.google.com/spreadsheets/d/1KuA3cItcWjFl-UmGXpdiONPubo2OaFonnWxl01kuWe4/edit#gid=524173569
- Kent State University's Bill for Construction:
  http://delta.stark.kent.edu/lightboard/construction
- Website of Matt Anderson's Company: Learning Glass Solutions:
  http://www.learning.glass
- Learning Glass Product List:
  http://www.learning.glass/learning-glass-products/
- Building a Low-cost Lightboard for Video Lectures:
  https://www.youtube.com/watch?v=FYwXOLU4TKk&list=PL0dcjleaDomqUk8C9JTMyQFzEY2uE2fYh&index=1&t=40s